

**Attachment J-03**  
**Contract Performance Work Statement**

## Table of Contents

<b>1</b>	<b>PERFORMANCE WORK STATEMENT.....</b>	<b>7</b>
1.1	Introduction.....	7
1.2	Background and Objective.....	7
1.3	PWS Organization and Structure .....	7
<b>2</b>	<b>REFERENCE DOCUMENTS.....</b>	<b>9</b>
2.1	Military Standards, Specifications, and Other Government Documents – Mandatory Compliance.....	9
2.2	Military Standards, Handbooks, and Other Government Documents – Guidance Only .....	10
<b>3</b>	<b>REQUIREMENTS .....</b>	<b>11</b>
3.1	CCtCap Program Management (All CLINs) .....	11
3.1.1	Program Management.....	11
3.1.1.1	Program Integration.....	11
3.1.1.2	Program Management Reviews (PMRs).....	11
3.1.1.3	Program Support.....	12
3.1.1.4	Government Insight.....	13
3.1.1.5	Independent Verification and Validation (IV&V) .....	13
3.1.2	Business Management .....	13
3.1.3	Supplier Management .....	14
3.1.4	Information Technology (IT).....	14
3.1.5	Risk Management .....	14
3.1.6	Configuration and Data Management.....	15
3.1.6.1	Configuration Management.....	15
3.1.6.2	Data Management.....	15
3.2	Design, Development, Test and Evaluation (DDTE)/Certification (CLIN 001).....	16
3.2.1	System Engineering and Integration (SE&I).....	16
3.2.1.1	System Engineering.....	16
3.2.1.1.1	Requirements and Verification and Validation .....	17
3.2.1.1.2	Interface Management .....	18
3.2.1.2	Milestone/Technical Reviews .....	19

- 3.2.1.2.1 Certification Baseline Review (CBR) [Mandatory Government Interim Milestone] ..... 19
- 3.2.1.2.2 ISS Design Certification Review (DCR) [Mandatory Government Delivery Milestone] ..... 19
- 3.2.1.2.3 Orbital Flight Test Flight Test Readiness Review (OFT FTRR) [Mandatory Government Interim Milestone] ..... 20
- 3.2.1.2.4 Crewed Flight Test Flight Test Readiness Review (CFT FTRR) [Mandatory Government Interim Milestone] ..... 20
- 3.2.1.2.5 Operations Readiness Review (ORR) [Mandatory Government Interim Milestone] ..... 20
- 3.2.1.2.6 Certification Review (CR) [Mandatory Government Delivery Milestone] ..... 21
- 3.2.1.3 System Analysis ..... 21
- 3.2.1.4 System Integration and Certification ..... 22
- 3.2.1.5 Specialty Engineering ..... 24
- 3.2.2 Safety, Reliability and Quality Assurance .....25
  - 3.2.2.1 System Safety ..... 25
  - 3.2.2.2 Environmental, Industrial, Launch Site and Range Safety ..... 27
  - 3.2.2.3 Reliability, Maintainability and Availability ..... 27
  - 3.2.2.4 Quality Assurance ..... 27
  - 3.2.2.5 Software Safety and Assurance ..... 28
- 3.2.3 Production Control .....28
- 3.2.4 Vehicle (CST-100 and LV) .....28
  - 3.2.4.1 Flight Hardware ..... 28
  - 3.2.4.2 Flight Software ..... 28
- (b) (4)** [Redacted]
- 3.2.5 Ground Systems .....32
  - 3.2.5.1 Assembly Integration and Test (AIT) Facility and Systems ..... 32
  - 3.2.5.2 Ground Communication Systems ..... 33
  - 3.2.5.3 Cargo Handling Operations, Facilities and Systems ..... 33
  - 3.2.5.4 Recovery Systems and Operations ..... 33
  - 3.2.5.5 Logistics and Logistic Systems ..... 33
  - 3.2.5.6 Pre-Flight and Launch Site Infrastructure ..... 33
  - 3.2.5.7 Ground Segment Test and Checkout ..... 33
- 3.2.6 Crew and Mission Operations (CMO) .....33
  - 3.2.6.1 Mission Planning and Analyses ..... 34
  - 3.2.6.2 Training ..... 34
  - 3.2.6.3 Flight Operations ..... 34
  - 3.2.6.4 Cargo Operations ..... 34

3.2.7	Test and Evaluation .....	34
3.2.7.1	Test Planning and Integration.....	35
3.2.7.2	Ground Test .....	35
3.2.7.3	Flight Test.....	35
3.2.8	Incorporation of NASA Disposition of CPC products .....	37
3.2.8.1	Alternate Standards (Reference PWS Section 3.2.1.1) .....	37
3.2.8.2	Hazard Reports (Reference PWS Section 3.2.2.1) .....	54
3.2.8.3	Variances (Reference PWS Section 3.2.1.1.1) .....	54
3.2.8.4	Verification and Validation Plan (Reference PWS Section 3.2.1.4) .....	71
3.2.8.5	Certification Plan (Reference PWS Section 3.2.1.4).....	71
3.3	Post Certification Missions (PCMs) Services (CLIN 002).....	72
3.3.1	Key PCM Milestones/Reviews.....	72
3.3.1.1	Vehicle Baseline Review (VBR) (At no later than 18 months prior to launch (L-18 mo)) .....	72
3.3.1.2	Mission Integration Review (MIR) (At no later than 13 months prior to launch(L-13 mo)).....	73
3.3.1.3	Mission Certification Review (MCR) (After Certification has been granted, and no later than 4 months prior to launch).....	73
3.3.1.4	ISS Stage Operational Readiness Review (SORR) (Approximately 3 weeks prior to launch) .....	75
3.3.1.5	Flight Readiness Review (FRR) (Approximately 2 weeks prior to launch) .....	75
3.3.1.6	Undocking Readiness (Approximately two (2) weeks prior to landing).....	75
3.3.1.7	Post Flight Review (PFR) (Approximately 2.5 weeks after landing) .....	75
3.3.2	PCM Vehicle Integration .....	76
3.3.2.1	Launch Vehicle (LV) and Crew Vehicle (CV) Integration .....	76
3.3.2.2	Safety, Reliability and Quality Engineering.....	76
3.3.3	PCM Mission Integration.....	77
3.3.3.1	PCM Approach.....	78
3.3.3.2	PCM Initiation.....	78
3.3.3.3	Mission Definition and Documentation .....	78
3.3.3.4	PCM Certification Maintenance.....	79
3.3.3.5	Safety and Mission Assurance.....	79
3.3.3.6	Analytical Integration.....	80
3.3.3.7	ISS Integration.....	80
3.3.3.8	Licenses and Permits .....	80
3.3.3.9	Range Safety.....	80

3.3.4 Crew and Mission Operations.....	80
3.3.4.1 Mission Planning and Analysis .....	80
3.3.4.2 Training .....	81
3.3.4.3 Flight Operations .....	81
3.3.4.3.1 Flight Operations .....	81
3.3.4.3.2 Emergency Crew Search and Rescue Interface .....	81
3.3.4.4 Ground Systems .....	81
3.3.4.4.1 Assembly Integration and Test (AIT) Facility and System.....	82
3.3.4.5 Ground Communication Systems .....	82
3.3.4.6 Recovery Systems and Operations .....	82
3.3.4.7 Logistics and Logistic Systems .....	82
3.3.4.8 Ground Segment Test and Checkout.....	82
3.3.5 PCM Cargo Integration.....	82
3.3.5.1 Cargo Integration.....	83
3.3.5.2 Return Cargo .....	83
3.3.6 Inherent Capabilities .....	83
3.3.6.1 Contractor System Inherent Capabilities.....	83
3.3.6.2 Coordination of Inherent Capabilities .....	85
3.4 Special Studies (CLIN 003).....	86
<b>Appendix A Milestone Acceptance Criteria and Payment Schedule.....</b>	<b>1 of 63</b>
<b>Appendix B Post Certification Mission (PCM) Milestone Acceptance Criteria and Payment Schedule.....</b>	<b>1 of 28</b>

### List Of Tables

Table 1.3-1.	PWS Layout .....	8
Table 3.2.1.1.1-1.	Definitions.....	17
Table 3.2.1.1.1-2.	CCtCap Applicable Documents .....	18
Table 3.2.4.3-1.	Products developed during Phase I & II that will be provided to NASA for review, comment and approval .....	30
Table 3.2.4.3-2.	Programmatic and Technical Reviews to be executed during Alternate Launch Vehicle Integration Phases I and II.....	31
Table 3.2.7.3-1.	PCM Task Performed during CLIN 001 for Crewed Flight Test to ISS.....	36
Table 3.2.8.1-1	Tasks for Alternate Standards based on CPC Disposition Letters.....	38
Table 3.2.8.3-1	Tasks for Variances based on CPC Disposition Letters .....	55
Table 3.3.6.1-1.	Inherent Capabilities .....	84

## **1 PERFORMANCE WORK STATEMENT**

### **1.1 Introduction**

The Performance Work Statement describes the scope of work to be performed by the Contractor under the Commercial Crew Transportation Capability (CCtCap) contract.

### **1.2 Background and Objective**

The CCtCap effort is the second phase of a two-phased Commercial Crew Program (CCP) procurement strategy to develop a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost effective access to and from low earth orbit (LEO) including the International Space Station (ISS) with a goal of no later than 2017.

The primary objective of Phase 1, Certification Products Contract (CPC), is the delivery, technical interchange, and National Aeronautics and Space Administration (NASA) disposition of early lifecycle certification products that address Crew Transportation System (CTS) compliance with NASA standards and requirements for an International Space Station (ISS) Design Reference Mission (DRM) within the CCT-DRM-1110, Crew Transportation Design Reference Missions.

The overall objective of Phase 2 (CCtCap) is focused on the final Design, Development, Test, and Evaluation (DDTE) activities necessary to achieve NASA certification of a CTS for the ISS DRM within the CCT-DRM-1110, Crew Transportation Design Reference Missions (DRM), culminating with execution of post certification missions (PCMs) to the ISS. Successful conclusion of the Certification Phase of CCtCap means that the Contractor's CTS meets NASA safety requirements for transporting NASA crew to the ISS (reference CLIN 001). Once the capability is achieved and available to the Government, the Commercial Crew provider will be eligible to provide services to and from the ISS. NASA intends to purchase transportation services to meet its ISS crew rotation and emergency return obligations defined under the Inter-Governmental Agreement as part of the PCM or Services Phase of CCtCap (reference CLIN 002).

The objective of this PWS is to document the requirements documented in Attachment J-01, Integrated Crew Transportation System Requirements, and J-02, Data Requirements Deliverables.

### **1.3 PWS Organization and Structure**

The PWS is comprised of two parts, the basic document which details the work scope required to execute the entire contract and appendices which provide specific requirements for the unique milestone reviews required for DDTE/Certification CLIN 001 and for each Post Certification Missions (PCM) CLIN 002 respectively (Table 1.3-1). The body of the PWS is segregated by the individual contract line item (CLINs). This PWS covers all three work scope areas/CLINs. This PWS is organized to align with the three CLINs with one additional section that is applicable to all CLINs (Table 1.3-1). Each of the PWS sections 3.2, 3.3, and 3.4 describes the unique efforts required to complete the scope of the required CLIN and are considered additive to PWS Section 3.1.

**Table 1.3-1. PWS Layout**

<b>PWS Section</b>	<b>CLIN</b>	<b>Description</b>
1.0		Introduction
2.0		Reference Documents
3.0		Requirements
3.1	All CLINs	CCtCap Program Management
3.2	CLIN 001	DDTE/Certification
3.3	CLIN 002	Post Certification Missions (PCM)
3.4	CLIN 003	Special Studies
Appendix A	CLIN 001	Milestone Acceptance Criteria and Payment Schedule
Appendix B	CLIN 002	PCM Milestone Acceptance Criteria and Payment Schedule

Section 3.1 (All CLINs): This section defines the work applicable to all CLINs and is associated with the tasks required to manage and lead the CCtCap contract.

Section 3.2 (CLIN 001 – DDTE/Certification (core contract)): This section defines the work necessary to:

- (a) Complete DDTE activities and certify the CTS to NASA requirements that comply with CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), for safely transporting NASA crew to the ISS.
- (b) Define, manage, and implement technical management plans and processes associated with achieving and maintaining NASA certification throughout the CTS lifecycle in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes.
- (c) Demonstrate long term operational plans to produce and operate CTS such that flight and ground articles are manufactured, assembled, and integrated, in a repeatable manner that satisfies NASA requirements.

Section 3.3 (CLIN 002) – Post Certification Missions (PCM): This section defines the work necessary to perform PCMs to the ISS.

Section 3.4 (CLIN 003 – Special Studies): This section defines the work necessary to perform risk reduction activities that may be performed as special studies as requested by NASA.

## 2 REFERENCE DOCUMENTS

### 2.1 Military Standards, Specifications, and Other Government Documents – Mandatory Compliance

Document Number	Date/Version	Document Title
AS9100	Rev. C, 15-Jan-2009	Quality Management Systems – Requirements for Aviation, Space and Defense Organizations
AFSPC MAN91-710	Jul-2004	Air Force Space Command Range Safety User Requirements Manual
CCT-PLN-1100	Rev. B-1, 23-May-2013	Crew Transportation Plan
CCT-DRM-1110	Rev. Basic-1, 8-Dec-2011	Crew Transportation System Design Reference Missions
CCT-PLN-1120	Rev. C, 25-Oct-2013	Crew Transportation Technical Management Processes
CCT-REQ-1130	Rev. C, 12-Nov-2013	ISS Crew Transportation and Services Requirements Document
CCT-STD-1140	Rev. A-1, 23-May-2013	Crew Transportation Standards and Processes Criteria
CCT-STD-1150	Rev. A-1, 16-Jul-2013	Crew Transportation Operations Standards
CCT-PLN-2000	Draft	NASA Crew Transportation and Services Certification Plan
JSC 35089	12-Jul-2012	Visiting Vehicle Operations Annex
NASA-STD-8739.8	With Change 1, 28-Jul-2004	Software Assurance Standard
NASA-STD-8719.13	Rev. C, 7-May-2013	Software Safety Standard
NPR 8715.3	Rev. C Chg-6, 3-Feb-2011	NASA General Safety Program Requirements
SSP 30234	Rev. B, Not 1 9-Sep-1992	Instructions for Preparation of Failure Modes and Effects Analysis and Critical Items List Requirements for International Space Station
SSP 30309	Rev. E, 28-Oct-1994	Safety Analysis and Risk Assessment Requirements Document
SSP 30599	Rev. B, 13-Feb-2000	ISS Safety Review Process
SSP 41170	Rev. A, 22-Jun-2000	ISS Configuration Management Requirements
SSP 50108	Rev. C, Nov-2006	ISS Certification of Flight Readiness Process Document

Document Number	Date/Version	Document Title
SSP 50260	Rev. B, 15-May-2003	ISS Medical Operations Requirements Document (MORD)
SSP 50667	Mar-2004	Medical Evaluation Document (MED)
SSP 50808	Rev. E, 20-Sep-2013 plus DCNs 0135B, 0146A*, 0149*, 0151*, 0152*, 0153*	International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD)  * indicates draft version
SSP 50964	Baseline, 9-Sep-2013	Visiting Vehicle ISS Integration Plan

## 2.2 Military Standards, Handbooks, and Other Government Documents – Guidance Only

Document Number	Date/Version	Document Title
CCT-REF-1121	Rev. A-1, 5-Nov-2012	Probabilistic Safety Analysis (PSA) Methodology Guide
DA8-13-193	31-Oct-2013	Notional Training Template for ISS Crew members

### **3 REQUIREMENTS**

#### **3.1 CCtCap Program Management (All CLINs)**

The following work statements are applicable to all CLINs related to this contract.

##### **3.1.1 Program Management**

###### **3.1.1.1 Program Integration**

The Contractor shall maintain a program management system to direct and control all elements of the Commercial Crew Transportation Capability (CCtCap) program. The system shall include planning, controlling, and monitoring the cost, schedule, risk, and technical objectives of the development, certification, and production efforts associated with this PWS.

The Contractor shall update existing program management plans that were developed and executed to in the prior phases of the CTS program, if required, to ensure processes associated with achieving and maintaining NASA certification throughout the CTS lifecycle are included in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes. The contractor's program plans shall contain sufficient detail to convey the approach for accomplishing program objectives (J-01 1120 3.0). The contractor shall ensure that the CCTS Program Management Plan (PMP), DCC1-00124-01, provides a roadmap for executing, monitoring and controlling the CCtCap program and spans the entire CTS lifecycle (J-01 1120 3.1.1). The CCTS PMP shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). The contractor shall develop, utilize, and maintain the tools to enable management of CCtCap (J-01 1120 3.1).

The Contractor shall ensure that other processes and management approaches not addressed in the PMP are documented in other program plans. The contractor shall ensure these plans are updated to address the entire lifecycle of the CTS (J-01 1120 3.1.1). The contractor shall provide these existing program management plans to NASA in support of the first milestone review for re-baselining for CCtCap at that review. The contractor shall execute, implement, and manage the CCtCap program in accordance with these program management plans.

###### **3.1.1.2 Program Management Reviews (PMRs)**

The Contractor shall conduct Quarterly Program status and management Reviews (QPRs) covering all CCtCap program matters with NASA. The contractor shall host these face-to-face meetings/reviews at the contractor's facilities associated with CCtCap execution or other mutually agreed to location. The contractor top level organizational and technical leadership shall chair these reviews/meetings. The agenda for the PMR meeting shall at a minimum address the contractor's progress in Certification and Post Certification Mission of the CTS and various areas to include technical/systems/safety engineering, testing, integrated logistics support, configuration management, manufacturing, fabrication and/or quality assurance issues, and other areas identified as high risk. As part of this meeting, the Contractor shall also present production progress material which includes: critical build status, manufacturing progress vs. plan, parts availability and shortages including Government Furnished items, quality issues impacting production, engineering actions needed by production, problem recovery plans, and delivery schedules. Status shall include discussion of the relationship between DDTE/Certification work and all authorized Post Certification Missions. The contractor shall include a discussion on program cost, schedule and technical risks to include status of previous identified issues including mitigations and resolutions. Cost updates shall be provided for expected costs through

Certification (CLIN 001) and the PCMs, and may include cost variations due to technical issues, schedules delays, corporate commitment progress and impacts to lifecycle cost estimates. The contractor shall identify cost growth and potential growth items with emphasis on changes since the last QPR. Additionally, the contractor shall present the Integrated Master Schedule highlighting updates/changes from previous Quarterly Program Reviews and readiness status of upcoming program milestones/reviews (with emphasis on milestones in the next six months) to ensure progression through performance milestones in compliance with established completion criteria. The contractor shall develop and deliver a QPR briefing package, DRD 005 Quarterly Program Review (QPR) Briefing Package, and provide to NASA prior to every QPR. Additionally, the contractor shall provide NASA a final package with action items and closure plans within five working days after the conclusion of the meeting.

### 3.1.1.3 Program Support

The Contractor shall support government program meetings/reviews by providing technical and programmatic subject matter expertise to participate and provide program data for NASA CCP decisions, perform evaluations and review of performance milestone deliverables and/or support other programmatic activities as requested/invited by NASA to include participating on Government Boards and Forums. NASA CCP Program Boards/Forums are defined in CCT-PLN-1100, Crew Transportation Plan include:

- a) Technical Review Board
- b) Program Control Board
- c) ISS Program (ISSP) Transportation Integration Control Board
- d) Space Station Program Control Board
- e) Joint Program Requirements Control Board (JPRCB) for requirements issues that are shared between CCP and ISSP
- f) NASA Program Boards - in support of issues related to Crew Transportation System (CTS) Certification, the Contractor may attend and support as invited. The Contractor may also request a NASA Program Board to be convened in support of issues related to CTS Certification.
- g) Operational forums (e.g., Joint Operations Panel (JOP) and Flight Operations Review (FOR)) to support the analyses and data delivered to NASA for the development of joint NASA operations products, analyses and tools
- h) Visiting Vehicle Integration Manager forums (VVIM) for joint development of ISS integration products and execution of joint processes
- i) NASA Independent Verification and Validation activities associated with contract data provided with Verification Closure Notices (VCNs)
- j) Integrated Safety Review process defined in CCT-PLN-1120, Crew Transportation Technical Management Processes. The contractor's participation shall include Phase Safety Reviews of Hazard Reports.
- k) The Contractor shall participate in NASA/Federal Aviation Administration (FAA)/Range trilateral discussions representing its recommendations when crew safety and public safety risk considerations are assessed

#### 3.1.1.4 Government Insight

The Contractor shall allow Government to actively participate in CCtCap coordination and/or planning forums, briefings, meetings, boards, readiness reviews/milestones, simulations, hardware or operational demonstrations, tests, and other events consistent with the model in CCT-PLN-1100, Crew Transportation Plan, Section 3.2 CCP Insight/Oversight and Appendix C, Insight Areas, and Contract Clause H.15 Government Insight. The contractor shall expand the existing insight provided through the Partner Integration Team (PIT) and extend Government participation into operations certification efforts with the Joint Test Team (JTT) approach. This approach allows the Government to assess the contractor's progress towards CTS certification in CLIN 001 and the execution of PCM flights in CLIN 002. The contractor shall document and deliver these approaches in an Insight Implementation Plan, DRD 001, in accordance with Clause H.15 Government Insight, and execute in accordance with the plan. The contractor shall ensure the requirements of Contract Clause H.15 Government Insight flow down to subcontractors and/or other business entities performing or supporting any critical work associated with this contract. Consistent with this insight approach, all Boeing products and activities developed outside of the CCtCap contract for the CTS program shall be updated, as required, and delivered to NASA in accordance with the applicable DRD's or made available to NASA in support of CCtCap in accordance with DRD 001, Insight Implementation Plan.

The contractor shall execute and perform in accordance with the Insight Implementation Plan delivered with the proposal from program start until DRD 001 is formally delivered and dispositioned.

#### 3.1.1.5 Independent Verification and Validation (IV&V)

The Contractor shall upon request and as necessary support the Government's IV&V efforts. The contractor shall develop and deliver CTS data to support verification and validation and input to NASA for integration and IV&V in accordance with DRD 114, Crew Transportation System (CTS) Data Input for NASA Integration and Independent Verification and Validation (IV&V). Types of data shall include existing CTS developed environments data, test data, CAD model data (in the contractor's format or .stp file) of vehicle OML and interfaces to ISS and cargo, mission trajectories and mission plans/events (nominal and aborts), analysis results and analytical models (executable code). The contractor shall support discussions, technical interchanges with the Government on development of provided data, ground rules, assumptions and limitations of data and analysis models, and interpretation of contractor's analytical results.

#### 3.1.2 Business Management

The Contractor shall implement the necessary business management functions to ensure all budget and schedule constraints are met and shall provide necessary contract, schedule, financial, and other program progress reporting for all CLINs under this contract. The contractor shall ensure the collecting and reporting of cost performance, and related data is accomplished in a disciplined manner so an integrated uniform cost database exists.

The Contractor shall develop and implement plans to support successful execution of all work projects and programs. The Contractor shall develop and deliver an Integrated Master Plan (IMP) in accordance with DRD 002, Integrated Master Plan and Integrated Master Schedule. The contractor's IMP may be an update to or amendment of the CCTS IMP, DCC1-00003-01. The IMP shall describe the significant accomplishments with the associated success criteria as

derived from the Contract Performance Work Statement (Attachment J-03, Contract PWS), DRDs, and other contract requirements.

The contractor shall develop, update, maintain, manage, and deliver a CCtCap Certification and Post Certification Missions Integrated Master Schedule (IMS) in accordance with DRD 002, Integrated Master Plan and Integrated Master Schedule. The IMS shall be an integrated logically linked schedule that captures the accomplishments described in the IMP and the lower level work necessary to support each of the IMP accomplishments. The IMS shall include all contract milestones, activities and tasks leading to the proposed date for CTS certification and all post certification mission development, integration and execution activities. The IMS shall identify priorities of tasks, order and sequence of tasks, primary and secondary critical path, schedule margin, and dependencies and relationships among tasks. The IMS shall identify tasks at the system level for major activities or products associated with design, development, integration, testing, certification, manufacturing, assembly and operations.

The Contractor shall provide a single point of contact (POC) for contract management. The duties of this Contracts Management POC shall coordinate any contract changes as they may arise, ensure compliance with applicable Federal, state and local regulations, laws, ordinances, directives and statutes regarding exports and imports and manages Government Furnished Property (GFP) per terms of the contract. The contractor shall develop and deliver the CCTS Export Control Plan in accordance with DRD 006, Export Control Plan, to encompass the CCtCap program and contract requirements.

### 3.1.3 Supplier Management

The Contractor shall monitor and control subcontractors and shall ensure proper flowdown of requirements. The contractor shall report subcontractor problems affecting schedule, quality, and performance at quarterly program reviews. The contractor shall ensure the government can participate in significant/major subcontractor reviews and meetings. The contractor shall notify the Government designee of supplier technical meetings, control boards, reviews, tests, and areas identified for Government Quality Assurance in the mutually agreed timeframe in accordance with the Insight Implementation Plan (reference DRD 001) and the risk based analysis (RBA) for safety critical items (per Contract Clause H.15 Government Insight) to permit meaningful Government participation through the entire event.

### 3.1.4 Information Technology (IT)

The Contractor shall implement and maintain throughout the lifecycle of the CCtCap program information systems, tools, and processes to ensure effective security, management and utilization of program data. The contractor shall develop and deliver an Information Technology (IT) Security Management Plan, DRD 003, and an IT Security Plan, DRD 004, in accordance with Contract Clause I.2 NFS 1852.204-76 Security Requirements for Unclassified Information Technology Resources. Responsibilities include implementation of effective information security protocols and file sharing protocols with customers. The Contractor shall document the processes and procedures that will be followed to ensure appropriate security of information technology (IT) resources are deployed, processed and used under this contract.

### 3.1.5 Risk Management

The Contractor shall execute program risk and opportunity management by identifying, assessing, and ensuring mitigation of program risks for items that are unique to CCtCap (J-01

1120 3.3). The risk management process shall be executed across teams, products, services and phases of the program and it shall address cost, schedule, and technical risks in accordance with the CCTS Risk Management Plan (RMP), DCC1-00250-01. The Contractor shall ensure that the RMP addresses the full CTS lifecycle (J-01 1120 3.3.1). The CCTS RMP shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). The RMP shall address risk identification, risk characterization, mitigation and elevation, risk controls and contingency and residual risk planning (J-01 1120 3.3.2). The risk process shall determine and mitigate safety risk to the lowest achievable level throughout the lifecycle. In addition, the RMP shall include opportunity management to identify opportunities to improve vehicle safety, improve operational efficiencies and reduce lifecycle costs across the entire program lifecycle. A status of the contractor risk assessment shall be discussed for the high risks and opportunities during the quarterly PMRs.

### 3.1.6 Configuration and Data Management

#### 3.1.6.1 Configuration Management

The Contractor shall plan and implement a Configuration Management (CM) system consistent with the policies, procedures and processes established in the CCTS Configuration Management Plan (CMP), DCC1-00009-01. The CCTS CMP shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). The contractor shall own and maintain configuration control over requirements, specifications, flight products, numerical models, and drawings that govern the development and baseline configuration of the CTS. The CMP shall define the tools and techniques to manage and document the integrated and approved CTS configuration including systems, equipment, and operations products (configuration control); control, record, and report changes (change management); variance and constraint handling, nonconformance reporting and disposition, and audit the systems and items to verify conformance (J-01 1120 3.2, 3.2.1).

#### 3.1.6.2 Data Management

The Contractor shall develop and implement data management (DM) processes and systems that address the needs of CCtCap program. The contractor shall establish a means for sharing, reporting, collecting, recording and accessing CCtCap program information, product information, performance data, and technical data unless otherwise detailed in this PWS or DRDs.

### **3.2 Design, Development, Test and Evaluation (DDTE)/Certification (CLIN 001)**

This PWS section contains the specific work scope associated with the activities required to perform CLIN 001 in addition to the work scope defined in PWS Section 3.1.

The Contractor shall obtain NASA certification of a CTS that meets or exceeds with CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD). The contractor shall demonstrate compliance to the technical requirements by designing, developing, testing and evaluating an end-to-end system culminating in a review for approval to grant NASA certification, including certification to technical requirements associated with all inherent capabilities of the CTS (reference 3.2.1.4, 3.3.6). The contractor shall assure that the CTS is developed, produced, and operated in a repeatable manner throughout the lifecycle of the system.

#### **3.2.1 System Engineering and Integration (SE&I)**

##### **3.2.1.1 System Engineering**

The Contractor systems engineering organization shall own, manage, and control the design and safety analysis approach and processes for producing a design that meets requirements, as well as identifying, understanding, eliminating, and controlling hazards and risks to safety (J-01 1120 4.0). The systems engineering team efforts include architecture and requirements development and verification, program configuration and data management, and safety/reliability and quality assurance.

The Contractor shall update existing technical management plans that were developed and executed to in prior phases of the CTS program, if required, to ensure processes associated with achieving and maintaining NASA certification throughout the CTS lifecycle are included in that lifecycle in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes. The contractor shall provide these existing technical management plans to NASA in support of the first milestone review for re-baselining for CCtCap at that review. The contractor shall execute, implement, and manage the CCtCap program in accordance with these technical management plans. Since the activities from the core certification effort (Reference PWS Section 3.2, CLIN 001) and the initial PCMs (Reference PWS Section 3.3, CLIN 002) can be conducted concurrently, the contractor shall ensure the interdependencies between the on-going core certification efforts and PCM objectives are addressed in development plans and mission execution planning.

The Contractor shall establish and utilize design, production, and operations Government standards or alternatives to NASA standards and CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and CCT-STD-1140, Crew Transportation Standards and Processes Criteria, requirements as proposed and approved in CPC (J-01 1120 4.1) that result in safe, reliable and usable end items and an integrated certified CTS system.

The Contractor shall provide/request alternatives to meet the intent of requirements in CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, when usage of the NASA standard is prohibitive. Alternate standards will be reviewed and approved by the Government Program Control Board (PCB) (Reference PWS Section 3.1.1.3) (J-01 1120 4.1).

The Contractor shall implement changes to alternate standards submitted under CPC to provide compliance to the intent of documented NASA standards in accordance with Government disposition and CPC Final Technical Summary Report (reference PWS paragraph 3.2.8.1). Proposed changes to applicable Alternate Standards shall be presented for approval as part of the Certification Baseline Review (CBR) milestone.

#### 3.2.1.1.1 Requirements and Verification and Validation

The Contractor shall develop, implement, and maintain a closed-loop requirements management process to ensure hardware, software, support equipment, ground systems processing (including facilities and ground support equipment for spacecraft assembly, integration and test; conduct planning, training and flight operations; and launch vehicle integration, test and launch operations for crewed and uncrewed), and configuration requirements are accounted for in the CTS configuration managed systems and equipment (J-01 1120 3.4). The contractor's requirements process shall address the process for architecture and requirements development, requirements management and control, requirements allocation and traceability (down to the module or component level including parent/child relationship and meet-the-intent requirements), requirements verification and validation planning, and variance and constraint handling (J-01 1120 3.4.2). The contractor shall document the requirements process in the CCTS Requirement Management Plan, DCC1-00422-01 (J-01 1120 3.4.1). The CCTS Requirements Management Plan shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). The contractor shall prepare and deliver one Verification Closure Notice per CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD) for all docked crewed and uncrewed requirements, and in accordance with DRD 111, Verification Closure Notices (VCN), as evidence of closure of each technical requirement.

The contractor shall provide the Government with access to all requirements, requirements products, requirements and the requirements management database. The contractor shall maintain a specification tree depicting requirements related products.

The Contractor shall process requests for variance (Table 3.2.1.1.1-1) (J-01 1120 3.4.3) to the requirements set defined in the Table 3.2.1.1.1-2 through the Government CCP Board (Reference PWS Section 3.1.1.3). Request for variance to SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), shall be processed in accordance with SSP 41170, ISS Configuration Management Requirements (J-01 1120 3.4.3).

**Table 3.2.1.1.1-1. Definitions**

Term	Definition
Variance	A formal request for relief from a requirement. Variances should be submitted as early in the lifecycle or workflow process as practical; a variance can be an exception, deviation or waiver.
• Exception	• A type of variance that authorizes permanent relief from a specific requirement and may be requested at any time during the lifecycle of the program

Term	Definition
• Deviation	• A type of variance that authorizes temporary relief in advance from a specific requirement and is requested during the formulation/planning/design stages of a program operation to address expected situations
• Waiver	• A type of variance that authorizes temporary relief from a specific requirement after the baseline system has been approved. Waivers are requested during the implementation of a program or operation to address situations that were unforeseen during design or advanced planning.

**Table 3.2.1.1.1-2. CCtCap Applicable Documents**

Document #	Document Title
CCT-PLN-1100	Crew Transportation Plan
CCT-DRM-1110	Crew Transportation System Design Reference Missions
CCT-PLN-1120	Crew Transportation Technical Management Processes
CCT-REQ-1130	ISS Crew Transportation and Services Requirements Document
CCT-STD-1140	Crew Transportation Standards and Processes Criteria
CCT-STD-1150	Crew Transportation Operations Standards
SSP 50808	International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD)

The Contractor shall continue to refine and implement changes to the variances submitted under CPC to provide compliance to the intent of documented NASA requirements in accordance with Government disposition and Final CPC product Technical Summary (reference PWS paragraph 3.2.8.3). Proposed changes to applicable variances shall be presented for approval as part of the Certification Baseline Review (CBR) milestone. The Contractor shall implement changes to its CTS requirements, appropriate hardware design, operational processes and procedure for variances to the CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), Government requirements that were submitted under the CPC contract where Government disposition and Final CPC product Technical Summary resulted in a disapproved submitted variance. Proposed changes (or plans to implement required changes) to mitigate disapproved variance(s) shall be presented for approval as part of the Certification Baseline Review (CBR) milestone. For variances identified after the start of CCtCap and disapproved by the Government, the Contractor shall implement required changes to the CCTS design, processes and procedures to bring the system into compliance with the Government requirements or sufficiently reduce the risk to allow Government acceptance of the variance.

#### 3.2.1.1.2 Interface Management

The Contractor shall establish procedures, practices, and agreements to ensure proper interface identification, definition, documentation, and compliance throughout the CTS lifecycle

(J-01 1120 3.5) for internal and external interfaces including operational (spacecraft to ISS, FAA, Range/Launch sites) (J-01 1120 3.5.1).

### 3.2.1.2 Milestone/Technical Reviews

The Contractor shall conduct milestone reviews/events to formally evaluate progress towards CTS certification which shall include, at a minimum, those identified in PWS sections 3.2.1.2.1 through 3.2.1.2.6 (J-01 1120 3.7). The contractor shall define additional interim reviews/events the contractor deems necessary to supplement the mandatory Government delivery/interim milestones. These events are structured to chart the maturity of the program in achieving certification. These reviews and the contractor defined interim reviews and events associated with progress payments shall be detailed in PWS Appendix A, Milestone Acceptance Criteria and Payment Schedule. These events represent essential decision points to accurately measure the success of the preceding phase of work and an entry point for subsequent work efforts.

The contractor shall develop and deliver a Milestone Review Plan (MRP) in accordance with DRD 101, Milestone Review Plan. The purpose of the MRP shall be to document for each review, detailed in PWS Appendix A, Milestone Acceptance Criteria and Payment Schedule: the review process, entrance criteria/readiness deliverables to address the milestone review objectives and timing by which data shall be made available to NASA for review, Technical Interchange Meetings (TIMs)/review meetings/applicable final RID boards, exit/success/acceptance criteria, and other logistics related information. The MRP shall define the specific data requirements required to successfully conduct each milestone review. The contractor shall implement, execute and perform in accordance with the Milestone Review Plan delivered with the proposal from program start until DRD 101 is formally delivered and dispositioned.

The MRP shall address requirements from the following:

- a) Data Package DRDs 102, 103, 104, 105 and 106 data requirements for each milestone review
- b) CCT-PLN-1120, Crew Transportation Technical Management Processes, Appendices F and H
- c) PWS Appendix A, Milestone Acceptance Criteria and Payment Schedule

Upon NASA approval/concurrence of the Milestone Review Plan, the content of the plan will supersede the specific milestone review statements in b) above and shall be considered approved tailoring of the associated requirements. The milestone review Data Package DRD noted above (a) shall be utilized as the transmitting vehicle of those artifacts mutually agreed to in the MRP with exception of other CCtCap specific DRD requirements.

#### 3.2.1.2.1 Certification Baseline Review (CBR) [Mandatory Government Interim Milestone]

The Contractor shall conduct a CBR and deliver the data described in DRD 102, Certification Baseline Review (CBR) Data Package, in support of the CBR. The contractor shall co-chair with NASA a CBR after award of contract. The purpose of the CBR is to establish the CTS design baseline, the contractor's certification plan, lifecycle costs, and schedules for CTS certification. (J-01 1120 3.7)

#### 3.2.1.2.2 ISS Design Certification Review (DCR) [Mandatory Government Delivery Milestone]

The Contractor shall conduct an ISS DCR and deliver the data described in DRD 103, Design Certification Review (DCR) Data Package, in support of the DCR. Prior to the first low Earth orbit (LEO) test flight that docks to the ISS, the flight test readiness process shall include a DCR of applicable elements from completed CTS Certification Milestones (for an interim CTS certification) and a Flight Test Readiness Review. The ISS DCR formally documents the configuration baseline (hardware, software, and processes used in design, production, and operations) and the conditions under which the CTS is certified (performance, fabrication and operational environments, constraints). The ISS DCR verifies the CTS capability to safely approach, dock, mate, and depart from the ISS in applicable ISS visiting vehicle configurations. The ISS DCR also presents the current state of the verification and validation effort, including the overall status of all verification closures and any changes to the Verification and Validation (V&V) plan since CBR. (J-01 1120 3.7)

#### 3.2.1.2.3 Orbital Flight Test Flight Test Readiness Review (OFT FTRR) [Mandatory Government Interim Milestone]

The Contractor shall conduct a Flight Test Readiness Review (FTRR) to assure procedure, process, flight hardware, facilities and personnel readiness to conduct the Orbital Flight Test and deliver the data described in DRD 104, Flight Test Readiness Review (FTRR) Data Package, in support of the OFT FTRR. The OFT FTRR examines tests, demonstrations, analyses, and audits that determine the system's readiness for a safe and successful flight/launch and for subsequent flight test operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready. The review will cover test objectives and requirements, verify required procedures are released, and verify flight hardware configuration and conformance to design requirements. Facility and support equipment readiness and personnel training will be verified. Program organizations will present certification of readiness to support the flight test. The review will be co-chaired by the Program Manager and the Contractor Mission Assurance lead. (J-01 1120 3.7)

#### 3.2.1.2.4 Crewed Flight Test Flight Test Readiness Review (CFT FTRR) [Mandatory Government Interim Milestone]

The Contractor shall conduct a Flight Test Readiness Review (FTRR) to assure procedure, process, flight hardware, facilities and personnel readiness to conduct the Crewed Flight Test and deliver the data described in DRD 104, Flight Test Readiness Review (FTRR) Data Package, in support of the CFT FTRR. The CFT FTRR examines tests, demonstrations, analyses, and audits that determine the system's readiness for a safe and successful flight/launch and for subsequent flight test operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready. The review will cover test objectives and requirements, verify required procedures are released, and verify flight hardware configuration and conformance to design requirements. Facility and support equipment readiness and personnel training will be verified. Program organizations will present certification of readiness to support the flight test. The review will be co-chaired by the Program Manager and the Contractor Mission Assurance lead. (J-01 1120 3.7)

#### 3.2.1.2.5 Operations Readiness Review (ORR) [Mandatory Government Interim Milestone]

Upon successful completion of the flight test phase of crewed flights, an Operational Readiness Review shall be conducted and deliver the data described in DRD 105, Operations Readiness Review (ORR) Data Package, in support of the ORR. The ORR occurs once during

the program lifecycle or at the introduction of new or significantly modified systems/facilities. The Contractor shall demonstrate the actual CCTS Production and Ground Systems, Mission Operations systems and Launch Vehicle ground systems characteristics, facilities, equipment and procedures used in operations match the deployed state. The ORR evaluates all project and support (flight and ground) hardware, software, personnel, plans, processes, and procedures to ensure flight and associated ground systems are in compliance with program requirements and constraints during the sustaining phase. The Contractor shall demonstrate the actual CCTS Production and Ground Systems, Mission Operations systems and Launch Vehicle ground systems characteristics, facilities, equipment and procedures used in operations match the deployed state. This review is co-chaired by Boeing and NASA CCP. (J-01 1120 3.7)

#### 3.2.1.2.6 Certification Review (CR) [Mandatory Government Delivery Milestone]

Upon successful completion of all flight tests, any delta DCRs, and the ORR, the Contractor shall conduct a Certification Review chaired by NASA. The contractor shall deliver the data described in DRD 106, Certification Review (CR) Milestone Data Package, in support of the CR. The CR determines that the CCTS meets CCT-DRM-1110, Crew Transportation System Design Reference Missions, for which it was developed. The CR will focus on System performance as validated from the end-to-end testing and flight test campaigns, closure of all verification and validation plans, and the Product Baseline to be used in Operations. (J-01 1120 3.7)

#### 3.2.1.3 System Analysis

The Contractor shall perform technical and management efforts for directing and controlling the integrated engineering effort for the spacecraft. This effort includes the development, update and maintenance of simulations, drawings, and computer aided design (CAD) models.

The Contractor shall perform aerodynamic characterization of the vehicle through all phases of atmospheric flight including plume/flow field interactions and on-orbit rarefied flows within the aerodynamic environment of the vehicle forces, vehicle moments, related surface pressure, and related shear forces.

The Contractor shall provide aero thermodynamic characterization of the vehicle through all phases of atmospheric flight including plume/flow field interactions and on-orbit rarefied flows. The aero thermodynamic environment includes heat transfer to the vehicle surface.

(b) (4)

The Contractor shall provide loads and dynamics analysis of the vehicle as part of the overall design analysis cycle process.

The Contractor shall provide definition of requirements for the specific dynamic environments and induced environments that the CTS must operate within and for which it must be qualified, encompassing all phases of production, testing and operation in all modes through disposal in accordance with the Natural and Induced Environments.

The Contractor shall provide identification and conduct of contractor-initiated trade studies and affordability analyses to ensure realistic options and alternatives are assessed for key CTS requirements and design decisions throughout the contract period of performance.

The Contractor shall collect spacecraft items mass properties, center of gravity, mass moments of inertia and mass products of inertia with respect to a reference coordinate system within the vehicle.

The Contractor shall develop an integrated vehicle performance and design margin allocation strategy, and implement it through a detailed set of vehicle stage, system, subsystem, and component performance requirements and specifications. The contractor's strategy shall identify and define the appropriate levels of design or performance margin needed at the vehicle stage, system, subsystem, and/or component level, and address uncertainties and the expected variations in vehicle manufacturing, operational performance, and/or operational environments. The contractor shall update the CCTS Margin Management Plan (MMP), DCC1-00424-01, that (J-01 1120 4.9, 4.9.1):

- a) Identifies the set of critical system resources (e.g., mass, propellant, power) that need to be managed in order for the design to meet its requirements
- b) Defines how margin is calculated for each resource
- c) Provides process to assess operating margin, growth allowance, and program manager's reserve for each parameter
- d) Documents the process for the margin specification required for each milestone review
- e) Defines Margin management report content requirement for each milestone review

The CCTS MMP shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR).

The contractor shall decompose and flow down higher-level CTS requirements and shall implement the strategy by clearly identifying and allocating the appropriate amount of margin into the approved stage, system, subsystem, and/or component requirements for the respective hardware and software designs (J-01 1120 4.9).

#### 3.2.1.4 System Integration and Certification

The Contractor shall design, develop, test, and evaluate the interfaces between the CST-100 and LV and the integrated performance of the CST-100 and LV for nominal and abort design cases. The contractor shall perform analyses and tests and provide reports and engineering data supporting integration and operation of CST-100 and LV, such as: structural models and analyses for static, dynamic and coupled loads analyses; mass properties, dimensions and physical (material, thermal, etc.) properties; abort mode design case trigger condition and implementation assessments; Integrated compatibility analyses (EMC, RF, etc.); Interface and integration drawings/models and build/test procedures.

The Contractor shall continue to refine, deliver and implement the Certification Plan, developed under the CPC contract, in accordance with DRD 107, Certification Plan, CPC Final Technical Summary Report findings, and the content defined in CCT-PLN-1120, Crew Transportation Technical Management Processes, which supports CCT-PLN-2000, NASA Crew Transportation and Services Certification Plan, and SSP 50964, Visiting Vehicle ISS Integration Plan, and execute the end-to-end certification plan. The Certification Plan shall define an integrated strategy for certification of the complete CTS and defines a structured and organized approach for implementing the strategy. The Certification Plan is a comprehensive development

plan and approach that shall document the processes, products and schedule encompassing all effort to demonstrate that the integrated CTS design and the associated production and operation capabilities shall achieve a NASA Certification. Certification is a progressive process and sensitive to the order of execution, the certification strategy shall clearly define the order of execution, with a schedule and critical path clearly outlined. The Certification Plan shall define the verification and validation (V&V) methods for all CTS technical requirements, including the requirements which result from the necessary decomposition and flow down of higher level CTS requirements to the appropriate level (including those requirements established to control critical hazards). The certification plan shall provide the objective evidence necessary to verify compliance with design and performance requirements governing the capability and performance of critical systems, subsystems, and the integrated CTS by inspection, demonstration, analysis and test (J-01 1120 7.0).

The Contractor shall continue to refine, deliver and implement the Verification and Validation (V&V) Plan developed under the CPC contract in accordance with DRD 108, Verification and Validation (V&V) Plan, the content defined in CCT-PLN-1120, Crew Transportation Technical Management Processes. The V&V Plan shall include NASA technical requirements in CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), and contractor's decomposed or derived requirements (J-01 1120 7.0).

The Contractor shall implement changes to the CCTS Verification and Validation Plan, DCC1-00005-01, and the CCTS Certification Plan, DCC1-00443-01, submitted under CPC to provide compliance in accordance with Government disposition and CPC Final Technical Summary Report findings. Proposed changes to the Verification and Validation Plan, and Certification Plan shall be presented for approval as part of the Certification Baseline Review (CBR) milestone.

In accordance with the Technical Reviews (Reference PWS Section 3.2.1.2), the Contractor shall utilize Milestone Reviews to mark progress towards CTS certification. The contractor shall deliver a CTS Certification Data Package which collectively illustrates, with supporting evidence, that the system meets the technical requirements and is safe to carry NASA crew to and from the ISS (J-01 1120 7.0) in accordance with the content defined in CCT-PLN-1120, Crew Transportation Technical Management Processes, Table 7-1, CTS Certification Data Package Content and in accordance with DRD 112, Certification Data Package.

The Contractor shall establish human systems integration (HSI) strategy to ensure that humans and human needs, as well as human capabilities and limitations, are considered during the design, build, test, operation, and maintenance across nominal, emergency, and contingency operating conditions of the system (J-01 1120 4.8). The contractor shall document the HSI strategy (CCTS HSI Standard, DCC1-00013-01). The CCTS HIS Standard shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR).

The Contractor shall provide:

- a) a master task list including identification of nominal and critical tasks necessary for established mission objectives and concepts of operation

- b) evaluations of functional allocation for manual and automated crew and system tasks; expected utilization of operator capabilities to execute the mission, prevent aborts, and prevent catastrophic events; and evaluations of the crew's ability to accomplish mission critical and volume driving tasks
- c) crew workload and usability evaluations that demonstrate the impact of crew interface designs on human error and total human-system performance
- d) Human-In-The-Loop Testing in support of planned human test and demonstration activities (J-01 1120 4.8.1)

The Contractor shall conduct a human error analysis (HEA) for all mission phases, to include nominal operations and those operations planned for response to system failures. The results shall be incorporated into design and operational procedures to minimize the likelihood and negative effects of human error (J-01 1120 4.7). The HEA shall qualitatively characterize how human error affects the system. The HEA shall manage potential hazards which could be caused by humans, identify inadvertent operator actions which would cause a catastrophic event and determine the appropriate level of tolerance, identify other human error that would cause catastrophic event, and ensure application of the appropriate error management (J-01 1120 4.7.1, 4.7.2).

The contractor shall implement requirements that document the “inherent capabilities” of the CCTS system design that are in excess of NASA requirements (ref. paragraph 3.3.6.1) for SM propellant, number of crew, amount of cargo and uncrewed mission to ISS.

(b) (4)

### 3.2.1.5 Specialty Engineering

The Contractor shall apply crosscutting specialty engineering disciplines of materials and processes, electromagnetic compatibility, EEE parts, aerosciences, instrumentation, mass properties, Micrometeoroid and Orbital Debris (MMOD) analyses, and radiation analyses to the spacecraft design.

The Contractor shall ensure materials are selected, controlled, implemented and verified to be consistent with intended usage environments. The contractor shall select, treat, fabricate, inspect, test, and analyze materials of construction to ensure the safety and success of the CTS in accordance with the Materials and Processes (M&P) Selection, Implementation, and Control Plan, Material Usage Agreements (MUAs), and Material Identification Usage Lists (MIULs).

The Contractor shall develop, update, and implement an Electrical, Electronic and Electromechanical (EEE) Parts Management and Implementation Plan for the CTS. The contractor shall establish processes to control aspects of EEE parts from part selection through testing and hardware fabrication and part failure analysis.

The Contractor shall design, develop, and verify the CTS is electromagnetically compatible with internally generated electromagnetic energy, the external electromagnetic energy environments, and the ISS. The contractor shall implement and execute to the Electromagnetic Compatibility Control and Verification Document to design, construct, and verify the CTS System Electromagnetic Compatibility requirements. The contractor shall develop and design the

CTS to control and mitigate hardware malfunction and damage that can be caused by lightning in accordance with the Lightning Verification Plan/Report.

The Contractor shall provide Radiation Analyses to describe the internal CTS radiation environments that result from exposure to natural radiation background environments and events. The contractor shall use these analyses including crew radiation exposure analysis to certify that the spacecraft meets the CTS radiation requirements for the space radiation environments described in the Natural and Induced Environment Document (NIED).

The Contractor shall provide micrometeoroid and orbital debris (MMOD) analyses. The analyses shall include assessment of the risk to the spacecraft and crew resulting from damage or penetration from micrometeoroid and orbital debris impacts during the following mission phases: ascent to mating, mated, and separation to reentry.

### 3.2.2 Safety, Reliability and Quality Assurance

#### 3.2.2.1 System Safety

The Contractor shall plan and implement a system safety program consistent with the policies, procedures and processes established in the CCTS System Safety and Reliability Plan, DCC1-00459-01. The plan shall describe how safety methodologies are integrated into the design process and used to identify and eliminate or control catastrophic or critical hazards and balance risks and trades. The System Safety and Reliability Plan shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). For software and safety items where ISS is identified as being an effected party and/or stakeholder, the plan shall address (1) the process for complying with SSP 30234, Instructions for Preparation of Failure Modes and Effects Analysis and Critical Items List Requirements for International Space Station, SSP 30309, Safety Analysis and Risk Assessment Requirements Document, NASA-STD-8739.8, NASA Technical Standard: Software Assurance Standard, Sections 6, 7.1, 7.2.4, 7.3 and 7.4, and NASA-STD-8719.13, NASA Technical Standard: Software Safety Standard, Chapter 17 (J-01 1120 4.2.1). The contractor shall put in place controls that reduce the risk to an acceptable level that ensures crew safety. The contractor's safety process shall provide an integrated, systematic, and comprehensive approach, which can be used to determine the need for design changes and safety measures. The safety process shall include (J-01 1120 4.2):

- a) the evaluation of hardware and software capabilities, limitations, and interdependence, as well as environmental and human factors relevant to safety
- b) the use of industry standard safety analyses (e.g. hazards probability of occurrence, severity and severity categories) throughout the CTS lifecycle
- c) closed-loop tracking and verification of hazard controls
- d) detailed plans for the communication and acceptance of risk to stakeholders and/or the appropriate control boards to ensure residual risk is appropriately managed
- e) a plan for communication and approval of safety analyses
- f) the safety review process

The Contractor shall conduct safety analyses that include an assessment of crew survival strategies for all mission phases and the system capabilities required to execute each strategy.

The scenarios shall include system failures and emergencies (such as fire, collision, toxic atmosphere, decreasing atmospheric pressure, and medical emergencies) with specific capabilities or proposed capabilities (such as abort, safe haven, rescue, emergency egress, emergency systems, and emergency medical equipment or access to emergency medical care) identified to protect the crew. (J-01 1120 4.2)

The Contractor shall provide, develop, and manage a Mishap Reporting and Investigation Plan and process (J-01 1120 3.8) that are in accordance with Contract Clause H.26 Mishap Reporting. When applicable, the Contractor shall support a Commission appointed by the President per 51 U.S.C Section 70701 et seq, (J-01 1120 3.8).

The Contractor shall conduct a probabilistic safety analysis (PSA) following the guidance in CCT-REF-1121, Probabilistic Safety Analysis (PSA) Methodology Guide. The contractor shall implement reasonable design and operational modifications to achieve best possible Loss of Crew and Loss of Mission levels. The contractor shall improve modeling approach as the design matures including level of redundancy, component reliability, MTBF (mean time between failure), and operational enhancements. The PSA shall be applied throughout the lifecycle in order to verify through analysis that the CTS meets established Loss of Crew (LOC) and Loss of Mission (LOM) requirements (J-01 1120 4.3).

The Contractor shall define a safety review process that allows for the systematic identification and review of hazards related to the design, operations, and functional capabilities of transportation systems developed in support of milestone reviews (Reference PWS Section 3.2.1.2). This methodology shall ensure that proper controls are identified and implemented for all hazard causes consistent with CCP certification processes and requirements. The safety review process also shall include reviews of hazards and controls performed by contractor subject matter experts in the form of a peer review to ensure hazards are identified and controls are adequate. At the milestone reviews, the associated hazard reports shall be segregated by stakeholders as follows (J-01 1120 4.5):

- a) Occupant safety throughout all mission phases, including docked operations as it relates to hazards created by the CTS vehicle (stakeholder: CCP).
- b) Integrated hazards created by the combined operations during the Rendezvous, Proximity Operations, Docking and Undocking (RPODU) phase (stakeholder: ISS).

The Contractor shall conduct Phase Safety Reviews. The goal of each Phase Safety Review is for the safety analysis to achieve the relevant Phase II or III approval from NASA, resulting in a product that meets the criteria in SSP 30599, ISS Safety Review Process. The contractor shall deliver CTS hazard reports in accordance with DRD 110, Hazard Reports, and CCT-PLN-1120, Crew Transportation Technical Management Processes. The Contractor shall implement hazard controls documented in the approved hazard reports. The Contractor shall implement changes to CTS requirements, appropriate hardware design, operational processes and procedures for hazard reports submitted under the CPC contract where Government disposition and Final CPC product Technical Summary disapproved the submitted hazard report. Proposed changes (or plans to implement required changes) to strengthen controls to mitigate hazards to acceptable levels shall be presented as part of the Certification Baseline Review (CBR) milestone.

The CCP will participate in the contractor's safety review process by performing insight functions (Reference PWS Section 3.1.1.4) and working in a collaborative environment to gain

an understanding of the incremental safety process: focusing on the assurance that all hazard and hazard causes inherent in the design and operations are identified; evaluating the means employed to control hazards; and assessing methods identified to verify all hazard controls. Risks identified as a result of the hazard analysis that are deemed a CCP risk and shall be coordinated with the CCP Risk Management Process (J-01 1120 4.5).

For hazard reports where the ISS is identified as being an affected party and/or stakeholder, the Contractor shall coordinate with the CCP to prepare and deliver such items for approval to the ISS Safety Review Panel (reference SSP 30599, ISS Safety Review Process, and SSP 30309, Safety Analysis and Risk Assessment Requirements Document) (J-01 1120 4.5).

The Contractor shall be responsible for characterizing and reporting potential risks associated with a planned launch of radioactive materials into space on launch vehicles and spacecraft, during normal or abnormal flight conditions in accordance with NPR 8715.3, NASA General Safety Program Requirements, Chapter 6 (J-01 1120 4.6).

#### 3.2.2.2 Environmental, Industrial, Launch Site and Range Safety

The Contractor shall implement a safety and health program which identifies, eliminates, mitigates and control hazards and risks in activities in accordance with the existing CTS Safety and Health Plan and document the plan in the safety program plan. The contractor shall perform a Ground Processing Safety Analysis to derive requirements for implementation into the ground support equipment design, processes and procedures including data to support a range safety flight termination system (FTS) determination analysis per ASPC Manual 91-710, Air Force Space Command Range Safety User Policies and Procedures. The contractor shall support the range safety analysis to meet local test range safety requirements including a list of hazardous operations to be performed. The contractor shall comply with all Range requirements and deliver DRD 113, Range Safety Documentation.

#### 3.2.2.3 Reliability, Maintainability and Availability

The Contractor shall implement an integrated, systematic and comprehensive reliability approach into the design process to balance risk and trades (J-01 1120 4.2). The contractor shall update the CCTS System Safety and Reliability Plan, DCC1-00459-01, to document Failure Modes Effects Analyses/Critical Items Lists (FMEA/CIL) processes including the CCtCap System Probabilistic Safety Assessments to include the entire CTS lifecycle. The CCTS System Safety and Reliability Plan shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). The reliability program plan shall also include participation in Exchanging Parts, Materials, and Safety Problem Data utilizing the Government Industry Data Exchange Program (GIDEP) (J-01 1120 3.6.1).

#### 3.2.2.4 Quality Assurance

The Contractor shall develop and execute a quality management system that assures quality requirements are flowed down from design into the manufacturing and operational processes and is compliant with the requirements of AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations (J-01 1120 3.6). The contractor shall update the CCTS Quality Management Plan (QMP), DCC1-00455-01, to capture any processes and procedures that are unique to CTS program lifecycle. The CCTS QMP shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification

Baseline Review (CBR). The Contractor shall flow down and ensure implementation of appropriate quality assurance requirements to applicable suppliers.

#### 3.2.2.5 Software Safety and Assurance

The Contractor shall be responsible for the management of software safety throughout the CTS lifecycle for flight software, flight support software, ground support equipment (GSE) ground software, and hardware and software used in the design, development, test, verification, storage, maintenance of software, and ensures that software products obtained from any source meet the software assurance requirements. The contractor shall define a software safety plan (CCTS Software Quality Program Plan, DCC1-00415-01) to document safety-critical software determination processes, management, software development and analysis methods (including support of hazard analyses and production of hazard reports), implementation and test, and operational use (J-01 1120 4.4). The CCTS Software Quality Program Plan shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR).

#### 3.2.3 Production Control

The Contractor shall produce CTSs such that each first article and ground article, including software, is manufactured, assembled, and integrated in a repeatable manner. The contractor shall establish and implement production control and manufacturing processes for the production and assembly of CTS hardware. The production control process shall include: (a) manufacturing, fabrication, storage and transportation, (b) inventory control, (c) nonconformance identification, tracking, and corrective action (d) material review process for acceptance of hardware not fully meeting drawing requirements (e) procedures for use of tooling and equipment, and (f) metrology and other critical production support activities. The contractor shall document assembly/integration test plans/procedures and test results/reports at the subsystem, system, and vehicle levels (J-01 1120 6.0, 6.1.1).

#### 3.2.4 Vehicle (CST-100 and LV)

##### 3.2.4.1 Flight Hardware

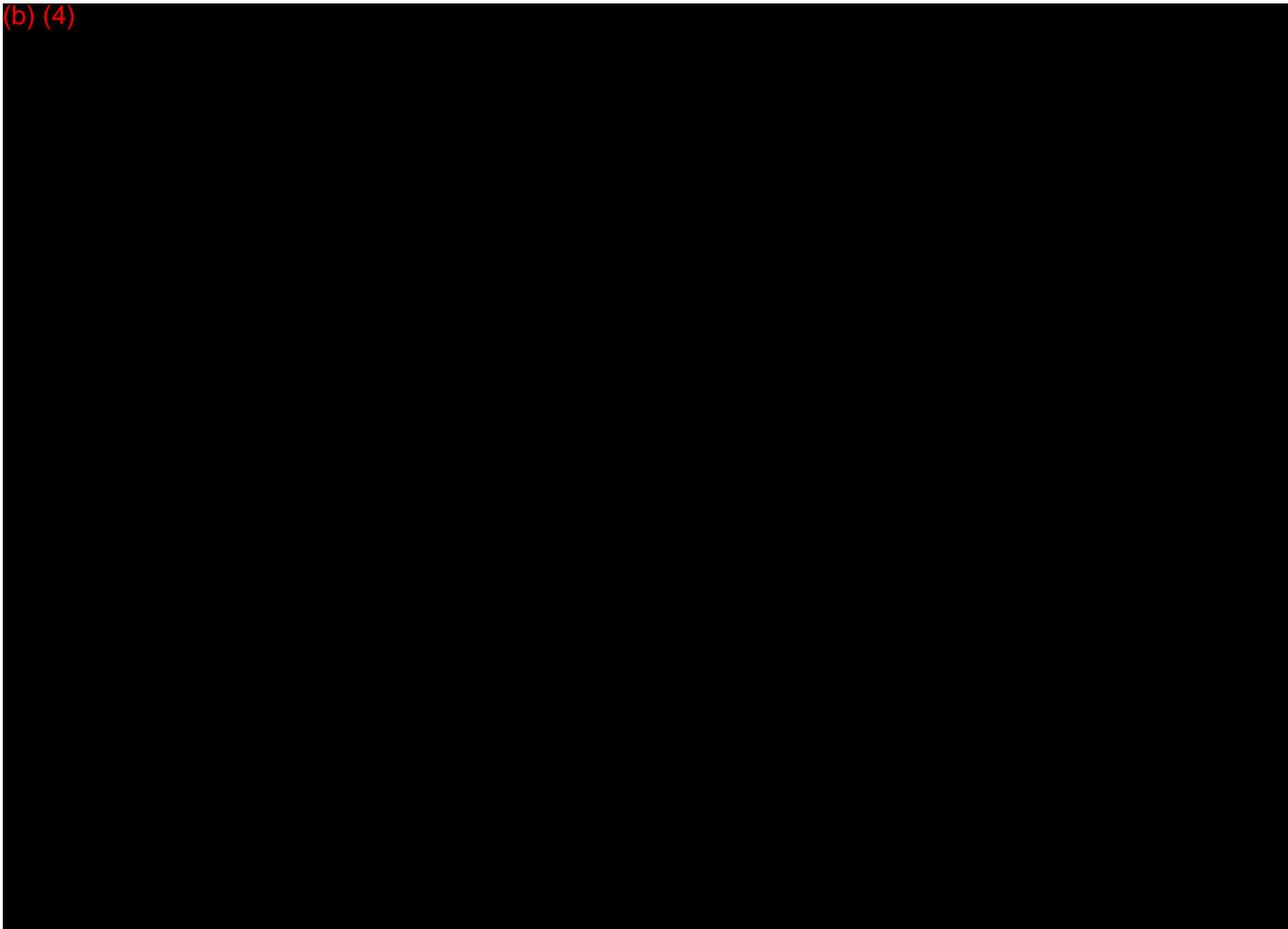
The Contractor shall continue to finalize the CTS design, perform analyses; manufacture, assemble, produce; and build-up the CTS vehicle. The contractor shall perform subsystem integration, verification, end-to-end testing, qualification, acceptance test; and checkout of the CTS vehicle hardware and software subsystems (J-01 1120 5.0, 5.1.1, 5.2). The contractor shall document, as part of the qualification and acceptance testing process, test plans and procedures, test results/reports, requirements traceability, test configurations, environments data, and margins and deviations data (J-01 1120 5.1.1). The contractor shall document the test procedures for demonstrating that the design and performance requirements can be demonstrated for all CCtCap program requirements, including the range of projected environments and operating conditions anticipated over the service life. The contractor shall prepare and deliver one Verification Closure Notice (VCN), DRD 111, per CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD) for all docked crewed and uncrewed requirements, as evidence of closure of each technical requirement.

##### 3.2.4.2 Flight Software

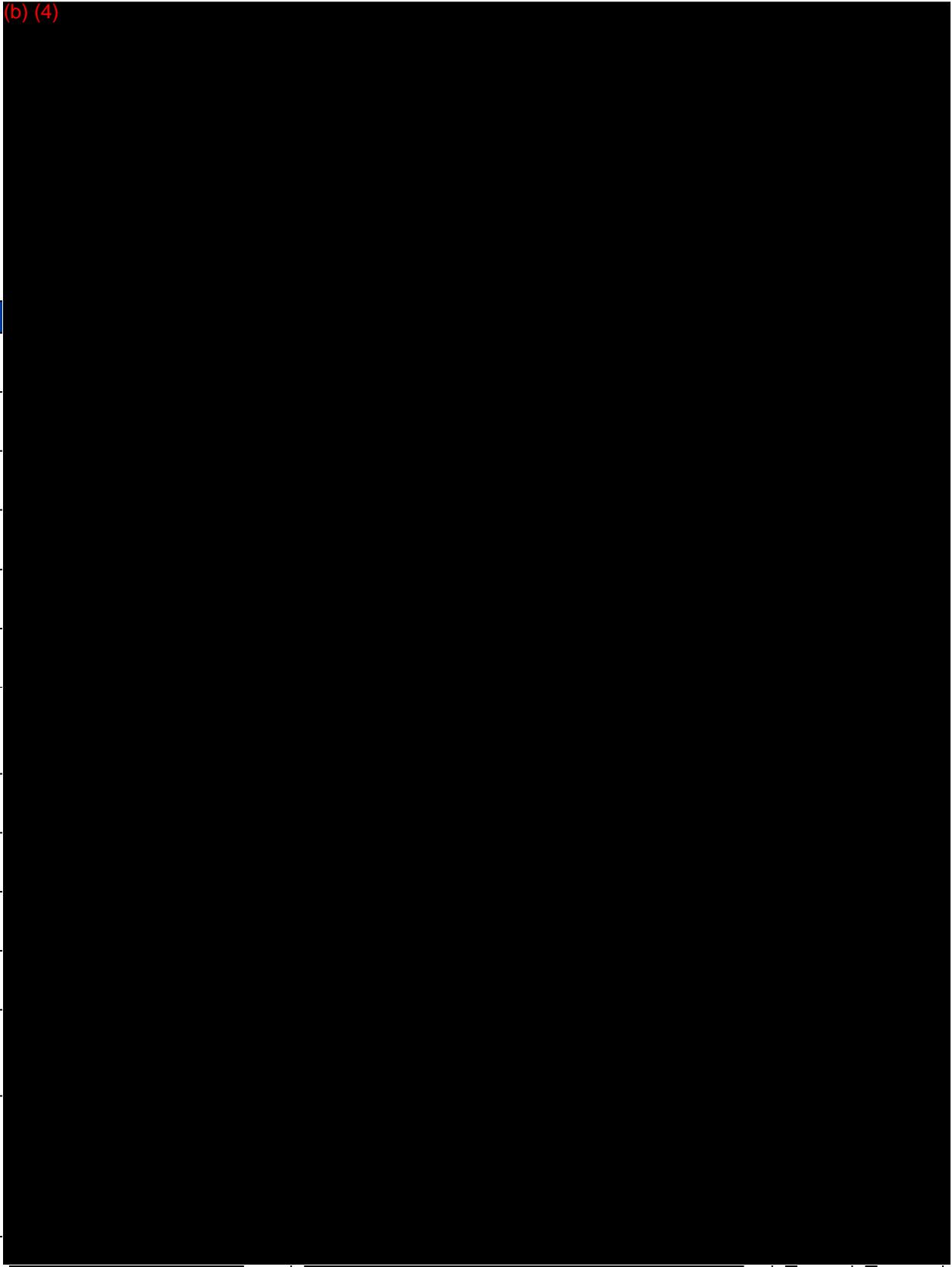
The contractor shall continue to develop, design, integrate, test, verify, qualify, and certify flight software (J-01 1120 5.0) to include software for vehicle avionics functions, including systems management, Command and Data Handling (C&DH), Communication and Tracking (C&T), instrumentation, crew interfaces, external interfaces, and the application software for other subsystems in accordance with the CCTS Software Development Plans, DCC1-00006-01 (for Spacecraft Segment) and DCC1-00115-01 (for Ground Systems Segment) (J-01 1120 5.1.1). The CCTS software development plans shall be delivered as part of DRD 102, Certification Baseline Review (CBR) Data Package, in support of Certification Baseline Review (CBR). Also included is firmware and acquired software (e.g. operating systems, device drivers, etc.). This includes facility integration for hardware and software (J-01 1120 5.0, 5.1.1, 5.2). The contractor shall prepare and deliver one Verification Closure Notice (VCN), DRD 111, per CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD) for all docked crewed and uncrewed requirements, as evidence of closure of each technical requirement.

The contractor shall design and build an Avionics System Integration Laboratory (ASIL) with integrated test equipment, rigs, infrastructure, and test environments for hardware and software integration, checkout and verification testing. (J-01 1120 5.2)

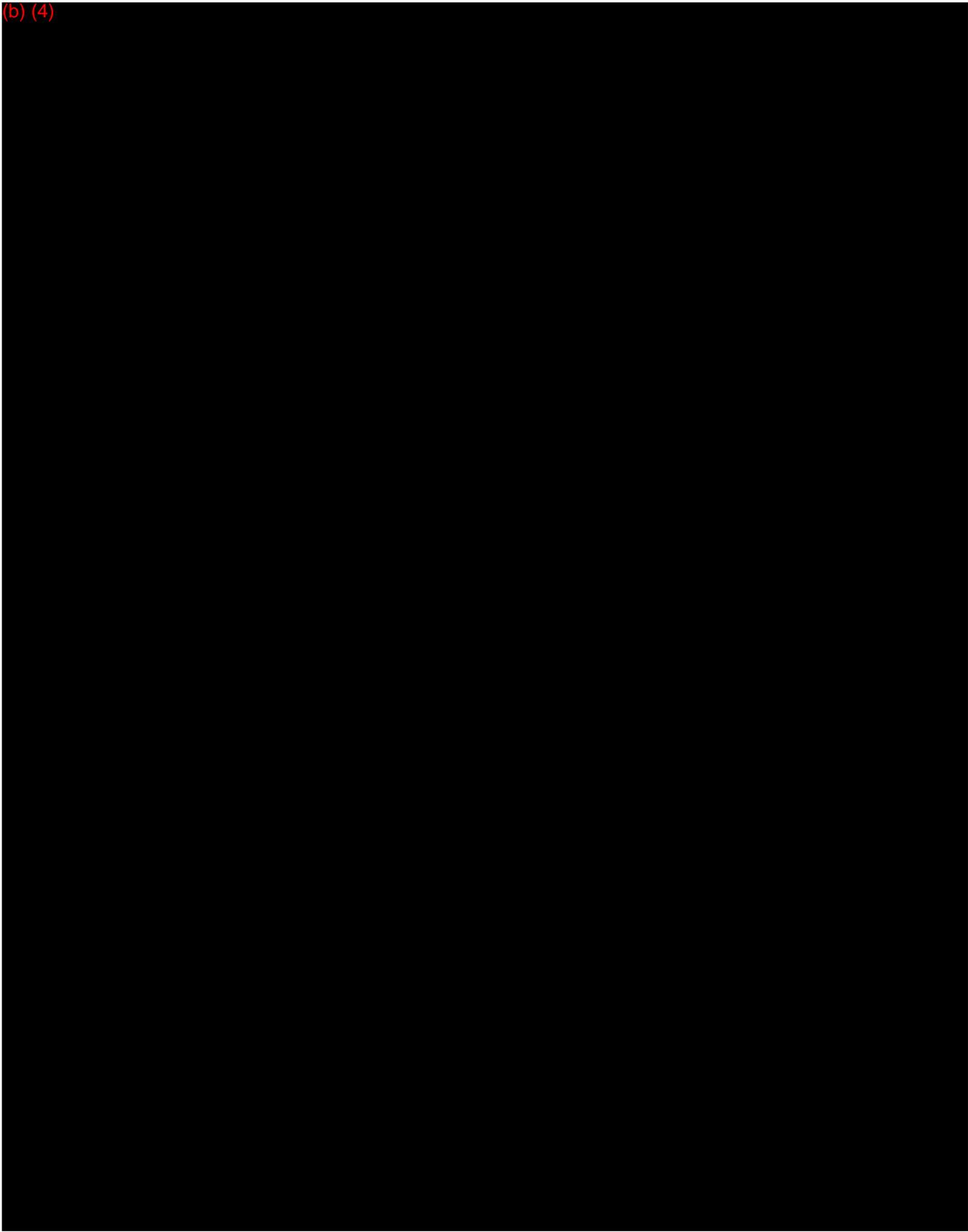
(b) (4)



(b) (4)



(b) (4)



(b) (4)



### 3.2.5 Ground Systems

The Contractor shall develop a ground processing process to support validation of the CTS. Ground processing shall include a process that tracks and resolves anomalies, captures potential process improvements, and lessons learned to improve and inform future ground operations and CTS design changes (J-01 1120 6.5.1). The Contractor shall provide Ground Systems (J-01 1120 5.0) supporting facilities, support equipment, and hardware and software required for ground and flight operations.

#### 3.2.5.1 Assembly Integration and Test (AIT) Facilities and Systems

The Contractor shall perform vehicle (hardware and software) assembly, integration and end-to-end test (J-01 1120 5.2) at the contractor's facility or facilities.

The Contractor is responsible for providing all mechanical and electrical ground support equipment (GSE) required to support the AIT, vehicle integration, crew operations, and pre- and post-flight mission activities (e.g., fueling, cargo/crew loading, crew ingress/egress and crew/cargo recovery).

The Contractor is responsible for providing all tooling required to support refurbishment of the Spacecraft elements.

### 3.2.5.2 Ground Communication Systems

The Contractor shall provide a Ground Communications System that will encompass remotely operated ground stations to provide Space-to-Ground communications and recovery communications.

### 3.2.5.3 Cargo Handling Operations, Facilities and Systems

The Contractor shall provide Ground Support Equipment (GSE) for physical cargo integration including nominal stow cargo, late stow cargo and post mission cargo extraction, for early destow and nominal destow.

### 3.2.5.4 Recovery Systems and Operations

For a nominal land landing at a Primary Landing Site, the Contractor will provide all required services and equipment for the recovery of the crew, cargo and Crew Module (CM). For an emergency landing at an unsupported site, NASA will provide SAR support for the rescue and recovery of the crew. The Contractor shall provide Support Equipment (SE), training for the SAR provider, cargo and CM recovery.

### 3.2.5.5 Logistics and Logistic Systems

The Contractor shall provide ground segment logistics activities to include (1) databases for shipping/receiving, sparring analysis/tracking, ground maintenance planning/scheduling, and limited life items, (2) packaging, handling, storage, and transportation.

### 3.2.5.6 Pre-Flight and Launch Site Infrastructure

The Contractor shall provide pre-flight and launch site infrastructure required to successfully conduct launch operation. The infrastructure shall include an integration facility, crew access accommodations, and ground support equipment areas. The contractor shall provide crew and pre-flight operations support to successfully manage and coordinate crew operations and events.

The Contractor shall develop, design, and build a suitable access tower to allow crew, support personnel, and cargo, to ingress and egress from the CST-100. Emergency egress shall be available to provide evacuation of the flight crew and support personnel from the spacecraft access level to a suitable safe-haven. The launch-pad-to-CST-100 interface area and white room shall be designed to provide a controlled, clean environment for ingress/egress of the spacecraft habitable volume.

### 3.2.5.7 Ground Segment Test and Checkout

The Contractor shall conduct Ground Segment test and checkout. The integrated tests shall include the [REDACTED] Mission Control Center (MCC), hardware and software integration facility, electrical GSE, ground communications networks, space communication networks, landing sites, [REDACTED]

(b) (4)

### 3.2.6 Crew and Mission Operations (CMO)

The Contractor shall conduct mission planning and analysis; training; crew, flight and cargo operations; and mission systems/controls consistent with CCT-STD-1150, Crew Transportation Operations Standards, and SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD). The planning activity

shall be based on an assumed flight rate of two (2) flights per year to the ISS. The Contractor shall develop real-time and post flight review process to support validation that the CTS is performing as predicted and operating within design limitations. Real-time review process shall analyze and assess in-flight anomalies and CTS performance such that mission execution can continue safely. The post flight review process shall include debriefing the flight crew and operations personnel (J-01 1120 6.5.1).

#### 3.2.6.1 Mission Planning and Analysis

The Contractor shall develop operational processes and products for mission planning and execution. Operations processes shall define methods to develop, validate, and certify the operations products and facilities. Operations products shall include: mission manifesting; flight design; ground operations procedures supporting nominal and off-nominal operations, mission controller/flight crew procedures supporting nominal and off-nominal scenarios while in-flight, nomenclature definition, vehicle and crew timelines, ground monitoring/control systems, and flight rules (J-01 1120 6.2.1).

#### 3.2.6.2 Training

The Contractor shall develop a training program for personnel having safety critical or mission critical roles. The Contractor shall jointly develop with NASA a crew training template that covers CTS and ISS training (Reference DA8-13-193, Notional Training Template for ISS Crew members, Dated October 31, 2013). This training program shall include simulation training for flight crew, mission controllers, pre-flight/launch operations, and crew support personnel that closely mimics the conditions that will be seen during flight and shall address nominal and off-nominal scenarios. Personnel with safety or mission critical roles include mission designers, assembly/integration/testing and launch engineers, technicians and quality control personnel, mission and ground controllers, all flight crew, launch site and landing recovery personnel (J-01 1120 6.3.1). The training program shall also define standards for non-critical roles.

#### 3.2.6.3 Flight Operations

The Contractor shall develop a mission execution process addressing operational communication plans, operational management plans, real-time analyses, and contingency action plans (J-01 1120 6.4.1). For ISS integrated operations, the Contractor shall jointly develop with NASA the operational products and mission planning and joint execution.

#### 3.2.6.4 Cargo Operations

The Contractor shall work with NASA to identify cargo capabilities and integrate cargo onto the CST-100 for OFT and CFT flight test missions. The cargo definition and integration activities shall follow the same process as outlined for the PCM missions PWS Section 3.3.5.

#### 3.2.7 Test and Evaluation

The Contractor shall develop and implement a CCtCap test program as part of the verification and validation effort to include abort and flight tests (J-01 1120 5.3) and end-to-end integrated system qualification tests. The Contractor shall implement a Joint Test Team (JTT) for the planning and execution of flight test activities in order to leverage the joint knowledge and experience shared between the Government and the contractor.

The Contractor's test and evaluation program shall include conduct of site surveys, design and development and set-up of test instrumentation, simulators and test articles, performance of

applicable reviews and briefings, conduct of the test event(s), performance of data analysis and data reduction and preparation of test plans/procedures and result reports. The contractor shall prepare and deliver one Verification Closure Notice (VCN), DRD 111, per CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD) for all docked crewed and uncrewed requirements, as evidence of closure of each technical requirement.

#### 3.2.7.1 Test Planning and Integration

The Contractor shall conduct test planning for all CCtCap test and evaluation activities. The Contractor shall determine test requirements, procedures, and data requirements for development of test plans that describe the approach for conducting tests, document test objectives with linkage to the specific requirement that are verified by the test (J-01 1120 7.0), and analyzing the test results to show how the system will satisfy the requirements of the applicable design.

The Contractor shall maintain, deliver and implement a Flight Test Plan in accordance with DRD 109, Flight Test Plan, and the content defined in CCT-PLN-1120, Crew Transportation Technical Management Processes, and shall address the test objectives in CCT-PLN-1120 Table 7-1 (J-01 1120 5.3.1).

The Contractor shall conduct test readiness review(s) prior to conduct of an uncrewed or crewed flight test event to demonstrate readiness for flight (J-01 1120 7.0) and define the risk baseline for flight activities in accordance with PWS Section 3.2.1.2, and the following:

- a) Flight Test Readiness Review (FTRR) Data Package, DRD 104
- b) CCT-PLN-1120, Crew Transportation Technical Management Processes, Appendix F, CTS FTRR/FRR Milestone Data
- c) PWS Appendix A, Milestone Acceptance Criteria and Payment Schedule

The Contractor shall be responsible for design and development of test instrumentation, test articles and simulators required to support the test program to include Development Flight Instrumentation (DFI), Pad Abort/Crewed Flight Test (PAT/CFT) Article Qualification Test Vehicle (QTV) Article, and Orbital Flight Test (OFT) Article instrumentation and mass simulators.

#### 3.2.7.2 Ground Test

The Contractor shall conduct static loads testing, pressure cyclic testing, modal testing, and separation shock testing.

The Contractor shall conduct Performance testing, acoustic testing, Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) testing and lightning testing.

(b) (4)

#### 3.2.7.3 Flight Test

The Contractor shall operate a CTS such that execution of the flight tests are within the constraints of the NASA certification and recurring ISS requirements.

The Contractor shall satisfy at least one of the following decision criteria when determining flight test objectives:

- a) Ground testing is not sufficient to adequately test the objective
- b) Significant risk exists after all ground testing and analysis is complete
- c) Flight test is the only method to achieve validation of the objective

The Contractor's flight test program shall include an uncrewed orbital flight test to the ISS. The OFT shall include a CCTS that validates end-to-end connectivity, LV and CST-100 integration, launch and flight operations, automated rendezvous and proximity operations, and docking with the ISS, assuming ISS approval.

(b) (4)

The Contractor's flight test program shall include a crewed flight test to the ISS. The crewed flight test shall include a NASA crew that docks with the ISS, remains docked for a sufficient duration to check-out ISS interfaces, and then return to a supported landing site (J-01 1120 5.3).

The following (Table 3.2.7.3-1) work statements from PWS Section 3.3, PCM (CLIN 002), shall apply to the OFT and CFT to ISS (except for the first sentence in paragraph 3.3.3.1 dealing with ATP).

**Table 3.2.7.3-1. PCM Task Performed during CLIN 001 for Crewed Flight Test to ISS**

Paragraph	Title	DRD
3.3.3.1	PCM Approach	DRD 201
3.3.3.3	Mission Definition and Documentation	DRD 204
3.3.3.4	PCM Certification Maintenance	DRD 110, DRD 111, DRD 112, DRD 205
3.3.3.7	ISS Integration	
3.3.3.9	Range Safety	DRD 113
3.3.4	Mission Operations	
3.3.5	PCM Cargo Integration	DRD 206
3.3.1.4	ISS Stage Operational Readiness Review	
3.3.1.6	Post launch Ascent Review	
3.3.1.7	Undocking Readiness Review	
3.3.1.8	Post Flight Review	DRD 209, DRD 210

The Contractor shall perform ISS integration activities in accordance with the intent of SSP 50964, Visiting Vehicle ISS Integration Plan, SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), and associated ISS documents (e.g., JSC 35089, Visiting Vehicle Ops Annex, SSP 30599, ISS Safety Review Process, SSP 50108, ISS Certification of Flight Readiness Process Document). The ISS Program and the CCP will work with the Contractor to negotiate an ISS Visiting Vehicle Joint Integration, Verification, and Test Plan (JIVTP). This test plan will define the steps, planning agreements, and products to be completed for joint ISS Visiting Vehicle requirement verification, execution,

and closure. It also identifies organizational roles, responsibilities, and verification ownership (J-01 1120 5.4).

The Contractor shall participate in two (2) Mission Management simulations for the first crewed flight to ISS that includes mission management, flight controllers and crew participation. NASA will conduct the simulations from the NASA-Johnson Space Center (JSC) Mission Control Center (MCC) and the ISS Management Center (IMC). Each of these simulations may last up to 48 hours.

### 3.2.8 Incorporation of NASA Disposition of CPC Products

The Contractor shall perform the tasks identified below (referenced in the columns titled “PWS Work Scope”) and/or provide documentation for submittal to NASA in response to formal dispositions documented in the noted NASA disposition letters. Documentation may be provided in place of or in addition to the specific documents identified in the task descriptions, sufficient to allow NASA to definitively approve the subject CPC Product.

#### 3.2.8.1 Alternate Standards (Reference PWS Section 3.2.1.1)

The Contractor shall continue to refine, deliver and update the Alternate Standards developed under the CPC contract in accordance with PWS Section 3.2.1.1, the specific disposition letters, and the CPC Final Technical Summary Report findings. The contractor shall provide documentation / data in place of or in addition to the specific documents identified in Table 3.2.8.1-1, sufficient to allow NASA to definitively approve the subject Alternate Standard. If a Variance is required to resolve Alternate Standards open items, the contractor shall document the Variance Request and submit to NASA for disposition.

**Table 3.2.8.1-1 Tasks for Alternate Standards based on CPC Disposition Letters**

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reamt	SSP 50808 Reamt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

### 3.2.8.2 Hazard Reports (Reference PWS Section 3.2.2.1)

The Contractor shall continue to refine, deliver and update the Hazard Reports developed under the CPC contract in accordance with PWS Section 3.2.2.1, the specific disposition letters, and the CPC Final Technical Summary Report findings. The contractor shall provide documentation / data to allow NASA to definitively approve the subject Hazard Report.

### 3.2.8.3 Variances (Reference PWS Section 3.2.1.1.1)

The Contractor shall continue to refine, deliver and update the Variances developed under the CPC contract in accordance with PWS Section 3.2.1.1.1, the specific disposition letters, and the CPC Final Technical Summary Report findings. The contractor shall provide documentation / data in place of or in addition to the specific documents identified in Table 3.2.8.3-1, sufficient to allow NASA to definitively approve the subject Variance.

The Contractor shall implement an integrated approach that provides the data necessary to support the qualification, acceptance, and validation for the SM propulsion system (reference Variance Nos. CCTS-VR-0009 R1, CCTS-VR-0029, and CCTS-VR-0038).

**Table 3.2.8.3-1 Tasks for Variances based on CPC Disposition Letters**

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reqmt	SSP 50808 Reqmt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

No	Title	Rev	CCT-REQ-1130 Reamt	SSP 50808 Reamt	Disposition Letter Filename	All Areas Approved Except for ...	PWS Work Scope
(b) (4)							

3.2.8.4 Verification and Validation Plan (Reference PWS Section 3.2.1.4)

The Contractor shall continue to refine, deliver and update the CCTS Verification and Validation Plan (DCC1-00005-01) developed under the CPC contract in accordance with PWS Section 3.2.1.4, DRD 108 (Verification and Validation Plan), the specific disposition letters, and the CPC Final Technical Summary Report findings. The contractor shall provide documentation / data to allow NASA to definitively approve the Verification and Validation Plan.

3.2.8.5 Certification Plan (Reference PWS Section 3.2.1.4)

The Contractor shall continue to refine, deliver and update the CCTS Certification Plan (DCC1-00443-01) developed under the CPC contract in accordance with PWS Section 3.2.1.4, DRD 107 (Certification Plan), the specific disposition letters, and the CPC Final Technical Summary Report findings. The contractor shall provide documentation / data to allow NASA to definitively approve the Certification Plan.

### **3.3 Post Certification Missions (PCM) Services (CLIN 002)**

This PWS section contains the specific work scope associated with conducting post certification missions (CLIN 002). The contractor's approach for post certification mission planning and execution shall be repeatable with the lowest achievable safety risk. A Post Certification Mission is defined as services provided by the Contractor, from Task Order Authority to Proceed, to Plan, Process, Train, Conduct Operations, Execute, Launch, On Orbit support, landing/recovery services through Contracting Officer Mission Success Determination and Acceptance as specified in Article H.21. Each PCM shall include all activities from mission planning through post flight assessment including unplanned events and inflight anomalies. For PCMs to ISS, the contractor shall support the objectives of CCT-STD-1150, Crew Transportation Operations Standards, and SSP 50808, International Space Station (ISS) to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), which define preflight and mission planning and integration processes; standards; and products required to successfully complete the mission. The contractor processes defined in support of this objective shall satisfy CCT-PLN-1120, Crew Transportation Technical Management Processes, which defines mission integration rhythm, handover points, and roles of the contractor's team.

The efforts detailed in 3.3 are additive to the work scope defined in PWS Section 3.1. Since the activities from the core certification effort (Reference PWS Section 3.2, CLIN 001) and the initial PCMs (Reference PWS Section 3.3, CLIN 002) can be conducted concurrently, the contractor shall ensure the interdependencies between the on-going core certification efforts and PCM objectives are addressed in development plans and mission execution planning.

#### **3.3.1 Key PCM Milestones/Reviews**

The Contractor shall conduct reviews to prepare and execute each PCM in accordance with Contract Clause H-19 Post Certification Mission Payments Milestones and Authority to Proceed (ATP) Criteria. Each PCM shall include, at a minimum, the milestones/reviews identified in PWS sections 3.3.1.1 through 3.3.1.7. The contractor shall define additional interim reviews/events the contractor deems necessary to supplement the mandatory Government reviews and those associated with progress payments shall be detailed in PWS Appendix B, Post Certification Mission (PCM) Milestone Acceptance Criteria and Payment Schedule. These events represent essential decision points to accurately measure the success of the preceding phase of work and an entry point for control of subsequent work efforts. PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule, defines the success requirements to allow progress to next event for all payment milestones/reviews.

The PCM Work shall address the requirements from Attachment J-02, Data Requirements Deliverables; CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document; and PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

##### **3.3.1.1 Vehicle Baseline Review (VBR) (At no later than 18 months prior to launch (L-18 mo))**

The Contractor shall co-chair a Vehicle Baseline Review (VBR) with NASA with the objective that establishes the integrated mission CTS configuration (launch vehicle, orbital vehicle, and ground systems) that accommodates NASA requirements for crew and cargo

transportation. The intent of the VBR is to establish the baseline CTS for the mission and identifies any design or operations changes from the previous baseline and the corresponding plans for executing and verifying the changes. The content of the VBR shall include: A) Mission Baseline CTS and B) Design and Operation changes from prior mission baseline CTS which are detailed in PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

The VBR shall review updated versions, as required, of MIOMP, DRD 201, PCM Work Plan, DRD 202, and Vehicle IDD, DRD 203. The VBR shall be a payment milestone in accordance with Contract Clause H.19 Post Certification Mission Payments, Milestones and Authority to Proceed (ATP) Criteria and readiness and success criteria for this event shall be detailed in PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

### 3.3.1.2 Mission Integration Review (MIR) (At no later than 13 months prior to launch (L-13 mo))

The Contractor shall co-chair a Mission Integration Review (MIR) with NASA with a current mission integration status including specific mission hardware delivery schedules and vehicle layout arrangements. NASA and contractor will review and baseline the conditions and inputs for mission specific analytical assessments. The contractor shall demonstrate CTS operations and production activities in support of the launch date. A status of all open items presented at VBR shall be presented at this review. For open items, schedule plans for completion shall be presented. All milestones to this point shall have been met. The content for the MIR shall include: A) Mission Baseline CTS and B) Design and Operation changes from prior mission baseline CTS which are detailed in PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

The review data package shall include detailed design and associated analysis that implement and support the mission requirements. The MIR shall review updated versions, as required, of Hazard Reports, DRD 110, VCNs, DRD 111, MIOMP, DRD 201, Vehicle IDD, DRD 203, and MRAD, DRD 204, if updated since VBR. The review shall provide NASA with specific mission success determination criteria as well as overall mission integration status. Updated products and action closure from the VBR are presented. The intent of this review is to provide NASA the necessary information to determine if scheduled delivery dates can be achieved and if integration activities should continue as planned. The MIR establishes a 30-day window for the mission to ISS. The MIR shall be a payment milestone in accordance with Contract Clause H.19 Post Certification Mission Payments, Milestones and Authority to Proceed (ATP) Criteria and readiness and success criteria for this event shall be detailed in Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

### 3.3.1.3 Mission Certification Review (MCR) (After Certification has been granted, and no later than 4 months prior to launch (L-4))

The Contractor shall co-chair with NASA a Mission Certification Review (MCR) that allows NASA to assess if the contractor has completed certification of all requirements (existing "generic" CCTS, mission specific and new requirements due to hardware, software and process changes), has completed ISS integration, has all infrastructure, facilities, personnel and services in place and will be ready for the mission and for crewed operations, included agreement on cargo turnover and crew handover. As status of all open items presented in

both VBR and MIR shall be presented at this review. All mission unique design qualification and acceptance testing shall be completed. For open items, schedule plans for completion shall be presented. All milestones to this point shall have been met. The content of the MCR is detailed in PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

The contractor shall confirm agreements are in-place to support cargo turnover and flight crew handover. The contractor shall provide evidence that design; testing, qualification and acceptance of all mission-unique hardware have been completed. The MCR shall establish the final data and mission success determination criteria. The MCR shall review updated version, as required, of Vehicle IDD, DRD 203, if updated since MIR. The MCR shall be a payment milestone in accordance with Contract Clause H.19 Post Certification Mission Payments, Milestones and Authority to Proceed (ATP) Criteria and readiness and success criteria for this event shall be detailed in PWS Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

#### 3.3.1.4 ISS Stage Operational Readiness Review (SORR) (Approximately 3 weeks prior to launch)

At approximately three (3) weeks prior to launch, the Contractor shall support a pre-requisite review for the FRR and shall participate in the ISS Stage Operational Readiness Reviews (SORR). The contractor shall provide, at a minimum, the following data and presentation:

- (a) Status of integration of CTS, cargo, and crew.
- (b) Planned launch windows and available back-up opportunities; planned mission profile and activities including any special operations.
- (c) CTS propellant and power budget (nominal and margins) and associated loiter capability.
- (d) Crew consumables budget (nominal and margins) for free flight phases.
- (e) Summary of all open work and closure plan.
- (f) Summary of all risks or watch items including mitigation plans and/or acceptance rationales that may affect the crewmember(s) or commercial spacecraft's ability to complete the mission.
- (g) Operations support readiness (facilities, tools, processes, products, personnel) for all phases of the mission.

#### 3.3.1.5 Flight Readiness Review (FRR) (Approximately 2 weeks prior to launch)

The Contractor shall support a NASA Flight Readiness Review (FRR). The contractor shall provide a mission specific DRD 208, Flight Readiness Review Data Package, in support of FRR. The Contractor shall present a Certification of Flight Readiness endorsement for the upcoming flight including verification of all flight and ground systems readiness for launch, closure of previous review open items, review of documentation for residual risk items and plan showing completion of open work prior to launch. Launch Site, Range, FAA and Recovery forces ready to support mission. ISS program is ready to accept CCTS vehicle and crew. The FRR shall be a payment milestone in accordance with Contract Clause H.19 Post Certification Mission Payments, Milestones and Authority to Proceed (ATP) Criteria and readiness and success criteria for this event shall be detailed in Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

#### 3.3.1.6 Undocking Readiness (Approximately two (2) weeks prior to landing)

The Contractor shall participate in an Undocking Readiness Integrated Management Team (IMT) and, at a minimum, provide: (a) Planned landing windows, available backup opportunities, weather report, (b) Cargo to be returned, and (c) CTS resources margins.

#### 3.3.1.7 Post Flight Review (PFR) (Approximately 2.5 weeks after landing)

The Contractor shall conduct Post Flight Reviews with NASA participation to assess mission success with supporting data in accordance with DRD 209, Post Flight Assessment Report. The PFR following each mission landing shall address CCTS system performance for ascent, rendezvous and docking; quiescent docked operations; undocking, entry and landing; post landing crew recovery. The review shall include a preliminary review of predicted vs. actual performance; evaluation of actual vs. predicted environments; a summary of any anomalies

(flight hardware and ground systems) from start of LV tanking through crew recovery and the impacts on execution of the flight and preliminary assessment of flight crew and ground personnel training. The contractor shall present a determination of meeting the mission success criteria that was finalized at MCR. The Contractor shall conduct and deliver preliminary, updates, and final post flight assessment. The PFR shall be a payment milestone in accordance with Contract Clause H.19 Post Certification Mission Payments, Milestones and Authority to Proceed (ATP) Criteria and readiness and success criteria for this event shall be detailed in Appendix B, Post Certification Mission (PCM) Acceptance Criteria and Payment Schedule.

### 3.3.2 PCM Vehicle Integration

#### 3.3.2.1 Launch Vehicle (LV) and Crew Vehicle (CV) Integration

The Contractor shall build, process, integrate and operate the CTS for the mission to the ISS. Integration shall include the physical integration of the CTS.

The Contractor shall define the necessary pre-launch testing such as Terminal Countdown Demonstration Test (TCDT) and Crew Equipment Interface Test (CEIT) that include flight controllers, crews, and required NASA and Contractor support personnel.

#### 3.3.2.2 Safety, Reliability and Quality Engineering

The Contractor shall provide in-line system safety, reliability and quality engineering support.

The Contractor shall implement a system safety program consistent with the policies, procedures and processes established in the contractor's developed system safety program plan. The contractor's safety process shall provide an integrated, systematic, and comprehensive approach, which can be used to assess changes in risk resulting from design and operational changes, including anomaly resolutions. The safety process shall include:

- a) the evaluation of hardware and software changes, operational changes, anomaly resolutions, as well as environmental and human factors relevant to safety
- b) the use of industry standard safety analyses (e.g. hazards likelihood and severity categories) throughout the CTS lifecycle
- c) closed-loop tracking and verification of mission unique hazard controls
- d) detailed plans for the communication and acceptance of risk to stakeholders and/or the appropriate control boards to ensure mission unique residual risk is appropriately managed
- e) the safety review process for communication and approval of updated safety analyses for flight readiness reviews

The Contractor shall provide and manage a Mishap Reporting and Investigation Plan and process that are in accordance with Contract Clause H.26 Mishap Reporting. When applicable, the Contractor shall support a Commission appointed by the President per 51 U.S.C Section 70701 et seq.

The Contractor shall conduct a safety review process that allows for the systematic identification and review of hazards related to the design, operations, and anomaly resolutions in support of PCM flight readiness reviews. This methodology shall ensure that

proper controls are maintained for all hazard causes consistent with CCP certification processes and requirements. Risks identified as a result of the hazard analysis that are deemed a CCP risk shall be coordinated with the CCP Risk Management Process (J-01 1120 4.5). For hazard reports where the ISS is identified as being an affected party and/or stakeholder, the Contractor shall coordinate with the CCP to prepare and deliver such items for approval to the ISS Safety Review Panel (reference SSP 30599, ISS Safety Review Process, and SSP 30309, Safety Analysis and Risk Assessment Requirements Document) (J-01 1120 4.5).

The Contractor shall implement a safety and health program which identifies, eliminates, mitigates and control hazards and risks in activities in accordance with the existing CTS Safety and Health Plan. The contractor shall support the range safety analysis to meet local test range safety requirements including a list of hazardous operations to be performed. The contractor shall deliver Range Safety Documentation.

The Contractor shall implement its reliability program plan to update Failure Modes Effects Analyses/Critical Items Lists (FMEA/CIL), including the CCtCap System Probabilistic Safety Assessments, to reflect any changes in risk. The reliability program plan shall also include participation in Exchanging Parts, Materials, and Safety Problem Data utilizing the Government Industry Data Exchange Program (GIDEP).

The Contractor shall develop and execute a quality management system that assures quality requirements are flowed down from design into the manufacturing and operational processes and is compliant with the requirements of AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations. The Contractor shall implement a quality function for inspection, material review, supplier quality control, quality investigations and manufacturing support, and software quality metrics. The Contractor shall flow down and ensure implementation of appropriate quality assurance requirements to applicable suppliers.

The Contractor shall be responsible for the management of software safety throughout the CTS lifecycle for flight software, flight support software, ground support equipment (GSE) ground software, and hardware and software used in the design, development, test, verification, storage, maintenance of software, and ensures that software products obtained from any source meet the software assurance requirements. The contractor shall maintain the software safety plan to document safety-critical software determination processes, management, software development and analysis methods (including support of hazard analyses and maintenance of hazard reports), implementation and test, and operational use.

### 3.3.3 PCM Mission Integration

The Contractor shall ensure the safe integration and transport of crew and cargo to and from the ISS. The Contractor shall put in place and support integration and operations process for all Post Certification Missions. The Contractor shall integrate the crew and cargo complement, and at the vehicle level, perform analysis and integration to safely execute the flight to and from the ISS including cargo turnover and crew handover.

(b) (4)

If there is contractor crew(s) or commercial passenger(s) on a mission to ISS, the Contractor shall define and implement a process that complies with SSP 50260, ISS Medical Operations Requirements Document, and SSP 50667, Medical Evaluation Document, Volumes A-C.

### 3.3.3.1 PCM Approach

Upon receipt of Authorization to Proceed (ATP), the Contractor shall initiate initial mission planning work. The Contractor shall prepare and deliver a Mission Integration and Operations Management Plan (MIOMP), DRD 201, that details the contractor's approach to PCM mission integration including coordination with Government for mission planning and execution. The MIOMP shall outline the key aspects of mission integration activities, describe operations and processes, product delivery templates, and organization interfaces necessary for the contractor to implement integration and operations activities for the PCM to the ISS.

### 3.3.3.2 PCM Initiation

The Contractor shall prepare and deliver a Post Certification Mission Work Plan (PCM WP), DRD 202, that establishes for each milestone, including interim payment milestones/reviews leading up to the mandatory Government delivery milestones: the review process, the sequence of all reviews/milestones, anticipated schedule, entrance criteria/readiness deliverables to address the milestone review objectives and timing by which data will be made available to NASA for review, boards, exit/success/acceptance criteria, and other logistics related information. The PCM WP shall define the specific data requirements required to successfully conduct each review. The PCM Work Plan is a template that shall be updated and tailored to the unique requirements of each PCM.

### 3.3.3.3 Mission Definition and Documentation

The Contractor shall document mission requirements and definition for each flight, from which all other planning data is derived, in a Mission Requirements Document, Launch Vehicle (LV) Interface Control Document (ICD), Mission Resource allocation Document (MRAD), DRD 204, and Vehicle Interface Definition Document (VIDD), DRD 203. The contractor shall utilize these documents as the starting point for deriving all other mission products. The Mission Requirements Document shall be an internally controlled document and through Government insight the document shall be collaboratively prepared to include applicable ISS Interface Requirements Document (IRD), software load, vehicle number and configuration, crew complement, cargo complement/powering, launch/landing date, launch vehicle configuration and special mission requirements.

(b) (4)

The contractor shall complete required mission specific analysis to ensure mission safety and success and deliver for each flight a Mission Resource Allocation Document (MRAD) in accordance with DRD 204, Mission Resource Allocation Document (MRAD). NASA and the Contractor will utilize the data from the MRAD in the mission analysis, mission procedures/ training, and crew/cargo integration. The MRAD establishes the allocation of resources and technical data requirements needed for each PCM. The contractor shall prepare and deliver a VIDD. The VIDD shall include specific mission interfaces for each flight and address the topics of environments

and sensor information. The associated data shall provide the required assessment to confirm compatibility with the spacecraft environments defined in the Vehicle IDD (reference DRD 203) and compatibility with SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), and CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document.

The Contractor shall measure and provide telemetry data confirming the required launch, entry, and orbit conditions and cargo environments were met as stated in DRD 203, Vehicle Interface Definition Document (IDD). This shall include a detailed listing and description of all measurements and calibration coefficients.

The Contractor shall submit spacecraft Engineering Computer Aided Design models and CTS imagery plan and associated cataloging in accordance with DRD 205, Spacecraft Computer Aided Design (CAD) Models, and DRD 210, Imagery Plan and Associated Cataloging.

#### 3.3.3.4 PCM Certification Maintenance

The Contractor shall maintain the product baselines and perform the mission and analytical integration for each flight. The contractor shall review and evaluate design, production, or operational changes from the NASA certification baseline for compliance to the requirements of CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD). The contractor shall maintain NASA certification for the CTS for all PCMs. Additionally, system performance from previous production, operation or flights shall be reviewed for potential impacts to the NASA certification. The contractor shall ensure that post flight inspections and test results are reviewed, nonconforming hardware is isolated and dispositioned. For changes to vehicle design, reference missions, or operational environments that require re-verification/certification, the contractor shall update and deliver CTS Hazard Reports in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes, and DRD 110, Hazard Reports, Verification Closure Notices (VCNs), DRD 111, and Certification Data Package, DRD 112 as required in support of MCR.

#### 3.3.3.5 Safety and Mission Assurance

The Contractor shall implement a safety and mission assurance program consistent with the policies, procedures and processes established in the contractor's developed mission assurance plan. The contractor shall provide safety assessments of the mission as part of the Flight Readiness Review in support of mission planning. The contractor shall conduct mission assurance activities that assure product integrity and mission success focusing on issue prevention with Mission Assurance Independent Reviews (MAIRs) and Technical Independent Reviews (TIRs), independent risk assessment, and technical integrity verification. The contractor shall provide an independent evaluation of program and S&MA readiness assessments, including defining success criteria for the assessments. The contractor shall proactively identify the need for independent assessments (including technical, execution, cultural, and other issues) and facilitate independent reviews. The contractor shall monitor activities and process trends to ensure process discipline is maintained, review engineering products throughout maturation to ensure technical integrity, and independently assess the level of technical risk incurred and quality of mitigation plans. In cases where anomalies or unfavorable technical trends emerge or mishaps occur, the contractor shall ensure appropriate engineering root-cause analysis activities are conducted and that effective corrective actions are implemented, to include documentation of

lessons learned and procedural updates. The contractor mission assurance discipline shall participate in the CCTS Risk process, and attends the program risk board meetings to ensure the program maintains the necessary rigor in the identification and disposition of program level and lower level risks. The Contractor shall annually review the mission assurance plan for updates with the objective of strengthening the mission assurance program and incorporating applicable lessons learned. The contractor shall provide input to critical Go-No-Go calls during critical mission events including the launch countdown polls, undocking, and deorbit burn maneuvers.

#### 3.3.3.6 Analytical Integration

The Contractor shall perform pre- and post flight analyses as required to support the PCM Mission Milestones and Reviews defined in PWS Section 3.3.1, Appendix B, Post Certification Mission (PCM) Milestone Acceptance Criteria and Payment Schedule and other appropriate contractor internally conducted reviews.

#### 3.3.3.7 ISS Integration

The Contractor shall perform ISS integration activities in accordance with the intent of SSP 50964, Visiting Vehicle ISS Integration Plan, SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), and associated ISS documents (e.g. JSC 35089, Visiting Vehicle Ops Annex, SSP 30599, ISS Safety Review Process, and SSP 50108, ISS Certification of Flight Readiness Process Document).

#### 3.3.3.8 Licenses and Permits

The Contractor shall obtain the support services, permits and licenses to complete the mission to ISS such as Federal Communications Commission (FCC) and NASA frequency use agreements for the CV telecommunications. The contractor shall secure a Federal Aviation Administration (FAA) license for all post certification missions in accordance with Contract Clause H.18 Licenses, Permits, and Other Authorizations for a Launch or Reentry Service Operator.

#### 3.3.3.9 Range Safety

The Contractor shall comply with applicable Launch Site Range Safety regulatory requirements (ASPC Manual 91-710, Air Force Space Command Range Safety User Policies and Procedures) and deliver Range Safety Documentation DRD 113, Range Safety Documentation.

### 3.3.4 Crew and Mission Operations

#### 3.3.4.1 Mission Planning and Analysis

The Contractor shall perform mission planning, management and execution activities. The Contractor shall perform mission planning prior to all CLIN 002 PCMs. Operations products developed during the planning process shall include Timelines, Trajectories, Flight Crew and Ground Procedures, Flight Rules, Launch Commit Criteria, Operations Handbooks, Console Notes and other tools necessary to define and execute the PCM. These operations products shall be reviewed at key milestones during the PCM planning flow and culminate in a Flight Operations Review (FOR). The contractor shall certify that all operations products are complete and ready for flight for each PCM at the FRR. The contractor shall provide real-time re-planning in the event the mission plan changes during the flight due to inflight anomalies with either the CTS or ISS.

(b) (4)

### 3.3.4.2 Training

The Contractor shall perform training of NASA Flight Crews, Boeing Flight Controllers, and Trainers, as well as key operations personnel supporting launch and landing. The contractor-developed Training System shall provide mission preparation in the form of CTS systems training and mission simulations including stand-alone, joint, and joint-integrated training with the ISS and MCC-CST. The contractor shall develop syllabi which reflect the experience level of the trainee and shall maintain appropriate training certifications consistent with CCT-STD-1150, Crew Transportation Operations Standards, and JSC 35089, Visiting Vehicle Operations Document. The contractor training syllabus shall be developed jointly with NASA's ISSP to ensure the timeline is consistent with the ISS training flow, and records of training shall be maintained in a Learning Management repository which shall be used to reflect personal training certifications. In addition to operations personnel, the contractor shall provide training events to develop Mission Management Team decision making skills.

The Contractor shall provide the required high fidelity CTS and ground facilities hardware, software, and data for interfacing with NASA, Software Development Integration Laboratory, and JSC Mission Control Center (MCC) to execute Joint spacecraft-ISS testing and Joint Multi-Segment Simulation Trainings (JMSTs).

The Contractor shall participate in Joint Multi-Segment Simulation Training (JMST) that includes flight controllers and crews participation and maintain the Training system to ensure that it meets the reliability needs of NASA.

### 3.3.4.3 Flight Operations

#### 3.3.4.3.1 Flight Operations

The Contractor shall provide end-to-end real-time flight operations necessary to support the CTS mission to ISS. The contractor shall provide the Mission Control facility (MCC-CST), ground software tools, and mission systems necessary to execute spaceflight operations.

(b) (4)

The contractor shall provide continuous flight following from the MCC-CST during non-quiet operations to ensure mission success and address in-flight anomalies which are beyond the capabilities of the flight crew to resolve. During quiet docked operations, the contractor shall provide on-call support to address issues and anomalies which arise, as well as support ISS anomalies which may lead to unscheduled operations (i.e. safe haven operations). The contractor shall provide all landing operations support (excluding off-nominal landings outside of nominal landing area) including CST systems or weather-based landing, i.e. go-no go decisions.

#### 3.3.4.3.2 Emergency Crew Search and Rescue Interface

The Contractor shall provide an operational interface and coordinate with the Government in the planning for emergency crew search and rescue services.

### 3.3.4.4 Ground Systems

The Contractor shall provide the ground operational resources necessary to support the CTS mission to ISS. The contractor shall build, process, integrate and operate the CTS for the mission

to the ISS. The contractor shall provide Ground Systems supporting facilities, support equipment, hardware, and software required for ground and flight operations. The contractor shall participate in Joint Multi-Segment Simulation Training (JMST) that includes flight controllers, flight crews, ground crews, and landing sites.

#### 3.3.4.4.1 Assembly Integration and Test (AIT) Facility and System

The Contractor shall perform vehicle (hardware and software) assembly, integration and end-to-end test at the contractor's facility or facilities. [REDACTED]

(b) (4)

The Contractor shall maintain and operate all mechanical and electrical ground support equipment (GSE) required supporting the AIT. The contractor shall perform vehicle integration and pre- and post-flight mission activities (e.g., fueling, cargo/crew loading, and recovery).

The Contractor shall provide all tooling required to support refurbishment of the Spacecraft elements. [REDACTED]

(b) (4)

#### 3.3.4.5 Ground Communication Systems

The Contractor shall maintain and operate a Ground Communications System that provides Space-to-Ground communications to the spacecraft from launch through landing. The contractor shall provide ground communications capability between recovery ground crews, flight crew, and mission control.

#### 3.3.4.6 Recovery Systems and Operations

The Contractor shall provide GSE, services, and equipment for nominal landing crew and crew module recovery. Services include: medevac evacuation, metrology forecasting, landing site maintenance, and landing site air traffic control/radar tracking.

#### 3.3.4.7 Logistics and Logistic Systems

The Contractor shall provide ground segment logistics activities to include (1) databases for shipping/receiving, sparring analysis/tracking, ground maintenance planning/scheduling, and limited life items, (2) packaging, handling, storage, and transportation.

#### 3.3.4.8 Ground Segment Test and Checkout

The Contractor shall conduct Ground Segment test and checkout. The integrated tests shall include the contractor's Mission Control Center (MCC), software integration facility, electrical GSE, ground communications networks, space communication networks, landing sites, Launch Control Center (LCC), and ISS Mission Control interfaces.

#### 3.3.5 PCM Cargo Integration

The Contractor shall safely integrate cargo into the spacecraft. The Contractor shall maintain and operate Ground Support Equipment (GSE) for physical cargo integration including nominal stow cargo, late stow cargo and post mission cargo extraction, for early destow and nominal destow.

### 3.3.5.1 Cargo Integration

The Contractor shall develop an internal cargo interface control agreement (ICA) in accordance with DRD 206, Internal Cargo Interface Control Agreement (ICA), for middeck lockers and for items planned to be hard-mounted in the spacecraft volume per DRD 204 MRAD.

The Contractor shall provide a spacecraft pressurized module physical configuration per DRD 204, MRAD, and any constraints related to manifest and return flexibility.

The Contractor shall document the cargo ground handling procedures and constraints.

The Contractor shall document discrepancies to hardware turned over to the Contractor and report those discrepancies to NASA within forty-eight (48) hours of identifying the discrepancy.

The Contractor shall affix bar code labels per the ISS Inventory Management System (IMS) standard to Commercial cargo that will be transferred from the spacecraft to the ISS and shall correlate IMS bar code numbers to stowage location data for all cargo flown and provide this data to NASA in accordance with the final DRD 204, MRAD.

The Contractor shall conduct power/data testing for all first time flown powered middeck lockers to ensure interface compliance.

The Contractor shall prepare and submit Integrated Cargo Phase III Hazard Report, DRD 207, per SSP 30599, ISS Safety Review Process, at L-4 months, to ensure the hazards associated with the packaging of the cargo complement have sufficient controls. The Contractor shall submit, as required, a delta Integrated Cargo Phase III Hazard Report, DRD 207, that represents the final integrated cargo hazard assessment. .

### 3.3.5.2 Return Cargo

The Contractor shall identify constraints to the on-orbit packing of cargo for return per the final DRD 204, MRAD. NASA will plan cargo transfers with Contractor coordination and in accordance with identified constraints while the spacecraft remains docked to the ISS. NASA will maintain the capability to adjust the return cargo complement within the identified constraints while the spacecraft remains mated to the ISS.

## 3.3.6 Inherent Capabilities

### 3.3.6.1 Contractor System Inherent Capabilities

The Contractor's inherent capabilities beyond the requirements in Attachment J-01, Integrated Crew Transportation System (CTS) Requirements that are added value to the Government as a result of the unique contractor's robust design and/or operational concept that enhances operational flexibility and/or mission performance are described in Table 3.3.6.1-1. The contractor shall perform the required planning and analyses to define the inherent capabilities in excess of requirements to accomplish each PCM and provide these capabilities to NASA in the MRAD, DRD 204, and update in accordance with Table 3.3.6.1-1.

**Table 3.3.6.1-1. Inherent Capabilities**

No.	Description of Contractor Inherent Capability	Notification Date (Decision Date)
(b) (4)		

No.	Description of Contractor Inherent Capability	Notification Date (Decision Date)
	<div style="background-color: black; color: red; padding: 5px;">(b) (4)</div>	

### 3.3.6.2 Coordination of Inherent Capabilities

The Contractor shall define and coordinate with the Government usage of the above noted (b) (4) that are available to the Government for each mission in accordance with Clause B.4, Post Certification Missions (IDIQ) (CLIN 002) and Clause H.23, Non-NASA Passengers, Cargo and Payloads.

### **3.4 Special Studies (CLIN 003)**

The Contractor shall provide engineering, logistics and related technical support functions for the CCtCap program as detailed and in accordance with the task ordering procedures in this contract, B.5 Special Studies Services (Indefinite Delivery Indefinite - IDIQ) (CLIN 003). Contractor shall perform special studies in support of this (CCtCap) contract/program as initiated by written direction from the Contracting Officer. These activities provide technical support to include but are not limited to:

- a) research, analysis and recommendations of Government provided what-if exercises;
- b) design, development, and test investigations/modeling/analyses/trade studies to provide further confidence and understanding of robustness of design, advance planning, or feasibility for development and certification activities;
- c) assessment of new/additional requirements/systems, software, or product improvements and impacts on the Contractor's design, schedule and cost as it relates to the CCtCap or lifecycle activities;
- d) new Training Aids, Devices, or training products development;
- e) analyses in support of change requirements to authorized missions;
- f) development, fabrication, and test of hardware or software to support planning studies, special tests, or mission-unique studies
- g) development, fabrication, test, certification and integration for unique cargo configurations, mounting equipment and support equipment