NNK14467515R

Commercial Crew Transportation Capability (CCtCap)

Performance Work Statement (Attachment J-03) Solicitation NNK14467515R

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INTRODUCTION

The purpose of the Commercial Crew Program (CCP) is to facilitate the development of a US commercial crew space transportation capability with the goal of achieving safe, reliable and cost- effective access to and from the International Space Station (ISS). The program includes spacecraft, launch vehicles, ground and mission systems.

NASA is using a two-phased acquisition to certify fully integrated crew transportation systems (CTS) that meet specified NASA safety and ISS requirements and standards, and begin missions to the ISS. Phase 1, the Certification Products Contract (CPC), requires delivery and disposition of specified early lifecycle plans and products that address CTS compliance with NASA's standards and requirements for an ISS design reference mission (DRM). The CPC deliverables mature in parallel with the CTS design. Phase 2, the Commercial Crew Transportation Capability (CCtCap) contract, includes the final design, development, test and evaluation (DDTE) activities necessary to achieve NASA certification of a CTS for the ISS DRM within CCT-DRM-1110. CCtCap culminates in NASA's certification of the CTS and the execution of post-certification missions (PCMs) transporting NASA crew to the ISS.

This Performance Work Statement (PWS) defines the work to be accomplished by SpaceX during CCtCap in support of certification of its CTS, the Dragon-Falcon 9 Crew System, and the performance of post-certification missions. SpaceX shall perform the services and deliver the products described in this PWS, in compliance with the contract terms and conditions and the requirements contained in the applicable documents, CTS Requirements, Data Requirements Descriptions (DRDs), and other plans and sections contained within the contract.

SCOPE

SpaceX shall complete the design, development, test, evaluation and certification of an integrated CTS capable of transporting NASA crew to and from the ISS, in accordance with the DRM and the certification standards and requirements specified in this contract under CLIN 001. The CTS is the collection of all space-based and ground-based systems (encompassing hardware and software) used to conduct space missions or support activity in space, including the integrated space vehicle (Dragon), space-based communication and navigation systems, launch systems (Falcon 9) and mission/launch control. Certification of the CTS shall be determined by NASA. SpaceX shall also provide complete, initial PCMs to and from the ISS including ground, launch, on-orbit, return and recovery operations, as ordered by IDIQ tasks under CLIN 002 of this contract. SpaceX shall provide special studies for risk reduction and other purposes related to its CTS, to the extent ordered under CLIN 003 of this contract.

SpaceX shall provide all facilities, resources, personnel, items or services necessary to perform the requirements specified in Section B, Supplies or Services and Prices/Costs (except for government-furnished property as listed in Clause G.6, NFS 1852.245-76, List Of Government Property Furnished Pursuant To FAR 52.245-1 and Government Furnished Services and Data as listed in Clause H.12) in accordance with the following:

- Attachment J-01, Integrated Crew Transportation System (CTS) Requirements.
- Attachment J-02, Data Requirement Deliverables (DRDs).
- Attachment J-03, Contract Performance Work Statement (PWS).
- Attachment J-03, Appendix A, Milestone Acceptance Criteria and Payment Schedule.

All CCtCap services require compliance with the governing regulations and laws affecting the procurement and execution of the contract. Compliance with applicable documents, CTS Requirements, and DRDs is mandatory. However, SpaceX’s use of alternative means and methods to meet these is acceptable, provided the same level of rigor and stringency is preserved and their alternate use or variance is approved by NASA.

1 MANAGEMENT

In close cooperation with NASA, SpaceX shall define, manage and implement technical management plans and processes associated with achieving and maintaining NASA certification and executing post-certification missions throughout the CTS life cycle in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes. The execution of these processes will ensure that the CTS is developed, produced and operated in a repeatable manner throughout the life cycle of the system.

SpaceX shall identify and implement a process to determine and mitigate the CTS safety risk to the lowest achievable level throughout the lifecycle and clearly communicate to NASA all associated mitigations and residual safety risk.

[redacted] (b) (4) [redacted] The following work statements under this Section 1, Management, are applicable to all CLINs related to this contract.

1.1 Government Insight and Technical Interaction

1.1.1 Government Insight

SpaceX and NASA shall establish and maintain cooperative relationships to facilitate successful NASA insight. The NASA insight team includes the Joint Test Team and Government Quality Assurance personnel as documented in the Insight Implementation Plan. NASA insight personnel shall be provided with timely notification and access to the full range of appropriate activities listed in CCT-PLN-1100, Appendix C, Insight Areas, as well as any additional activities listed in the Insight Implementation Plan.

SpaceX, through the insight team, shall give NASA electronic access to [redacted] (b) (4) [redacted] (b) (4) [redacted]. NASA insight personnel shall also have electronic access to [redacted] (b) (4) [redacted]. SpaceX shall accommodate designated NASA insight personnel, including members of the Joint Test Team, [redacted] (b) (4) [redacted]

This insight will provide NASA an understanding of SpaceX's activities and data through an effective working relationship, inspections and interactions, without approval or disapproval authority, and will provide information for the eventual certification approval.

The DRD 001 Insight Implementation Plan delivered with SpaceX's proposal is approved for use in performance of the contract until subsequent DRD delivery. SpaceX shall deliver and execute DRD 001 Insight Implementation Plan, in accordance with Clause H.15, Government Insight.

1.1.2 SpaceX - NASA Technical Interaction

SpaceX shall develop the operational products for mission planning and execution. For ISS integrated operations, SpaceX shall jointly develop with NASA the operational products and mission planning and joint execution.

SpaceX shall jointly develop with NASA a crew training template for CTS and ISS training (Reference DA8-13-193, Notional Training Template for ISS Crewmembers, dated October 31, 2013).

SpaceX shall develop and deliver data in accordance with DRD 114 Crew Transportation System (CTS) Data Input for NASA Integration and Independent Verification and Validation (IV&V).

SpaceX shall provide technical expertise and participate:

(a) In NASA evaluation and review of performance milestone deliverables at NASA Commercial Crew Program (CCP) Program Boards as defined in CCT-PLN-1000, Crew Transportation Plan. In support of issues related to Crew Transportation System (CTS) Certification, SpaceX may attend and support NASA Program Boards, as invited. SpaceX may also request a NASA Program Board to be convened in support of issues related to CTS Certification.
(b) In 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.
(c) In Visiting Vehicle Integration Manager (VVIM) forums for joint development of ISS integration products and execution of joint processes.
(d) In NASA Independent Verification and Validation (IV&V) activities.
(e) In the Integrated Safety Review Process defined in CCT-PLN-1120, Crew Transportation Technical Management Processes. SpaceX's participation shall include technical expertise in support of Phase Safety Reviews of Hazard Reports. The end 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 and can be delivered in accordance with DRD 110 Hazard Reports.
(f) In NASA/FAA/Range trilateral discussions representing their recommendations when crew safety and public safety risk considerations are assessed.

1.2 Program Management

SpaceX shall maintain and comply with the management processes, systems and data deliverables used for all contract CLINs throughout the life of the contract.

SpaceX shall follow the applicable standards, documents, requirements and processes as specified in Attachment J-01 Integrated Crew Transportation System (CTS), Table J01-1 and Table J01-2.

SpaceX shall document its project management process in a Project Management Plan in accordance with CCT-PLN-1120.

SpaceX shall maintain current DRDs and data deliverables as specified in Attachment J-02 Data Requirement Deliverables (DRDs).

SpaceX shall perform the following program management activities to meet mission objectives:

- System architecture definition.
- System design.
- System performance.
    - System technical baseline definition and maintenance.
- Capability validation.
- Risk/issue management.
- Integration and test.
- [redacted] (b) (4) [redacted]
- Interface management.
- Customer requirements verification.
- Tracking and reporting of contract performance.

1.2.1 Milestones, ISS Integration and Certification

The DRD 101 Milestone Review Plan delivered with SpaceX's proposal is approved for use in performance of the contract until subsequent DRD delivery.

SpaceX shall perform ISS integration in accordance with the intent of SSP 50964, Visiting Vehicle ISS Integration Plan.

SpaceX shall deliver and implement all plans listed in CCT-PLN-1120, Crew Transportation Technical Management Processes.

1.2.2 Performance and Progress Management

SpaceX shall conduct Quarterly Program Reviews (QPRs) with NASA and shall develop and deliver DRD 005 Quarterly Program Review Briefing Package prior to every QPR. The reviews shall provide insight into SpaceX's overall technical progress, schedule status, cost assessment, and plans forward. [redacted] (b) (4) [redacted]

SpaceX shall develop and deliver an Integrated Master Plan/Integrated Master Schedule in accordance with DRD 002 Integrated Master Plan & Integrated Master Schedule. SpaceX shall manage the execution of the program using the IMP/IMS. SpaceX shall report on the contract

progress in accordance with the IMP at each QPR. SpaceX shall provide NASA with monthly updates to the IMS following the monthly schedule review meeting conducted by SpaceX.

1.2.3 Information and Security Management

SpaceX shall develop and deliver DRD 003 Information Technology (IT) Security Management Plan and DRD 004 IT Security Plan in accordance with Clause I.2 NFS 1852.204-76, Security Requirements for Unclassified Information Technology Resources.

SpaceX shall develop and deliver an Export Control Plan in accordance with DRD 006 Export Control Plan.

1.2.4 Risk Management

SpaceX shall employ measures to maximize safety and protect the public, crew, personnel and property.

SpaceX shall identify, evaluate, manage and control the safety, technical, cost and schedule related risks throughout the CCtCap contract. SpaceX shall identify and address risks early enough to allow adequate time to develop and implement mitigations, thereby reducing both the likelihood a risk will occur and the cost of mitigation.

SpaceX shall manage risks in accordance with the SpaceX Risk Management Plan, which is consistent with NPR 8000.4A and CCT-PLN-1120 requirements.

Before each flight SpaceX shall ensure that:

- Risks are mitigated or accepted.
- Issues are dispositioned and accepted.
- [redacted] (b) (4) [redacted]
- Procedures are reviewed and baselined.
- Corrective actions are completed.

1.2.5 Safety and Mission Assurance

[redacted] (b) (4) [redacted]

SpaceX shall complete analyses in compliance with CCT-PLN-1120 to meet all requirements in CCT-REQ-1130 and SSP 50808. To meet these requirements SpaceX shall complete at a minimum:

- Failure modes, effects and criticality analysis.

- Hazard analysis.
- Probabilistic safety analysis.
- Software safety analysis.

SpaceX shall comply with all applicable Range requirements and deliver DRD 113 Range Safety Documentation.

SpaceX shall conduct a crew survivability analysis for all mission phases in accordance with CCT-PLN-1120.

1.2.6 Systems Engineering and Configuration Management

SpaceX shall perform all the basic components of systems engineering—including requirements analysis and verification, design environments specification and certification, interface control, integrated test and verification, design control, configuration management, risk management, and problem reporting and corrective action.

- **Requirements Management** – SpaceX shall track requirements in [redacted], a requirements management tool. ReqX shall track and trace all requirements in CCT-REQ-1130 and SSP 50808. (b) (4)
- **Verification** – SpaceX shall deliver and implement a Verification and Validation (V&V) Plan in accordance with DRD 108 Verification and Validation (V&V) Plan and CCT-PLN-1120. This plan shall detail the approaches for verifying requirement compliance. As relevant to specific requirements, the event descriptions in the plan shall also contain verification and validation of manufacturing operations, hardware and software qualification and acceptance testing programs, environmental testing, and validation of models and simulations. The plan shall address all requirements from SSP 50808 and CCT-REQ-1130. SpaceX shall deliver verification closure notices in accordance with DRD 111 Verification Closure Notices (VCN).
- **CCtCap Design and Engineering Review Process** – SpaceX shall follow a formal review process during CCtCap as shown in the milestones in Attachment J-03, Appendix A. This design review process shall be implemented as described in the Milestone Review Plan (DRD 101).
- **Configuration Management** - SpaceX shall implement configuration control processes in accordance with the SpaceX Configuration Management Plan, which meets AS9100C quality system requirements. The Configuration Management Plan shall ensure the configuration of all data products, regardless of their source location, is effectively managed with respect to each mission those data products are used within.
- **Design Change Management** - SpaceX shall manage the change process using a formal system for documenting, analyzing, discussing and approving proposed changes to all elements of SpaceX vehicles and elements directly interfacing with the vehicle, [redacted] (b) (4) SpaceX shall deliver

information to NASA regarding any change that has an impact on NASA contract requirements, hazard reports, vehicle performance or NASA certification via [redacted] (b) (4)

- **Performance Margins** – SpaceX shall track key vehicle budgets, performance parameters and performance margins.

1.2.7 Mission Assurance, Inspection and Surveillance

SpaceX shall use a comprehensive approach to mission assurance, inspection and surveillance [redacted] (b) (4) [redacted] (b) (4) [redacted] SpaceX shall maintain a Quality Management System that documents the controls and systems used for the design and development of hardware and software, supply chain management, manufacturing, assembly, integration, test, and operations. SpaceX also shall maintain a Quality Assurance Plan that documents the processes and procedures used to meet contract requirements and support the consistent delivery of high-quality, professional products and services.

1.2.8 Management of Launch Slots and Launch Windows

[redacted] (b) (4) [redacted]

1.3 Lifecycle Cost Management

SpaceX shall conduct Quarterly Program Reviews (QPRs) with NASA and shall develop and deliver DRD 005 Quarterly Program Review Briefing Package [redacted] every QPR. The reviews shall provide insight into SpaceX's overall technical progress, schedule status, cost assessment and forward plans. (b) (4) [redacted]

2 DESIGN, DEVELOPMENT, TEST AND EVALUATION (DDTE)/ CERTIFICATION OF THE COMMERCIAL CREW TRANSPORTATION SYSTEM (CTS) (CLIN 001)

SpaceX shall obtain NASA certification of a CTS that meets or exceeds the requirements in CCT-REQ-1130 and SSP 50808. SpaceX shall demonstrate compliance to the technical requirements by designing, developing, testing and evaluating an end-to-end system culminating in an agency review for approval to grant NASA certification. SpaceX shall establish a comprehensive development plan and approach, documented in DRDs 107, 108, and 109, that encompasses all effort necessary to achieve NASA certification of the CTS.

SpaceX shall implement the development plan, products, processes and schedule that support NASA certification and ISS integration.

SpaceX shall establish and utilize design, production, and operations standards that result in safe, reliable and usable end items and integrated system.

SpaceX shall produce a CTS such that each flight article and ground article, including software, is manufactured, assembled, and integrated in a repeatable manner that satisfies both SpaceX and NASA requirements.

SpaceX shall conform to NASA's standard requirements for operational planning, operational controls, training, and mission execution documented in CCT-STD-1150, SSP 50808, and other applicable documents listed in Table J01-1.

SpaceX shall operate a CTS such that execution of the flight tests and PCMs is within the constraints of the NASA certification and recurring ISS requirements. SpaceX planning activity is based on an assumed flight rate of two (2) flights per year to the ISS.

2.1 Design, Development, Test and Evaluation (DDT&E)

The major elements of DDT&E include the crew vehicle (Dragon), launch vehicle (Falcon 9), ground systems and operations, and mission systems and operations. These elements comprise the collection of all space-based and ground-based systems (encompassing hardware and software) used to conduct space missions or support activity in space.

2.1.1 Crew Vehicle – Dragon

SpaceX shall design, develop, test, evaluate and certify a Crew Dragon spacecraft that satisfies requirements in CCT-REQ-1130 and SSP 50808. The Dragon shall be capable of carrying out the DRM described in CCT-DRM-1110.

2.1.1.1 Dragon DDTE Activities

SpaceX shall perform the tasks required to design, develop, produce, test, and certify the Crew Dragon. Activities to be performed include the following:

Structural development and qualification, including:

- Secondary structure qualification (crew seats and restraints, hatches, propulsion mounting brackets).
- Thermal protection system qualification.
- Micrometeoroid and orbital debris (MMOD) protection design, testing and analysis.
- Mechanism qualification, including:

  [redacted] (b) (4) [redacted]

- Parachute qualification including margins in off-nominal conditions per testing requirements of JSC-65985.

- Propulsion system development and qualification, including:

  [redacted] (b) (4) [redacted]

- Thermal control system (TCS) development and qualification, including:

  [redacted] (b) (4) [redacted]

- Environmental control and life support system (ECLSS) development and qualification, including:

  [redacted] (b) (4) [redacted]

[redacted]

[redacted]

- Guidance, navigation, and control (GNC) systems development and verification, including:

[redacted]

- Dynamics development and verification.

[redacted]

- Flight software development and verification.

[redacted]

2.1.2 Launch Vehicle – Falcon 9

SpaceX shall modify the Falcon 9 system to provide all capabilities required for crew missions and to meet the requirements called out in CCT-REQ-1130, as necessary. All modifications shall be designed, developed, tested, evaluated and reviewed with NASA prior to the Design Certification Review [redacted]

- [redacted]

[redacted] Postflight data reviews shall be performed and postflight reports, including comparisons of model predictions to flight performance, shall be delivered to NASA for all CCtCap test flights and PCMs.

2.1.2.1 Falcon 9 DDTE Activities

Falcon 9 and the Crew Dragon shall perform as an integrated space vehicle from crew ingress through separation of the Crew Dragon vehicle. The safe and reliable operation of this integrated vehicle will be the focus of SpaceX's Falcon 9 DDTE activities. These activities shall include the following:

[redacted]

[redacted] (b) (4) [redacted]

2.1.3 Ground Systems and Operations

SpaceX shall provide all required assembly, integration, testing, transportation, storage and processing for the CTS for launch and post-landing operations. These activities include the planning, pre-launch processing, launch, and post-landing operations.

SpaceX shall build, integrate and test the Crew Dragon and Falcon 9 systems [redacted] (b) (4) [redacted] (b) (4) [redacted]

The production of the Crew Dragon and Falcon 9 shall occur on [redacted] (b) (4) [redacted] (b) (4) [redacted]

SpaceX shall modify launch pads and ground support facilities as required for crew operations. To accommodate the Crew Dragon configuration, the major upgrades to existing ground operations shall include the following:

[redacted] (b) (4) [redacted]

SpaceX shall ensure operational safety as documented in the Falcon 9 System Safety Program Plan, Falcon 9 Ground Operations Plan, and Missile Systems Pre-Launch Safety Package.

SpaceX shall conform to all applicable Range requirements along with NPR 8715.5A, Range Safety Flight Safety Program, and deliver DRD 113 Range Safety Documentation.

2.1.3.1 Ground Operations DDTE Activities

The safe, reliable and repeatable operation of the facilities, ground systems and operations supporting the launch of Crew Dragon and the integrated vehicle will be the focus of SpaceX's ground operations DDTE activities. These activities shall include the following:

- Production facility additions:

[redacted] (b) (4) [redacted]

- [redacted]
- Engine and structural test facility additions and test practices shall include: [redacted] (b) (4) [redacted]
- Adapt Launch Complex 39A systems for CTS launches, including: [redacted] (b) (4) [redacted]
- Modify/develop existing Falcon 9 systems for use at Launch Complex 39A, including: [redacted] (b) (4) [redacted]
- Augment Launch Control capabilities, including: [redacted] (b) (4) [redacted]
- Evaluate and update countdown processes and launch commit criteria, including: [redacted] (b) (4) [redacted]
- Develop training for ground operations personnel.

2.1.4 Mission Systems and Operations

Mission Operations encompasses flight operations from launch through landing and recovery. SpaceX's [redacted] (b) (4) [redacted]

Each Mission Operations team (Mission Operations, Flight Crew Operations, Training and Simulation, Ground Segment, Ground Software, and Recovery) is expected to achieve key developments during the CCtCap program. The ability to safely and successfully complete crew missions will be the focus of SpaceX's Mission Operations DDTE activities. These activities shall include the efforts and events described in the following subsections.

2.1.4.1 Mission Operations Development

SpaceX shall perform modifications to the existing Mission Operations system to accommodate the Crew Vehicle concept of operations. The major activities shall include the following:

- Present the end-to-end mature operations design and developed under CCiCap in the Delta-CDR, including detailed concept of operations and mission timeline.
- Develop and document a full set of operations policies, practices and processes for crew missions. SpaceX shall work with the NASA Joint Test Team to develop ground and crew procedures [redacted] (b) (4) [redacted] The final procedures shall cover nominal, contingency and emergency scenarios.
- Develop joint operations products (e.g., flight rules, operations interface procedures, coordination tables) in collaboration with NASA to cover every phase of flight.
- Upgrade the design and layout of the Mission Control center and Launch Control center and add additional console positions needed to support crew.
- Perform all necessary planning, analysis, testing and coordination to prepare for each of the flight tests and PCMs.
- Plan and execute joint mission simulations to validate architecture.

2.1.4.2 Flight Crew Operations Development

SpaceX shall develop Flight Crew Operations to accommodate the Crew Vehicle concept of operations. The major activities shall include the following:

- Complete detailed task analysis.
- Develop crew-specific and joint crew-ground procedures, voice protocols, and crew roles covering nominal and contingency scenarios for every mission phase.
- Engage in formal evaluations, testing and delivery for all crew provisions and emergency kit items.
- Design, build, test and evaluate the crew displays and controls in an iterative manner with NASA Joint Test Team participation.
- Evaluate manual control handling with NASA Joint Test Team participation.

NASA Joint Test Team personnel will participate in crew-in-the-loop planning, development, and evaluation activities, not just the ones explicitly mentioned above.

2.1.4.3 Training and Simulation Development

SpaceX shall perform modifications and development for Training and Simulation to accommodate the Crew Vehicle concept of operations. The major updates and activities shall include the following:

- [redacted] (b) (4)
- Develop a complete set of supporting training material for the remaining ground operators.
- Develop a complete set of supporting training material for the crew training plan including a detailed crew training schedule that accommodates other ISS assigned crew member training requirements.
- [redacted] (b) (4)
- Augment the operator certification database to accommodate the internal requirements for crew missions, both for ground operators and crew members.
- Train and certify individual operators and full operator shifts for the CCtCap test flights and PCMs. [redacted] (b) (4)
- Train and certify the crew aboard the ISS for each CCtCap test flight and PCM mission with regard to docking, cargo, and undocking operations. [redacted]
- Train and certify flight crews for each CCtCap test flight and PCM. [redacted]
- [redacted] (b) (4)
- 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 forty-eight (48) hours.

2.1.4.4 Ground Segment Development

SpaceX shall perform modifications to the existing Dragon-Falcon 9 ground segment to accommodate the Crew Vehicle concept of operations. The major upgrades and activities shall include the following:

- [redacted] (b) (4) [redacted]
- Assess and upgrade ground station network to meet CTS requirements.
- [redacted] (b) (4) [redacted]
- Conduct compatibility tests, including command and telemetry, between Dragon systems and both TDRSS and ground stations.
- [redacted] (b) (4) [redacted]
- Con[redacted]

2.1.4.5 Ground Software Development

SpaceX shall perform modifications to the existing Dragon-Falcon 9 ground software to accommodate the Crew Vehicle concept of operations. The major upgrades and activities shall include the following:

- [redacted]
- [redacted] (b) (4) [redacted]
- [redacted]
- [redacted]
- [redacted]
- Conduct end-to-end verification testing.

2.1.4.6 Recovery Development

SpaceX shall perform modifications to the existing Dragon-Falcon 9 recovery operations to accommodate the Crew Dragon concept of operations. The major upgrades and activities shall include the following:

- [redacted] (b) (4) [redacted]
- Select supported land landing sites, which in combination shall provide at least [redacted] entry and landing availability on any given day, on average, due to weather limitations based on historical data collected from 2004 to 2013 from weather stations nearest the sites.

- [redacted] (b) (4) [redacted]
- Develop procedures and conduct analysis to govern land-based spacecraft landings and recovery through the deorbit, entry, descent, landing and post-landing phases including response to contingencies at supported landing sites.
- Evaluate and design custom GSE where necessary to facilitate and optimize critical operations of crew recovery.
- Provide GSE, including communication equipment, recovery vehicles, (b) (4) [redacted] (b) (4) [redacted] the necessary assets to execute safe recovery operations. SpaceX shall meet all mission safety requirements, including providing paramedic and firefighting personnel support.
- Validate procedures and analysis (both nominal and contingency) on recovery hardware though testing, simulations, demonstrations, and training.

Search and Rescue Coordination

- SpaceX shall coordinate and work with Detachment-3 (Det-3), 45th Operations Group, US Air Force to cover all search and rescue operations related to the Crew Vehicle.
- SpaceX and Det-3 shall iterate to complete detailed procedures, design rescue hardware, develop hands-on experience with the vehicle, and prepare for contingency scenarios.
- [redacted] (b) (4) [redacted]
- SpaceX shall provide the information, lessons learned in previous experience, equipment, tools, and training to Det-3 in order to ensure the proper contingency support capability is prepared for each mission.
- [redacted] (b) (4) [redacted]
- To facilitate crew rescue, the Dragon capsule shall provide its GPS location and include visual aids for search and rescue forces.
- SpaceX shall provide training for the operation and include a combination of briefings, and hands-on familiarization. Demonstrations using flight-like articles shall be performed.

2.1.5 Interim Development Milestones

SpaceX shall perform the following milestones and associated DRD data package deliveries in compliance with Attachment J-03, Appendix A, Milestone Acceptance Criteria and Payment Schedule.

SpaceX shall deliver and implement a Milestone Review Plan in accordance with DRD 101 Milestone Review Plan. DRD 101 Milestone Review Plan delivered with Contractor's proposal is approved for use in performance of the contract until subsequent DRD delivery.

- Certification Baseline Review (CBR)
  SpaceX shall deliver the data described in DRD 102 Certification Baseline Review (CBR) Data Package in support of the Certification Baseline Review (CBR).

  SpaceX shall deliver and implement a Flight Test Plan in accordance with DRD 109 Flight Test Plan.

  SpaceX shall deliver the other DRD data packages associated with CBR as set forth in Attachment J-03, Appendix A, Milestone Acceptance Criteria and Payment Schedule.

- Design Certification Review (DCR).
  - DCR Interim Payment Milestones.
    - Initial Propulsion Module Testing Complete.
    - Avionics Test Bed Activation.
    - Delta Critical Design Review (dCDR).
    - Docking System Qualification Testing Complete.
    - Propulsive Land Landing Test Complete.
    - Launch Site Operational Readiness Review.
    - Flight Test Without Crew Certification Review.
    - ECLSS Integrated Test Complete.
    - Flight to ISS without Crew.
    - Parachute Qualification Complete.
    - Space Suit Qualification Testing Complete.
    - Launch Site Operational Readiness Review for Crew.
  - Formal change management shall be enforced for all vehicle components, subsystems, and systems at the conclusion of the Delta Critical Design Review Milestone, at the latest.

  SpaceX shall deliver the data described in DRD 103 Design Certification Review (DCR) Data Package in support of the Design Certification Review.

  SpaceX shall deliver a Certification Data Package in accordance with DRD 112 Certification Data Package.

  SpaceX shall deliver and implement a Certification Plan in accordance DRD 107 Certification Plan.

- Flight Test Readiness Review (FTRR)

SpaceX shall deliver the data described in DRD 104 Flight Test Readiness Review (FTRR) Data Package in support of the Flight Test Readiness Review.

- Operations Readiness Review (ORR) Activities

  SpaceX shall deliver the data described in DRD 105 Operations Readiness Review (ORR) Data Package in support of the Operations Readiness Review (ORR).

- Certification Review (CR) Milestone
  - CR Interim Payment Milestones.
    - Flight to ISS with Crew.

  SpaceX shall deliver the data described in DRD 106 Certification Review (CR) Milestone Data Package in support of the Certification Review (CR).

2.1.6 Approach to Docking with the ISS

[redacted] (b) (4) [redacted]

2.1.6.1 Docking System Certification Approach

SpaceX shall perform Docking Certification activities as required for crew operations, including the following:

- Conduct acceptance testing at the lowest functional levels on all elements.
- [redacted] (b) (4) [redacted]
- Certify the Dragon Docking System prior to the Flight to ISS without Crew milestone.

[redacted] (b) (4) [redacted]

SpaceX shall not require NASA to perform any docking system certification work for any SpaceX-specific application.

2.2 ISS Integration

SpaceX shall perform ISS integration in accordance with the intent of SSP 50964, Visiting Vehicle ISS Integration Plan.

SpaceX shall deliver CTS hazard reports in accordance with DRD 110 Hazard Reports. SpaceX shall present the hazard analysis to NASA ISS SRP and the CCP STRB in order to complete the phased safety review in accordance with SSP 30599. The phased safety review is complete after NASA approval of all hazard reports and completion of all verification items.

SpaceX shall deliver and implement a Certification Plan in accordance DRD 107 Certification Plan.

SpaceX shall deliver and implement a Verification and Validation (V&V) Plan in accordance with DRD 108 Verification and Validation (V&V) Plan.

SpaceX shall deliver verification closure notices in accordance with DRD 111 Verification Closure Notices (VCN)

Flight operations products relevant to the Flight to ISS without Crew milestone shall be delivered to support ISS integration and FOR, and shall include appropriate flight procedures, operations timelines, flight rules and training syllabi in accordance with CCT-STD-1150. Additional crew-specific flight operations products shall be delivered for ISS integration prior to the Flight to the ISS with Crew mission.

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2.3 Flight Tests

SpaceX shall execute two end-to-end flight tests during the DDTE and certification phase. The first flight test, a flight to ISS without crew, is an uncrewed mission to the ISS using the Crew Dragon-Falcon 9 system. The second flight test, a flight to ISS with crew, is a crewed mission to the ISS using the Crew Dragon-Falcon 9 system. As set forth below, SpaceX shall make applicable work statements from CLIN 002, Post Certification Missions, that are applicable to any crewed flight test(s).

2.3.1 Mission Planning Management and Execution

SpaceX shall perform mission planning, management and execution activities related to the flight tests. Mission planning, management and execution includes the plans, processes, schedules, reviews and products required to perform the flight design, analyses, and flight planning activities; flight products and procedure development; and execution of the two flight tests. SpaceX shall deliver DRD 201 Mission Integration and Operations Management Plan (MIOMP). This document outlines the overall approach to managing and executing Crew Dragon-Falcon 9 missions to the ISS. The Baseline MIOMP shall be submitted as a formal deliverable 45 days prior to the Certification Baseline Review (CBR). SpaceX shall deliver updated MIOMPs as required and the Final MIOMP no later than 12 months prior to the Flight Test without Crew.

2.3.2 Mission Milestones

SpaceX shall complete the mission milestones as defined below for both of the flight tests. All milestones and associated DRDs shall be planned and tracked in the Integrated Master Schedule (IMS).

- **Post Qualification Review (PQR)** – At approximately 4 months prior to each of the flight tests, SpaceX shall complete ISS Integration and participate in the PQR.
- **ISS Stage Operational Readiness Review (SORR)** – At approximately three (3) weeks prior to launch (L-3 wk.), SpaceX shall participate in the ISS SORR and provide, at a minimum, the following via data and presentation:
    - Status of integration of CTS, cargo, and crew (if applicable).
    - Planned launch windows and available back-up opportunities; planned mission profile and activities including any special operations.
    - CTS propellant and power budget (nominal and margins) and associated loiter capability.

  - Crew consumables budget (nominal and margins) for free flight phases (if applicable).
  - Summary of all open work and closure plan.
  - Summary of all risks or watch items including mitigation plans and/or acceptance rationales that may affect the ability of the crew member(s) or spacecraft to complete the mission.
  - Operations support readiness (facilities, tools, processes, products, personnel) for all phases of the mission.
- **Flight Readiness Review (FRR) –** At approximately two (2) weeks prior to launch (L-2 wk.), SpaceX shall host an FRR with NASA participation. In this review, SpaceX shall verify that all critical items required to proceed into the final launch countdown are ready. NASA will provide go/no-go concurrence at the FRR for SpaceX to conduct the flight test.
- **Undocking Readiness Review –** At approximately two (2) weeks prior to landing, SpaceX shall participate in an Undocking Readiness Integrated Management Team (IMT) and, at a minimum, provide:
  - Planned landing windows, available backup opportunities, weather report.
  - Cargo to be returned.
  - CTS resources margins.
- **Post Flight Reviews (PFRs) –** SpaceX shall conduct PFRs with NASA participation to assess mission success with supporting data in accordance with DRD 209 Post Flight Assessment (PFA) Report and the following:
  - The initial PFA shall be delivered no later than 14 days after docking with the ISS. The first PFR shall be held at approximately the same time.
  - The final PFA shall be delivered no later than 30 days after landing. The final PFR shall be held at approximately the same time.

2.3.3 Mission Integration

SpaceX shall ensure the safe integration and transport of crew and/or cargo to and from the ISS during the flight tests. SpaceX shall put in place and support integration and operations processes for the entire mission from prelaunch to postlanding. SpaceX shall integrate the crew and/or 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 as applicable. The reviews and deliverables listed below will incrementally mature the mission design, cargo manifest and configuration, structural and environmental analyses, mission success criteria, operations and crew training, Federal and range safety documentation, ISS Safety Assessments and overall flight readiness.

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Hazard Reports, DRD 110. SpaceX shall deliver CTS hazard reports in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes, and DRD 110 Hazard Reports to ensure that hazards inherent to the design have been identified and that controls and verification methods have been implemented. SpaceX shall present the hazard analysis to NASA ISS SRP and the CCP STRB in order to complete the phased safety review in accordance with SSP 30599. The phased safety review is complete after NASA approval of all hazard reports and completion of all verification events used to verify hazard controls.

Verification Closure Notices, DRD 111. SpaceX shall deliver verification closure notices in accordance with DRD 111, Verification Closure Notices (VCNs). SpaceX shall meet all applicable SSP 50808 and CCT-REQ-1130 requirements and deliver verification rationale and evidence to show compliance with all these space station, crew safety and vehicle requirements.

Range Safety Documentation, DRD 113. SpaceX shall comply with all applicable Range requirements and shall deliver copies of all Range Safety documentation to NASA, including nonconformance requests in accordance with DRD 113.

CTS Data Input for NASA Integration and Independent Verification and Validation, DRD 114, as applicable. SpaceX shall provide insight, data, and support to meet the requirements of DRD 114 and ensure NASA has sufficient engineering data to do independent technical analysis.

Vehicle Interface Definition Document (IDD), DRD 203. SpaceX shall provide a vehicle IDD and instrumentation plan in accordance with DRD 203. SpaceX shall measure and provide telemetry data confirming that the required launch, entry, and orbit conditions and cargo environments were met as stated in DRD 203 Vehicle IDD. The Baseline IDD shall be submitted as a formal deliverable 45 days prior to the Certification Baseline Review (CBR). SpaceX shall deliver updated IDDs as required, including the Final IDD for the Flight Test without Crew no later than L-12 months and the Final IDD for the Flight Test with Crew at L-18 months.

Mission Resource Allocation Document (MRAD), DRD 204. SpaceX shall complete required mission specific analysis to ensure mission safety and success and deliver for each flight the Mission Resource Allocation Document (MRAD) in accordance with DRD 204 Mission Resource Allocation Document (MRAD). SpaceX shall incorporate the NASA provided pressurized cargo complements, if there is cargo on the test flights, into the MRAD and use the complements to develop the preliminary and final cargo configurations [redacted] (b) (4) [redacted] (b) (4) [redacted] Some configurations or changes may not be allowed to ensure the safety of the vehicle. Coupled loads analysis and integrated thermal analysis shall be run for the initial and delta MRADs. The MRAD confirms compliance with environments defined in the Vehicle IDD and applicable requirements outlined in SSP 50808 and CCT-REQ-1130. The initial MRAD shall be delivered at L-10 months, the delta MRAD shall be delivered at L-3 months, and the final MRAD shall be delivered at L-1 month.

CAD Models, DRD 205 and Mass Properties Reports. SpaceX shall submit spacecraft engineering computer-aided design models for each of the test flights in accordance with DRD 205 Spacecraft Computer Aided Design (CAD) Models. The Baseline CAD model shall be submitted as a formal deliverable 45 days prior to the Certification Baseline Review (CBR). SpaceX shall deliver updated CAD models as required and the Final CAD model no later than 13 months prior to each of the Flight Tests (with and without Crew). If laser scanned correlated CAD models are required, those shall be delivered after the Crew Dragon vehicle ships to the launch site. Additionally, SpaceX shall provide mass properties reports in accordance with the MRAD and IMS.

Imagery and Associated Cataloging, DRD 210. SpaceX shall submit CTS imagery in accordance with DRD 210 Imagery and Associated Cataloging. The imagery plan shall be submitted no later than L-6 months for each test flight.

2.3.4 CTS Integration

CTS integration shall be achieved in multiple stages, with rigorous testing at various phases.

Licenses - SpaceX shall provide technical expertise and participate in NASA/FAA/Range trilateral discussions representing their recommendations when crew safety and public safety risk considerations are assessed. SpaceX shall obtain all other required support services, permits, and licenses that are necessary to execute the mission. These may include Department of Transportation permits and Federal Communications Commission licenses.

Launch Site Processing Operations - SpaceX shall provide launch infrastructure at LC-39A that will be expanded to meet the needs of the CTS. The launch site infrastructure shall include dedicated ground support equipment, personnel, facilities and processing procedures to ensure safe missions to the ISS. The launch site facilities and operations shall support the following functions:

- Crew familiarization and training (only for the flight to ISS with crew).

- Crew flight processing (only for the flight to ISS with crew).
- Vehicle and cargo receiving inspection.
- Integration and storage areas, and all associated tooling.
- Post-shipping checkouts to verify the integrity of the avionics, propulsion, TCS, RF and ECLSS systems.
- Final mate of the capsule and trunk.
- Final closeout inspections.
- Crew interface operations (only for the flight to ISS with crew).
- ISS integration, as-built inspections.
- Crew equipment interface testing (CEIT) (only for the flight to ISS with crew).
- (b) (4) load readiness review.
- Consumables load (b) (4)
- Flight and launch readiness reviews.
- Final Crew Dragon mate to Falcon 9.
- Terminal countdown demonstration test (TCDT) (only for the flight to ISS with crew).
- Static fire.
- Crew and cargo turnover and load onto vehicle, if required.
- Launch.

Recovery Site Processing Operations - SpaceX shall provide primary and alternate landing support for both of the test flights. For the flight to ISS with crew, SpaceX shall provide the following services at the landing site:

- (b) (4)
- Perform crew extraction.
- (b) (4)
- Remove and inventory any time-critical cargo and turn over to NASA.

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

Range Support Services - SpaceX follows all Range requirements and protocol, and provides documentation to NASA according to DRD 113. SpaceX shall work with the Range to meet CTS needs in the following areas:

- Range scheduling.
- Tracking and flight termination.
- Telemetry.
- Imagery.

- Weather.
- Explosives storage.
- SCAPE (self-contained atmospheric protective ensemble) suits.
- Helium and nitrogen pipeline commodities.

Launch and Landing - SpaceX shall perform advance launch, rendezvous and entry opportunity studies, considering all relevant factors, including ISS trajectory projections and scheduled reboost activities, ISS visiting vehicle schedules, ISS crew and cargo manifest constraints, and specific landing sites.

Flight Imagery - SpaceX shall submit CTS imagery in accordance with DRD 210 Imagery and Associated Cataloging. Prior to launch, a pre-flight imagery plan shall be used to capture orbital vehicle, cabin layout, crew interfaces, instrumentation and pressurized cargo. The imagery plan shall be delivered at L-6 months.

Telemetry - SpaceX shall measure and provide telemetry data confirming that 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.

2.3.5 Crew Integration

For the flight to ISS with crew, SpaceX shall use the mission integration process, including certification and mission milestone reviews to prepare for crew and cargo integration with the Dragon-Falcon 9 Crew System.

Crew Integration - SpaceX shall develop plans to safely and effectively train and prepare the crew for flight.

- **Crew Training -** SpaceX shall provide a comprehensive training program to prepare NASA crew members for each mission. SpaceX shall provide general training to all crew members, including mission and systems familiarization, nominal and off-nominal crew procedures, space suit operations, monitoring and crew-commanding of ascent aborts, and nominal and emergency Dragon post-landing and pad ingress/egress. SpaceX shall provide syllabi, training materials, simulations, crew cabin task training, and certification for the crew training program.
    - SpaceX 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. Details of the crew integration process, training, CEIT, and TCDT shall be outlined in the MIOMP.

  - SpaceX shall participate in Joint Multi-Segment Simulation Training (JMST) that includes flight controllers and crew participation.
  - SpaceX 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).
- **Crew Flight Processing -** SpaceX shall assist in crew ingress on the launch pad and egress at the recovery site. SpaceX shall meet applicable landing, egress, and additional crew supplies requirements levied by CCT-REQ-1130.
- **Contractor Crew Operations of the CTS -** If there are contractor crew members on the Flight to ISS with Crew mission, SpaceX 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.

2.3.6 Cargo Integration

If cargo is to be flown on either of the test flights, SpaceX shall perform the tasks outlined in this section.

SpaceX shall provide a spacecraft pressurized module physical configuration per DRD 204 MRAD and any constraints related to manifest and return flexibility. SpaceX shall identify constraints to the on-orbit packing of cargo for return per the final DRD 204 MRAD. NASA will maintain the capability to adjust the return cargo complement within the identified constraints while the spacecraft remains mated to the ISS. NASA will plan cargo transfers with SpaceX coordination and in accordance with identified constraints while the spacecraft remains docked to the ISS.

Prior to cargo integration, SpaceX shall develop an internal cargo interface control agreement 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 Baseline ICA template shall be submitted as a formal deliverable 45 days prior to the Certification Baseline Review (CBR). Baseline cargo-specific ICAs will be delivered no later than L-12 months, and final ICAs will be submitted no later than L-8 months. SpaceX shall document the cargo ground handling procedures and constraints in the ICAs and/or integration procedures.

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

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

final integrated cargo hazard assessment provided to NASA. SpaceX shall present the Cargo Phase III hazard analysis to NASA in order to complete the phased safety review in accordance with SSP 30599 with both the ISS SRP and the CCP STRB. The safety review is complete after NASA has approved all cargo hazard reports and completion of all verification items used to verify controls for cargo hazards.

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

SpaceX shall affix their 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.

SpaceX shall safely integrate cargo into the spacecraft.

3 CERTIFICATION MATURITY

The Insight Implementation Plan (DRD 001), which was delivered with SpaceX's proposal, shall ensure effective and extensive technical interaction between SpaceX and NASA during CCtCap. An updated version of the Insight Implementation Plan shall be delivered at CBR.

At CBR, SpaceX also shall deliver documentation of previously approved variances and alternate standards incorporated or tailored in requirements, the DRD 108 Verification and Validation (V&V) Plan, and the DRD 107 Certification Plan.

SpaceX shall deliver DRD 110 Hazard Reports at the Design Certification Review. SpaceX also shall deliver any new, open or changed DRD 110 Hazard Reports at the Operations Readiness Review.

3.1 PWS Additions in Response to CPC Final Technical Summary Report

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4 POST-CERTIFICATION MISSIONS (CLIN 002)

SpaceX shall build, process, integrate and operate the CTS for the mission to the ISS. SpaceX shall conduct PCMs, including all activities from production, integration, and mission planning through safe recovery of the crew and postflight assessment, which shall include any unplanned events and in-flight anomalies. The approach for PCM planning and execution shall be repeatable with the lowest achievable safety risk. CCT-STD-1150, SSP 50808, and JSC 35089 define the preflight and mission planning and integration processes, standards and products that NASA uses for PCMs to ISS. SpaceX's processes defined in support of this objective shall satisfy CCT-PLN-1120 and define the expected mission integration rhythm, handover points, and roles of the SpaceX team.

SpaceX shall maintain NASA certification of the CTS for all PCMs. Design, production, or operational changes from the NASA certification baseline shall be reviewed for their effect on compliance to the requirements of CCT-REQ-1130 and SSP 50808. System performance from previous production, operation or flights also shall be reviewed for the potential effects on the NASA certification.

4.1 Mission Planning Management and Execution

SpaceX shall perform mission planning, management and execution activities. Mission planning management and execution includes the plans, processes, schedules, reviews and products required to perform the flight design, analyses and flight planning activities; flight products and procedure development; and execution of at least two (2) PCMs.

SpaceX shall deliver DRD 201 Mission Integration and Operations Management Plan (MIOMP) and DRD 202 Post Certification Mission (PCM) Work Plan. These documents outline the overall approach to managing and executing PCMs. SpaceX shall ensure that the interdependencies between the ongoing core certification effort and post-certification mission objectives are addressed in its development plan and mission execution planning.

4.1.1 Mission Milestones

SpaceX shall complete the mission milestones defined below. These milestones include reviews with NASA as well as performance-based milestones. SpaceX shall deliver and maintain the PCM Work Plan (DRD 202), which shall establish the planning, acceptance criteria, and execution of each milestone. SpaceX will ensure that there is adequate time for NASA-SpaceX interaction, adhere to our action item resolution process, and apply lessons learned from previously held mission reviews. All milestones and associated DRDs shall be planned and tracked in the Integrated Master Schedule (IMS). The PCM mission milestones are listed below along with their completion and acceptance criteria.

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- **Vehicle Baseline Review (VBR)**

  At no later than 18 months prior to launch (L-18 mo.), SpaceX shall co-chair a Vehicle Baseline Review (VBR) with NASA 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 identify any design or operation changes from the previous baseline and the corresponding plans for executing and verifying these changes. The content for the VBR shall include:

  - Mission Baseline CTS

SpaceX shall, at this review:

- Baseline the post-certification mission objectives, to include crew and cargo complement, and associated baseline CTS configuration, including ground accommodation specific interfaces and service agreements, so that mission integration efforts have definite configuration, environments and performance capabilities identified.
- Reconfirm the launch window as defined per Clause H.20, Adjustments to Post Certification Mission Schedule.
- Provide, if necessary, an updated DRD 201 Mission Integration and Operations Management Plan (MIOMP) and if necessary, an updated DRD 202 Post Certification Mission (PCM) Work Plan.
- Provide, as required, an update to DRD 203 Vehicle Interface Definition Document (IDD) and the mission-specific instrumentation plan for the Vehicle Interface Definition Document (IDD).
- Provide, as required, an update to DRD 205 Spacecraft CAD Models.

o <u>Design and Operation Changes From Prior Mission Baseline CTS</u>

SpaceX shall, at this review:

- Identify any design and operation changes from the previous mission baseline CTS.
- Identify all CCT-1100 series and SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD), requirements that require re-verification and have been allocated to the appropriate system, subsystem and/or component level. Demonstrate requirements flow down is adequate to verify compliance with CCT-1100 series and SSP 50808.
- Identify any hazards, controls, or verifications that are affected by design changes.
- Discuss analyses and tests to be performed to execute these designs and operation changes and include their methodology, assumptions and results, along with comparisons to any similar proven designs.
- Show how these changes affect performance, reliability and environments and associated risks.
- Discuss how previous in-flight anomaly (IFA) and previous production non-conformances affect the mission baseline.
- Present the status or results of any mission-unique or special study task assessments requested by NASA.

- Provide a schedule to complete all work required to accomplish the design changes and close requirement verifications prior to the Mission Certification Review (MCR).
- Provide updates to design margins (spacecraft and launch vehicle) if margins changed.
- Identify updates to the overall system architecture including ground accommodation specific interfaces and service agreements.
- Identify any mission-unique and unproven processes, risks and mitigation plans.
- Present the operations concept to satisfy mission objectives.
- Identify updates to operational products, personnel certification, facilities changes, and provide any scope and/or schedule changes for crew training.
- Status crew-related items to be proposed by SpaceX in the MIOMP.

VBR acceptance criteria:

[redacted]

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- **Mission Integration Review (MIR)**

At no later than (NLT) thirteen (13) months prior to launch (L-13 mo.), SpaceX shall co-chair a Mission Integration Review (MIR) with NASA with a current mission integration status. NASA and Contractor will review and baseline the conditions and inputs for

mission specific analytical assessments. SpaceX 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:

- Mission Baseline CTS

  SpaceX shall, at this review:

  - Reconfirm the launch window as defined in Table H.20.1, Launch Windows for PCM ATP Prior to ISS DCR, or defined in Table H.20.2, Launch Windows for PCM ATP after ISS DCR, per Clause H.20, Adjustments to Post Certification Mission Schedule.
  - Provide, as required, an update to DRD 203 Vehicle Interface Definition Document (IDD) and an update to the mission specific instrumentation plan for the Vehicle Interface Definition Document (IDD).
  - Provide initial data and parameters for Mission Success Determination per Clause H.21, Post Certification Mission Success Determination.
  - Provide, if necessary, an updated DRD 201 Mission Integration and Operations Management Plan (MIOMP) and if necessary, an updated DRD 202 Post Certification Mission (PCM) Work Plan.

- Design Changes From Prior Mission Baseline CTS

  SpaceX shall, at this review:

  - Present designs and their supporting analyses that implement mission-unique requirements.
  - Present progress in manufacturing and lay out remaining milestones and risks to accomplishing them.
  - Present progress towards closure of CCT-1100 series and SSP 50808 requirements, and lay out remaining milestones and risks to accomplishing them.
  - Present progress of ISS integration and integrated safety hazard assessments. Integrated safety analysis identifying any remaining hazards and proposed resolution per CCT-PLN-1120 Section 4.5, Integrated Safety Review Process.
  - Present progress for changes identified at VBR for:
    - The overall system architecture including ground accommodation specific interfaces and service agreements.
    - Mission-unique and unproven processes, risks and mitigation plans.

- Operational products, including personnel certification, facilities and crew training.

- Discuss how technical problems and anomalies have been resolved and effects of design changes on system performance, reliability and safety.
- Discuss how simulations and prototyping results for CTS do not present any potential mission risks.
- Present defined test plans for CTS.
- Status crew related items to be proposed by SpaceX in the MIOMP.

MIR acceptance criteria:

[redacted]

(b) (4)

- **Mission Certification Review (MCR)**
  After NASA certification has been granted, and no later than four (4) months prior to launch (L-4 mo.), SpaceX shall co-chair with NASA a Mission Certification Review (MCR) that allows NASA to assess if SpaceX has completed certification of all requirements, has completed ISS integration, has all infrastructure, facilities, personnel and services in place, and will be ready for the mission and for crewed operations, including agreement on cargo turnover and crew handover. A status of all open items presented in both the VBR and MIR shall be presented at this review. All mission-unique design qualification and acceptance testing shall be complete. For open items, schedule plans for completion shall be presented. All milestones to this point shall have been met.

SpaceX shall, at this review:

- Reconfirm the launch window as defined in Table H.20.1, Launch Windows for PCM ATP Prior to ISS DCR, or defined in Table H.20.2, Launch Windows for PCM ATP after ISS DCR, per Clause H.20, Adjustments to Post Certification Mission Schedule.
- Provide the final specific mission instrumentation plan and an update, as required, to DRD 203 Vehicle Interface Definition Document (IDD).
- Present evidence of verification closures for mission-unique designs and requirements.
- Present evidence of verification closures for all open CCT-1100 series and SSP 50808 requirements.
- Provide all analytical assessments that show the compatibility of crew and cargo mass, when applicable, with the launch and spacecraft such as integrated loads, Launch to Activation thermal assessments, electromagnetic interference (EMI), propellant resources and power.
- Present status of all anomalies and associated corrective actions showing low-risk closure plans in place to completion prior to ISS Stage Operational Readiness Reviews (SORR) / Flight Readiness Review (FRR).
- Present evidence that all Safety Assessments have been approved by NASA.
- Present evidence that all open items in both the VBR and MIR have been closed or present plans showing low risk to completion prior to SORR / FRR.
- Provide final data and parameters for mission success determination.
- Reach agreement on NASA-identified Launch Commit Criteria (LCC) constraints concerning CTS, ISS, crew and cargo.
- Present evidence that all operational products, plans, processes and training are complete or present plans showing low risk to completion prior to SORR/ FRR.
- Define the post-flight data for review.
- Present status of crew-related items to be proposed by SpaceX in the MIOMP.
- Present status of acceptance testing (launch vehicle and spacecraft).

<u>MCR acceptance criteria:</u>

(b) (4)

- Analytical assessments show compatibility of crew and cargo with the Crew Dragon resources (mass, thermal, loads, EMI, propellant, power).
- Anomalies and associated corrective actions have low-risk closure plans in place before FRR.
- All safety assessments have been approved by NASA.
- All open items for VBR and MIR have been closed or have plans in place showing low risk of non-completion prior to FRR.
- Final data and parameters for mission success determination have been provided.
- Agreement on NASA-identified launch commit criteria (LCC) constraints has been reached.
- Operational products, plans, processes and training have been completed or there are plans showing low risk of non-completion before FRR.

[redacted] (b) (4)

At approximately three (3) weeks prior to launch (L-3 wk.), SpaceX shall participate in the ISS Stage Operational Readiness Reviews (SORR) and provide, at a minimum, the following via data and presentation:

- Status of integration of CTS, cargo, and crew.
- Planned launch windows and available back-up opportunities; planned mission profile and activities including any special operations.
- CTS propellant and power budget (nominal and margins) and associated loiter capability.
- Crew consumables budget (nominal and margins) for free flight phases.
- Summary of all open work and closure plan.
- 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 their mission.
- Operations support readiness (facilities, tools, processes, products, personnel) for all phases of the mission.

- **Flight Readiness Review (FRR)**

At approximately two (2) weeks prior to launch (L-2 wk.), SpaceX shall support the NASA Flight Readiness Reviews (FRRs). SpaceX shall provide a mission-specific DRD 208, Flight Readiness Review Data Package in support of the FRR. This support will confirm the following:

- All critical items required to proceed into final launch countdown are ready.
- All CTS systems have been verified for launch.

- All previously held Contractor readiness review actions have been closed or resolved.
- Launch Site, Range, FAA, and recovery support organizations have committed to launch.
- Tracking and data support resources have committed to launch.
- Any open work or constraints to launch are identified, and closeout plans and schedules are in place and supportable.
- Residual mission risks are known, documented, and presented for acceptance.
- Operational elements are ready to support all phases of the mission.

FRR acceptance criteria:

[redacted]

(b) (4)

- **Undocking Readiness Review**
  At approximately two (2) weeks prior to landing, SpaceX shall participate in an Undocking Readiness Integrated Management Team (IMT) and, at a minimum, provide:
  - Planned landing windows, available backup opportunities, and weather report.
  - Cargo to be returned.
  - CTS resources margins.

- **Post Flight Reviews (PFR)**
  SpaceX shall conduct post flight reviews (PFRs) with NASA participation to assess mission success with supporting data in accordance with DRD 209 Post Flight Assessment (PFA) Report.
  - The initial PFA shall be delivered no later than 14 days after docking with the ISS. The first PFR shall be held at approximately the same time. The Launch and Docking payment milestone is tied to this initial PFR and the meeting of Mission Success Criteria from pre-launch through crew ingress to the ISS.
  - The updated PFA shall be delivered no later than 14 days after landing. The final PFR shall be held at approximately the same time. The Post Flight Review payment milestone is tied to this final PFR and meeting Mission Success Criteria from crew ingress on ISS through end of mission.
  - The final PFA report shall be delivered to NASA no later than 60 days after landing.

PFR acceptance criteria:

[redacted] (b) (4) [redacted]

4.1.2 Mission Schedule

SpaceX shall complete all required mission and interim performance milestones, as well as the associated DRDs to demonstrate progress and readiness for operational crewed missions to the ISS. SpaceX shall develop and deliver an Integrated Master Plan/Integrated Master Schedule in accordance with DRD 002 Integrated Master Plan & Integrated Master Schedule. All PCM activities, reviews and products shall be scheduled and tracked in the Integrated Master Schedule (IMS) throughout the entire mission cycle. The DRD 202 PCM Work Plan shall list all scheduled milestones, payment milestones and completion criteria for each milestone. The PCM Work Plan, updated IMP and IMS shall be delivered for the first time prior to PCM ATP. The IMS shall be maintained and updated by SpaceX and delivered to NASA on a monthly basis.

SpaceX shall be able to execute PCM mission integration milestones concurrently with DDTE and certification. Additionally, SpaceX shall be able to manage, build and integrate up to the maximum allowable six PCMs at a flight rate of no more than two missions per year.

4.1.3 Mission Integration

SpaceX shall ensure the safe integration and transport of crew and cargo to and from the ISS. SpaceX shall put in place and support integration and operations process for all post-certification missions. SpaceX 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. The mission integration and analysis process shall be structured by a series of reviews and deliverables implemented by NASA, SpaceX and cargo hardware providers. These reviews and deliverables will incrementally mature the mission design, cargo manifest and configuration, structural and environmental analyses, mission success criteria, launch window definition, operations and ISS crew training, Federal and range safety documentation, ISS Safety Assessments and overall flight readiness. The process shall begin at ATP, and end with the final postflight assessment report being submitted 60 days after landing.

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Mission Integration Reviews. SpaceX shall host a number of major program reviews throughout the [redacted] leading up to each PCM in order to review and discuss in detail the vehicle baseline design, mission integration status, certification status and ultimately flight readiness.

Mission DRDs and Analysis. SpaceX shall deliver all associated PCM DRDs and documentation to support mission integration and demonstrate progress as listed below:

Hazard Reports, DRD 110. SpaceX shall deliver CTS hazard reports in accordance with CCT-PLN-1120, Crew Transportation Technical Management Processes, and DRD 110 Hazard Reports to ensure that hazards inherent to the design have been identified and that controls and verification methods have been implemented.

Verification Closure Notices, DRD 111. SpaceX shall deliver verification closure notices in accordance with DRD 111, Verification Closure Notices (VCNs). SpaceX shall meet all SSP 50808 and CCP-REQ-1130 requirements and deliver verification rationale and evidence to show compliance with all these space station, crew safety and vehicle requirements.

Certification Data Package, DRD 112. SpaceX shall deliver a certification data package in accordance with CCT-PLN-1120 and DRD 112 that provides supporting evidence to show that the system meets all operational and design technical requirements.

Range Safety Documentation, DRD 113. SpaceX shall comply with all applicable Range requirements and shall deliver DRD 113 Range Safety Documentation to NASA, including nonconformance requests in accordance with DRD 113.

CTS Data Input for NASA Integration and Independent Verification and Validation, DRD 114. SpaceX shall provide insight, data and support to meet the requirements of DRD 114 and ensure NASA has sufficient engineering data to do independent technical analysis.

Mission Integration and Operations Management Plan (MIOMP), DRD 201. SpaceX shall deliver the MIOMP in accordance with DRD 201 MIOMP.

PCM Work Plan, DRD 202. SpaceX shall deliver the PCM Work Plan to establish mission milestones in accordance with DRD 202. Additionally, SpaceX shall use the PCM Work Plan to define launch windows.

Vehicle Interface Definition Document (IDD), DRD 203. SpaceX shall provide a vehicle IDD and instrumentation plan in accordance with DRD 203. SpaceX shall measure and provide telemetry data confirming that the required launch, entry, and orbit conditions and cargo environments were met as stated in DRD 203 Vehicle IDD. The IDD instrumentation plan shall include a detailed listing and description of all measurements and calibration coefficients. Additionally, SpaceX shall document the model requirements for cargo thermal and structural models in the Vehicle Interface Definition Document (IDD).

Mission Resource Allocation Document (MRAD), DRD 204. SpaceX shall complete required mission-specific analysis to ensure mission safety and success and deliver for each flight the Mission Resource Allocation Document (MRAD) in accordance with DRD 204 Mission Resource Allocation Document (MRAD). SpaceX shall incorporate the NASA-provided pressurized cargo complements into the MRAD and use the complements to develop the preliminary and final cargo configurations. [redacted] (b) (4) [redacted] (b) (4) [redacted] Some configurations or changes may not be allowed to ensure the safety of the vehicle. Coupled loads analysis and integrated thermal analysis shall be run for the initial and delta MRADs. The MRAD confirms compliance with environments defined in the Vehicle IDD and requirements outlined in SSP 50808 and CCT-REQ-1130. NASA and SpaceX shall utilize the data from the MRAD in the mission analysis, mission procedures/training and crew/cargo integration.

CAD Models, DRD 205 and Mass Properties Reports. SpaceX shall submit spacecraft engineering computer-aided design models in accordance with DRD 205 Spacecraft Computer

Aided Design (CAD) Models. Additionally, SpaceX shall provide mass properties reports in accordance with the MRAD and IMS.

Interface Control Agreements (ICAs), DRD 206. SpaceX shall develop interface control documents (ICDs) and stowage interface agreements (SIAs) in accordance with DRD 206 Internal Cargo Interface Control Agreement (ICA).

Integrated Cargo Hazard Report, DRD 207. SpaceX shall submit DRD 207 Integrated Cargo Phase III Hazard Report per SSP 30599, Safety Review Process, at L-4 months, to ensure that the hazards associated with the packaging of the cargo complement have sufficient controls. SpaceX shall submit a delta integrated cargo hazard report as required according to DRD 207 Integrated Cargo Phase III Hazard Report that represents the final integrated cargo hazard assessment provided to NASA. SpaceX shall integrate with NASA's existing ISS Safety Review Panel (SRP) process.

Flight Readiness Review Package, DRD 208. SpaceX shall provide the FRR data package in accordance with DRD 208.

Post Flight Assessment Report, DRD 209. SpaceX shall provide initial, updated and final postflight assessments (PFAs) in accordance with DRD 209. In conjunction with the assessment reports, SpaceX shall host two postflight reviews approximately 14 days after docking with ISS and approximately 14 days after landing.

Imagery and Associated Cataloging, DRD 210. SpaceX shall submit CTS imagery in accordance with DRD 210 Imagery and Associated Cataloging.

4.1.4 CTS Integration

CTS integration shall be achieved in multiple stages, with rigorous testing at various phases.

Licenses - SpaceX shall secure a Federal Aviation Administration (FAA) license for all post-certification missions in accordance with Clause H.18, Licenses, Permits, and Other Authorizations for a Launch or Reentry Service Operator. SpaceX shall provide technical expertise and participate in NASA/FAA/Range trilateral discussions representing their recommendations when crew safety and public safety risk considerations are assessed. SpaceX shall obtain all other required support services, permits, and licenses that are necessary to execute the mission. These may include Department of Transportation permits and Federal Communications Commission licenses.

Launch Site Processing Operations - SpaceX shall provide launch infrastructure at LC-39A that will be expanded to meet the needs of the CTS. The launch site infrastructure shall include dedicated ground support equipment, personnel, facilities and processing procedures to ensure a safe crewed mission to the ISS. The launch site facilities and operations shall support the following functions:

- Crew familiarization and training.
- Crew flight processing.
- Vehicle and cargo receiving inspection.
- Integration and storage areas, and all associated tooling.
- Post-shipping checkouts to verify the integrity of the avionics, propulsion, TCS, RF and ECLSS systems.
- Final mate of the capsule and trunk.
- Final closeout inspections.
- Crew interface operations.
- ISS integration, as-built inspections, and crew equipment interface testing (CEIT).
- (b) (4) load readiness review.
- Consumables load [redacted] (b) (4) [redacted]
- Flight and launch readiness reviews.
- Final Crew Dragon mate to Falcon 9.
- Terminal countdown demonstration test (TCDT).
- Static fire.
- Crew and cargo turnover and load onto vehicle.
- Launch.

Recovery Site Processing Operations - SpaceX shall provide primary and alternate landing site support including:

- [redacted] (b) (4) [redacted]
- Perform crew extraction.
- [redacted] (b) (4) [redacted]
- Remove and inventory time-critical cargo and turn over to NASA.

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

Range Support Services - SpaceX follows all Range requirements and protocol, and provides documentation to NASA according to DRD 113. SpaceX shall work with the Range to meet CTS needs in the following areas:

- Range scheduling.
- Tracking and flight termination.
- Telemetry.
- Imagery.
- Weather.

- Explosives storage.
- SCAPE (self-contained atmospheric protective ensemble) suits.
- Helium and nitrogen pipeline commodities.

Launch and Landing - SpaceX shall perform advance launch, rendezvous and entry opportunity studies, considering all relevant factors, including ISS trajectory projections and scheduled reboost activities, ISS visiting vehicle schedules, ISS crew and cargo manifest constraints, and specific landing site constraints. SpaceX shall present results of the launch, rendezvous and entry opportunity analysis at MCR and FRR.

Flight Imagery - SpaceX shall submit CTS imagery in accordance with DRD 210 Imagery and Associated Cataloging. Prior to launch, a preflight imagery plan shall be used to capture orbital vehicle, cabin layout, crew interfaces, instrumentation and pressurized cargo. The imagery plan shall be delivered at L-6 months and updated, if necessary, at L- 2 months.

Telemetry - SpaceX shall measure and provide telemetry data confirming that 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.

4.1.5 Crew and Cargo Integration

SpaceX shall use the mission integration process, including certification and mission milestone reviews to prepare for crew and cargo integration with the Dragon-Falcon 9 Crew System.

Crew and Cargo Facilities - SpaceX shall provide procedures, timelines and constraints associated with crew and cargo, including roles and responsibilities and interfaces associated with NASA personnel, equipment and facilities in the MIOMP. The launch sites and landing sites shall provide resources for both crew and cargo needs.

Crew Integration - SpaceX shall develop plans to safely and effectively train and prepare the crew for flight.

- **Crew Training** - SpaceX shall provide a comprehensive training program to prepare NASA crewmembers for each mission. SpaceX shall provide general training to all crew members, including mission and systems familiarization, nominal and off-nominal crew procedures, space suit operations, monitoring and crew-commanding of ascent aborts, and nominal and emergency Dragon postlanding and pad ingress/egress. SpaceX shall provide syllabi, training materials, simulations, crew cabin task training and certification for the crew training program.
    - SpaceX shall define the necessary prelaunch 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. Details of the crew integration process, training, CEIT, and TCDT shall be outlined in the MIOMP.

- SpaceX shall participate in Joint Multi-Segment Simulation Training (JMST) that includes flight controllers and crew participation.
- SpaceX 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).

- **Crew Flight Processing** - SpaceX shall assist in crew ingress on the launch pad and egress at the recovery site. SpaceX shall meet the landing, egress and additional crew supplies requirements levied by CCT-REQ-1130.

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Cargo Integration - SpaceX shall provide a spacecraft pressurized module physical configuration per DRD 204 MRAD and any constraints related to manifest and return flexibility. SpaceX shall identify constraints to the on-orbit packing of cargo for return per the final DRD 204 MRAD. NASA will maintain the capability to adjust the return cargo complement within the identified constraints while the spacecraft remains mated to the ISS. NASA will plan cargo transfers with SpaceX coordination and in accordance with identified constraints while the spacecraft remains docked to the ISS.

Prior to cargo integration, SpaceX shall develop an internal cargo interface control agreement 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. SpaceX shall document the cargo ground handling procedures and constraints in the ICAs and/or integration procedures.

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

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

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

SpaceX shall affix their 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.

SpaceX shall safely integrate cargo into the spacecraft.

4.1.6 CTS Certification Maintenance

SpaceX shall maintain NASA certification of the CTS for all PCMs. Design, production or operational changes from the NASA certification baseline are reviewed for their effect on compliance to the requirements of CCT-REQ-1130 and SSP 50808. System performance from previous production, operation or flights is also reviewed for the potential effects on the NASA certification. In addition, SpaceX shall ensure the interdependencies between the ongoing core certification effort, and PCM objectives are addressed in our development plan and mission execution planning.

Certification maintenance of the CTS shall be a collaboration between SpaceX and NASA to verify that each Dragon-Falcon 9 vehicle in the fleet is ready for flight as built, with all requirements verified. The certification maintenance effort consists of [redacted]

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SpaceX shall deliver a Certification Data Package in accordance with DRD 112 Certification Data Package.

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5 IDIQ SPECIAL STUDIES (CLIN 003)

In accordance with the task ordering procedures in this contract, SpaceX shall perform special studies in support of this contract as initiated by written direction from the Contracting Officer.