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Description of document: National Aeronautics and Space Administration (NASA) records regarding issues with parachute riser/link/attachment on the Starliner spacecraft 2022-2024

Requested date: 12-May-2024

Release date: 06-September-2024

Posted date: 06-October-2024

Source of document: FOIA Request  
Government Information Specialist  
c/o NASA Headquarters  
MS 5-R30, 300 E Street, SW  
Washington, DC 20546  
Email: [hq-foia@mail.nasa.gov](mailto:hq-foia@mail.nasa.gov)

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National Aeronautics and Space Administration



**Headquarters**

Washington, DC 20546-0001

September 6, 2024

Reply to attn. of:

Office of Communications  
History and Information Services Division

Re: NASA FOIA Tracking Number 24-00820-F-HQ

This is our final response to your Freedom of Information Act (FOIA) request to the National Aeronautics and Space Administration (NASA), dated May 12, 2024, and received in this office on May 13, 2024. Your request was assigned the above-referenced tracking number. You seek:

A copy of each NASA report, memo and presentation slide deck regarding issues with the parachute riser/link/attachment on the Starliner spacecraft, and/or resolution of those issues. Please limit this request to records during the years 2022 to the present.

-Exclude exclusively proprietary records. -Limit search to higher level NASA overviews that discuss the challenges or concerns that have been publicly reported.

-Limit search to records that subject matter experts are aware of – exclude bulk and lengthy computer searches.

-Include only Boeing information; exclude other company's/companies' information.  
(Date Range for Record Search: From 1/1/2022 To 5/13/2024)

In an email, dated June 10, 2024, you agreed to narrow your request to exclude information pertaining to other companies, and only include information pertaining to Boeing. A copy of that email is enclosed for reference.

In response to your request, we conducted a search of NASA's Kennedy Space Center, Commercial Crew Program Office using the information provided in your request. That search identified records responsive to your request. We reviewed the responsive records under the FOIA to determine whether they may be disclosed to you. Based on that review, this office is providing the following:

32 page(s) are released in full (RIF);<sup>1</sup>  
 27 page(s) are released in part (RIP);

NASA redacted from the enclosed documents certain information pursuant to the following FOIA exemptions:

### **Exemption 3, 5 U.S.C. § 552(b)(3)**

Exemption 3 concerns matters that are “specifically exempted from disclosure by statute if that statute (i) requires that the matters be withheld from the public in such a manner as to leave no discretion on the issue; or (ii) establishes particular criteria for withholding or refers to particular types of matters to be withheld.” 5 U.S.C. § 552 (b)(3).

- Pursuant to the Arms Export Control Act, 22 U.S.C. § 2778(e), NASA withholds certain information pertaining to export license applications and items that are on the U.S. Munitions List (22 C.F.R. § 121.16).

### **Exemption 4, 5 U.S.C. § 552(b)(4)**

Exemption 4 protects trade secrets and commercial or financial information obtained from a person that is privileged or confidential. See 5 U.S.C. § 552(b)(4). The Supreme Court of the United States has held that where commercial or financial information is both customarily and actually treated as private by its owner and provided to the government under an assurance of privacy, the information is “confidential” within the meaning of 5 U. S. C. §552(b)(4). *Food Marketing Institute v. Argus Leader Media*, 139 S. Ct. 2356 (2019). Thus, NASA invokes exemption 4 to protect internal Boeing processes and methodologies, Boeing product manufacturing and design information, and contract cost performance information.

### **Exemption 6, 5 U.S.C. § 552(b)(6)**

Exemption 6 allows withholding of “personnel and medical files and *similar files* the disclosure of which would constitute a clearly unwarranted invasion of personal privacy.” 5 U.S.C. § 552(b)(6)(emphasis added). NASA invokes exemption 6 to protect third party private company employee names.

### **Fees**

Provisions of the FOIA allow us to recover part of the cost of complying with your request. In this instance, because the cost is below the \$50 minimum, there is no charge.

### **Appeal**

You have the right to appeal my action regarding your request. Your appeal must be received within 90 days of the date of this response. Please send your appeal to:

<sup>1</sup> All page counts are approximate numbers.

Administrator  
NASA Headquarters  
Executive Secretariat  
ATTN: FOIA Appeals  
MS 9R17  
300 E Street S.W.  
Washington, DC 20546

Both the envelope and letter of appeal should be clearly marked, "Appeal under the Freedom of Information Act." You must also include a copy of your initial request, the adverse determination, and any other correspondence with the FOIA office. In order to expedite the appellate process and ensure full consideration of your appeal, your appeal should contain a brief statement of the reasons you believe this initial determination should be reversed. Additional information on submitting an appeal is set forth in the NASA FOIA regulations at 14 C.F.R. § 1206.700.

### **Assistance and Dispute Resolution Services**

If you have any questions, please feel free to contact me at [derek.m.moore@nasa.gov](mailto:derek.m.moore@nasa.gov) or (202) 358-2681. For further assistance and to discuss any aspect of your request you may also contact:

Stephanie Fox  
FOIA Public Liaison  
Freedom of Information Act Office  
NASA Headquarters  
300 E Street, S.W., 5P32  
Washington D.C. 20546  
Phone: 202-358-1553  
Email: [Stephanie.K.Fox@nasa.gov](mailto:Stephanie.K.Fox@nasa.gov)

Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services it offers. The contact information for OGIS is as follows: Office of Government Information Services, National Archives and Records Administration, 8601 Adelphi Road-OGIS, College Park, Maryland 20740-6001, e-mail at [ogis@nara.gov](mailto:ogis@nara.gov); telephone at 202-741-5770; toll free at 1-877-684-6448; or facsimile at 202-741-5769.



***Important:*** Please note that contacting any agency official including myself, NASA's FOIA Public Liaison, and/or OGIS is not an alternative to filing an administrative appeal and does not stop the 90 day appeal clock.

Sincerely,

Derek Moore  
Government Information Specialist

Enclosure(s)



# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Program Manager, Commercial Crew Program**  
**August 2, 2023**

ITAR Category XV, (f), ECCN 9E515.a, EAR99 NLR

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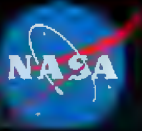
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# CST-100 Drogue and Main Low Margin – Soft Links



Available for Public Discussion

## Public Status:

- New soft link joint identified that will meet the required 2.0 factor of safety for the main and drogue parachutes.
- The new joint design is in testing.
- Recent Technical Interchange Meeting at the parachute supplier verified no other joint concerns on the parachute system.

## Background:

- (b) (4)
- Testing was from 2009, configuration was incorrect for CST-100 application
- Airborne found error upon final “scrub” of report for VCN submittal
- (b) (4)

## Status:

- (b) (4)
- (b) (4)
- Boeing has elected to move to the 511 main parachute chute configuration for CFT
- This change will incorporate the new soft link design, a pre-planned upgrade to reinforce the suspension line strength in some key areas and will require a drop test for validation.

## Path Forward:

- (b) (4)
- Resultant Main FOS = 2.25 (against 2.0 requirement); Drogue FOS is higher
- Final flight drawings for soft links in work and will be implemented on CFT+

Internal ASAP Use Only

(b) (4)

(b) (4)

(b) (4)

(b) (4)



# Forward Heatshield Parachute (FHSP) Over-Q Test



## Public Status:

Available for Public Discussion

- Recently executed the planned Forward Heat Shield parachute ground test.
- The system performed nominally.

## Test Configuration and Results:

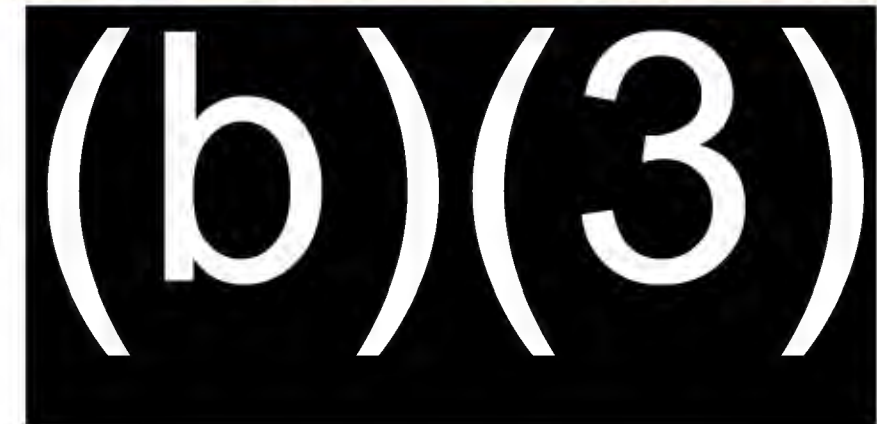
- Testing was conducted at the Navy's China Lake Naval Air Warfare Center on 6/8/2023

- (b) (4)
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- (b) (4)

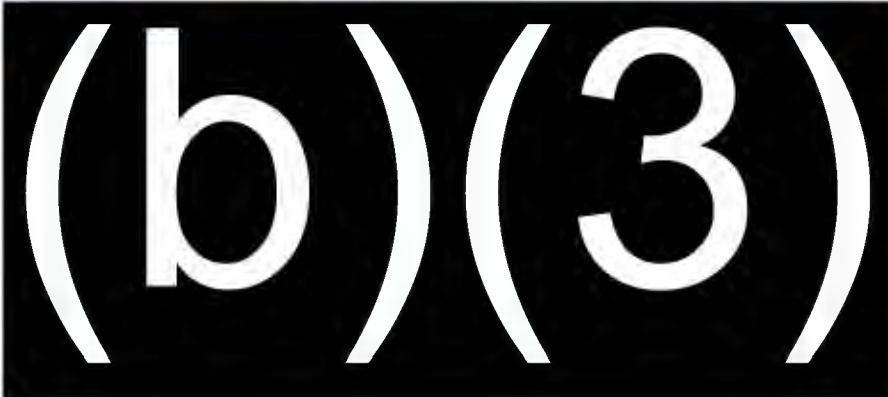
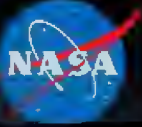
- (b) (4)
- (b) (4)

- (b) (4)
- (b) (4)





# D-Ring Retention System IFA Closure



- **Background:**
  - OFT-2 retention system IFA root cause determined to be out-of-sequence loading during deployment (pilot load arrived before rings released)
  - During CFT Main parachute removal, D-rings were found slightly bent (for a system that had not yet been deployed)

- **Status:**
  - Fault tree re-opened, investigation ongoing
  - Likely root cause is damage to D-rings during final packing load application
    - Lid application requires roughly 100,000 lbs force
    - D-rings are in the load path, oriented in a manner that would cause bending
    - Witness marks on packing fixture lid show extremely high loads

- **Forward Work:**
  - Design modifications to add cutout to the lid in work to remove the D-rings from the load path
  - Note that it is NOT clear whether packing is the only factor in bending or is a contributory factor
    - It is a fact that loading is out-of-sequence during deployment
    - Bending may be caused by packing, deployment, or both
    - Packing trials ongoing to verify changes

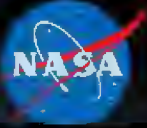


Orientation of D-Ring during packing





# Parachute TIM / System Review



- **Combined NASA / Boeing / Airborne teams held a TIM at Airborne 7/10/23 – 7/13/23**
  - Goal was to make decisions on open issues and resolve the path forward for soft links and retention system
  - In addition, the team worked to ensure there were no additional issues not yet identified, and worked to minimize the opportunity for issues moving forward
- **Seam and Joint Deep Dive**
  - Independent NESC / Parachute expert came in and reviewed the seam and joint report / data and individual seam and joint sample drawings compared to flight drawings
  - There were several minor findings, one joint will need to be retested (not a driving joint – does not affect margins)
  - Boeing identified several joints that need additional testing to get from 5 to 10 samples, per requirements
- **Design Review**
  - The integrated team walked through the CST-100 design in depth to assess all design and analysis assumptions – no significant findings
  - CST-100 parachutes were designed over a decade ago, and last built in 2016
    - Airborne within the last month completed a thorough internal review of all drawings for completeness / clarity and made updates prior to the start of PCM-1 parachute fabrication
- **Surveillance**
  - Boeing has recently implemented Mandatory Inspection Points (BMIPs) during manufacturing, packing, integration where Boeing witness and signoff is required during Airborne processing
  - NASA has inserted PAAs (Product Assurance Actions) to witness packing and integration as well as perform “clear to pack” reviews and perform record reviews for all parachutes



# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Program Manager, Commercial Crew Program**  
**February 8, 2023**

ITAR Category XV, (f), ECCN 9E515.a, EAR99 NLR

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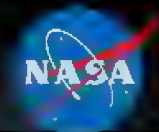
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# OFT-2 In-Flight Anomaly (IFA) Summary



- Total of 14 IFA's were identified from OFT-2 by NASA
  - 8 are closed
- Projected schedule for remaining items listed below

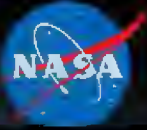
| Systems Office | Issue Title | Status            | PCB Agenda ID (Required For Closure) |
|----------------|-------------|-------------------|--------------------------------------|
| SC             | (b) (4)     | Open              | PCB February 2023                    |
| SC             |             | Open              | PCB February 2023                    |
| G&MO           |             | Open              | PCB February 2023                    |
| LV             |             | Open              | PCB February 2023                    |
| SC             |             | Open              | PCB February 2023                    |
| SC             |             | Open              | PCB February 2023                    |
| SC             |             | Closed (CFT only) | JPRBC November 15                    |
| SC             |             | Closed            | PCB January 10                       |
| SC             |             | Closed (CFT only) | PCB January 10                       |
| SC             |             | Closed            | PCB November 8                       |
| SC             |             | Closed            | PCB January 10                       |
| SC             |             | Closed            | PCB December 8                       |
| SC             |             | Closed            | PCB November 29                      |
| SC             |             | Closed            | PCB September 23                     |

As of 01/26/23





# CFT / PCM Parachute Design and Cert



- **Background**

- CFT and PCM-1+ parachute system designs have been baselined

- **Status**

- High dynamic pressure/Over-Q airdrop testing for the drogue and main parachutes completed at the Yuma Proving Ground 11/15/2022
- Successfully demonstrated a drogue mortar packing change. Pneumatic mortar testing to complete validation of this change is currently on hold after completion of 1 of 4 test shots at parachute vendor (ECD: February 2023)
- High dynamic pressure testing for the Forward Heatshield Parachute (FHSP) is currently in planning

- **Path forward/flight rationale**

- VCN Closure
  - Boeing has submitted 23 of 33 Verification Closure Memos (VCMs) for NASA review. Substantial work to resolve questions and obtain remaining artifacts.
  - Remaining VCMs planned for delivery during the week of 2/6
- Hazard Reports
  - Boeing and NASA Parachute Teams made significant progress at two recent TIMs
  - Parachute HR is scheduled for STRB review and Phase III kickoff
- CFT Parachutes
  - Two open S&MA Finding Letters regarding packing cycles and a slipped packing plate are planned for closure at PAA Forum based on use of appropriate degradation factor
- PCM-1+ Parachute design change has been concurred
  - Implementing a change to the joint design at each radial to suspension line attachment
  - Design change increases joint efficiency and improves margins in the main parachutes. Final margins are under review.
  - Supply chain delays and long lead procurement are schedule risks for PCM-1

Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1+



# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Program Manager, Commercial Crew Program**  
**March 19, 2024**

**ITAR Category IV (i)**

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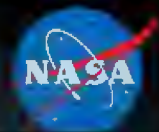
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# Starliner Parachute Status



Available for Public Discussion

(b) (4)

**Current Status:**

- The modified parachute system, with redesigned soft link joints and a strengthened suspension line textile joint, was tested over the Arizona desert on Jan. 9
- Parachute deployment and a soft landing of the test article were confirmed.
- Data analysis of the two-parachute test confirm primary test objectives were met.
- Engineering teams have reviewed the results, inspected the test parachutes, and are working to complete system certification.

- **Issue:** Soft Link seam and joint testing (4k Kevlar 3-Turn) resulted in reduced capability from previous test; Factor of safety (FoS) was found to be below requirement of 2.0

**Background/Status**

- The soft link was redesigned to increase strength / margin
  - New design exceeds FoS requirement of 2.0
- Boeing incorporated the new soft link design as well as an upgraded radial at suspension line joint design into new parachute release – chose to fly the new design (-511) on the CFT mission
  - All -511 main parachute changes (soft link, radial at suspension line joint, retention system) successfully validated via NPCQT-02 drop test conducted 1/9/2024
- Boeing final analysis shows positive margins for main parachutes, NASA IV&V margins in work

**Path Forward**

- Final seam and joint testing with lot specific materials – **Complete**
- Parachute System Margin Calculations  $\geq 1.6$ FoS – **Complete**
  - **NASA IV&V margins in work – ECD 3/27/2024**
- Flight Parachutes Deliveries and Installation: **Complete**
- Drop Test NPCQT-02 (NASA performed): **Complete**
- Drop Test Data Review: **Complete**
- Parachute VCNs Approved: Planned closure JPCB 3/27/23
- Hazard Report Status: **Planned closure STRB 3/22/2024**

(b) (4)

(b) (4)

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(b) (4)

Internal ASAP Use Only

Suspension Line analysis



# Parachute Retention System IFA



(b)(3)

- **Issue Statement:** During removal of main parachute retention systems on CFT, all horizontal retention strap D-Rings installed on new main deployment bags were observed to be bent.
- **Background/Status:**
  - CCTS had dispositioned bent D-Rings phenomenon observed after drop tests and OFT / OFT2 test flights with belief that bending was occurring in-flight during parachute deployment
  - When removing CFT (unflown) parachutes, **ALL** horizontal retention strap D-Rings were observed to have some degree of bending. None of the vertical retention strap D-Rings were bent.
  - RCCA Investigation:
    - D-Rings position during final press w/ loads up to 100Klb force is different than assumed
    - Rings under riser plate during packing is determined as the root cause of the CFT Bent D-Rings
    - Fixture modified to remove rings from load path; procedures modified to inspect rings for flatness
      - Post-packing / pre-integration onto the Spacecraft
- **Next steps**
  - Conducted NPCQT-02 with parachutes packed per new processes; **Complete 1/9/2024**
  - Perform video and strain analysis, including retention system loads and timing: **Complete 2/14/2024**
  - Final inspection of test D-rings (4x) as FLAT post-test; **Complete**
  - Continue to monitor parachute performance (**ongoing surveillance**)
  - IFA closed for CFT+ at JPCB; **Complete 2/14/2024**



# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Manager, Commercial Crew Program**  
**May 10, 2022**

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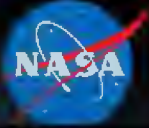
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## CFT Top Issue Summary Table (1 of 2)

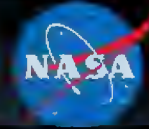


| Issue  | Summary  | Closure Plan or Next Step for CFT  |
|--|--|--|
| <b>OFT-2 Anomaly Investigation</b>                   | 13 of 24 SM oxidizer isolation valves failed to open prior to OFT-2 launch. Root cause might drive CFT SM re-work.   | Wait for conclusion of OFT-2 Anomaly Investigation Team and implement required mitigations for CFT.  |
| Parachutes   | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts  | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs. Finalizing closure plan for remaining technical issues  |
| LAE Fault Tolerance                                  | LAE pre-valve and main valves are OFT to leakage during pre-launch and ascent and 1FT while in free flight and docked; potential ISS contamination   | Conceptual designs complete. Testing of leak detection sensors to begin May 3 and run through May 17. Schedule assessment of Leak Overboard option shows significant risk to closure by CFT. Down select briefing to program in early May. |
| <b>Landing Loads &amp; Landing System Complexity</b> | Potential for excessive landing loads (both hardware and crew injury) due to (1) Potential Limit Cycle or Medium Pendulum motion during descent can cause load exceedances (2) Boeing approach to landing margins do not allow easy assessment of increased loads            | Perform parachute testing to define pendulum model<br>Boeing/NASA working to concur to initial conditions<br>Analysis to be conducted when pendulum tests are complete<br>Feasibility assessment in work for Gantry test if required.      |
| Lightweight Service Module Model Correlation         | The CM Starliner FEM is fully correlated, but the full stack (CM+SM) model is not correlated. Modal test completed with heavyweight SM, but full model correlation was not obtained making transition to lightweight SM difficult analytically. CFT will fly lightweight SM. | Meeting held 2/4 to discuss testing forward paths; Boeing agree gap exists<br>Evaluating SM2 for modal testing options   |
| Abort Loads Analysis                                 | Risk that both primary and secondary structure (tanks, batteries, crew seats, e.g.) cannot withstand abort loads. This risk is due to differences in statistical binning of load cases which can cause un-conservative loads for which structure is evaluated.               | Closure plan for CFT is for Boeing to assess primary structure load indicators with exceedances greater than 5%  |
| <b>Hazard Report Process</b>                         | Need to increase efficiency and integration of safety, engineering, and operations to enable success of Phase III HRs for CFT  | CFT tactical plans complete; CFT kickoff held 8/25; CCP/ISS agreed to hold parallel boards   |

**Bold** indicates issue joint with ISS

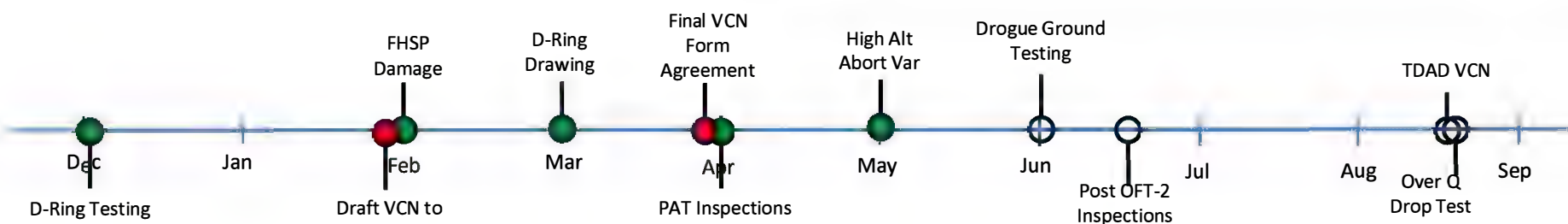
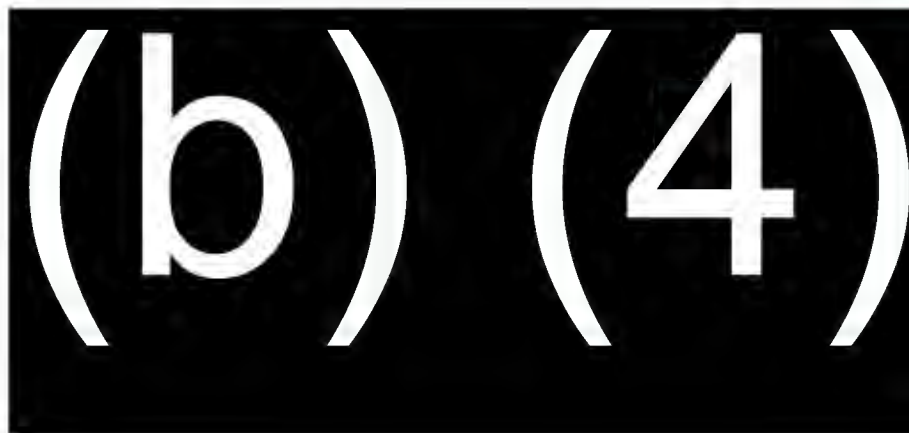


# Main Parachute Loading and FHS Drogue Chute Debris



| Issue      | Summary  | Closure Plan or Next Step for CFT   |
|------------|--|---|
| Parachutes | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current conops for 1a aborts | Single flight use of Starliner main parachutes for CFT+ waiver Procuring new build main parachutes for PCM-1 and subs. Finalizing closure plan for remaining technical issues |

- FHS parachute technical discussion complete
  - Boeing in process of shipping chute to NASA
- Over-Q test work progressing
  - Dart updates / refurbishment progressing on schedule in Yuma
  - Boeing identifying assets for test (drogue/pilot/main chutes and mortars)
    - Parachute deliveries from Boeing delayed / not on contract jeopardizing schedule – been discussed with (b) (6), (b) (4)
- PCM 1+ SOW design down selecting final design solution
  - Changes limited to those that do not require delta qual testing
  - Working on presentation for ERB 5/9, PCB 5/12
- Drogue packing hardware/testing awaiting SOW
- **VCN plan/deliveries continue to be delayed**



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# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Program Manager, Commercial Crew Program**  
**May 24, 2023**

ITAR Category XV, (f), ECCN 9E515.a, EAR99 NLR

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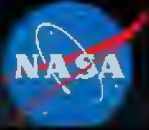
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# CFT / PCM Parachute Design and Cert



## Parachute Team executing to plan for closure for CFT with low technical risk

### • Current Status

- CFT and PCM-1+ parachute system designs have been baselined
- For PCM-1+ implementing a change to the joint design at each radial to suspension line attachment, improves margin
- Parachute Verification and Hazard Reports are a pacing item for CFT
  - An additional ground test will be conducted in May related to deployment of the Forward Heat Shield parachute to obtain data points needed for verification

Available for Public Discussion

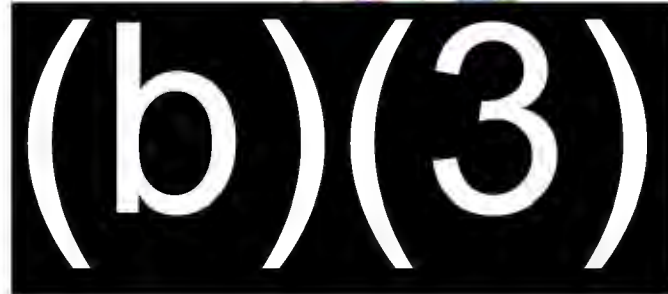
### • Closure Status acceptability

- Pneumatic mortar testing to complete validation of drogue packing change completed 2/10/2023
- Retention system IFA closure: Testing and analysis closed at PCB on 5/18/2023
- Forward Heatshield Parachute (FHSP) high dynamic pressure testing scheduled for 6/7/2023



### • Path Forward & Flight Rationale

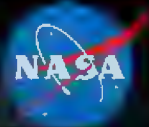
- VCN Closure: Boeing has submitted all closure paperwork and NASA has reviewed
  - Boeing currently updating products to close comments; ECD 5/31/2023
- Hazard Reports: STRB Phase III occurred 5/18/2023 with standard forward work to close for CFT
- CFT Parachutes
  - NASA and Boeing presented final margin position to PCB on 5/2/2023
  - Program and all Technical Authorities accepted CFT margins, including degradation factor for single parachute that had been packed 3¼ times
- PCM-1+ Parachute design change has been concurred
  - Final margins under review
  - Materials being received: ECD of four parachutes (3x for PCM-1 shipset 8/31/2023 + 1x for Single Canopy Airdrop Test 11/15/2023)
    - Airdrop test scheduled for early January 2024



Internal ASAP Use Only



# CST-100 Drogue and Main Low Margin



- **Background**

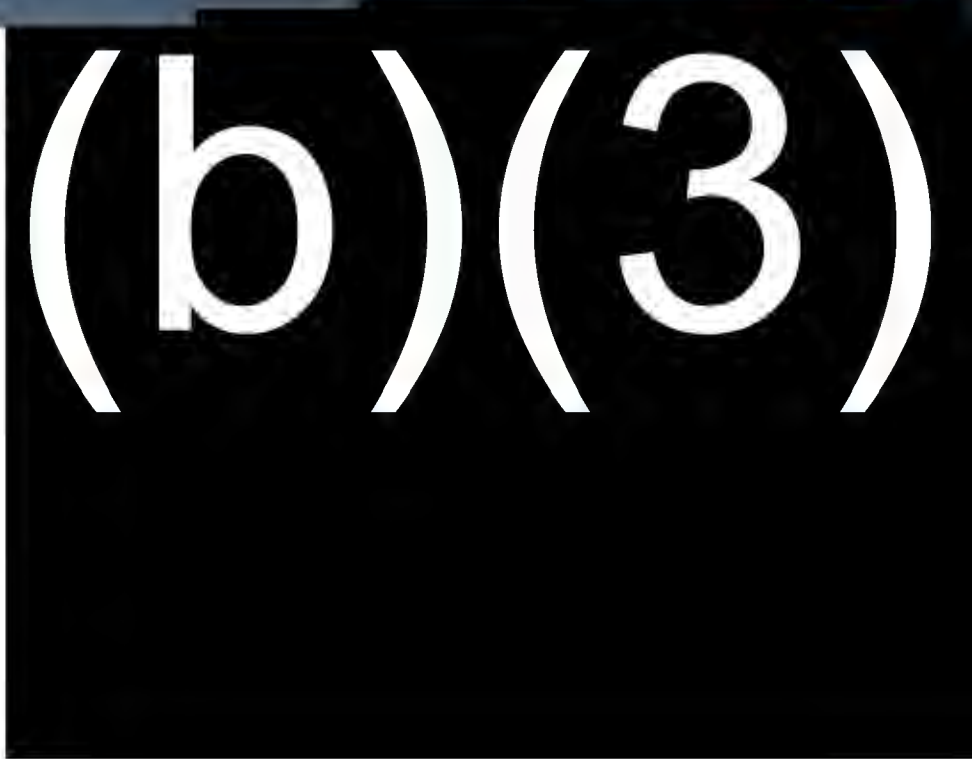
- (b) (4) [Redacted]
- (b) (4) [Redacted]
- (b) (4) [Redacted]

- **Status**

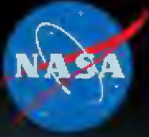
- Upon final review of their Design Analysis Report, parachute vendor (Airborne Systems) noted only two valid test samples to determine strength of this item – this testing had strength at 79% efficiency
- Airborne performed required testing to determine strength (May 2023)
- New testing with 10 samples as required showed 38% efficiency
- This hardware / joint is considered “safety critical” and requires FOS = 2.0

- **Path Forward**

- All three teams (Airborne / Boeing / NASA) are evaluating flight data, test setup and test results for conservatism
- Final margins are being evaluated for impacts to CFT



Parachute Team evaluating impacts to final margin



# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Program Manager, Commercial Crew Program**  
**October 25, 2023**

**ITAR Category IV (i)**

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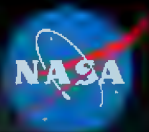
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# CST-100 Drogue and Main Low Margin – Soft Links



## Public Status:

Available for Public Discussion

- Preparations underway for an upcoming drop test of Starliner's upgraded drogue and main parachutes.
- New parachutes will incorporate planned strengthening of main canopy suspension lines and recent redesign of drogue and main parachute soft-link joints, which will increase the safety factor for the system.

(b) (4)

## Background:

- Airborne had been using old CEV Parachute Assembly System (CPAS) data / seam and joint testing with 72% efficiency
  - Testing was from 2009, configuration was incorrect for CST-100 application
  - Airborne found error upon final "scrub" of report for Verification Change Notification (VCN) submittal
  - (b) (4)

## Status:

- (b) (4)
- (b) (4)
- (b) (4)
  - (b) (4)
  - (b) (4)
    - (b) (4)
  - (b) (4)
  - (b) (4)

## Path Forward:

- All parachutes being reworked to the corrected shorter configuration w/ positive margins – Root Cause and Corrective Action (RCCA) in work
- Parachutes for drop testing on schedule to support test, planned for January 2024
- Parachutes for CFT on schedule to support spacecraft install

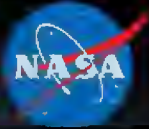
(b) (4)

(b) (4)





# CST-100 Parachute System Airdrop Test



## Background:

- (b) (4)
- Upgraded soft links require airdrop test to verify / validate performance
- Use of the "heavy dart" parachute compartment drop test vehicle (PCDTV) requires two mains for successful recovery of the test article
- (b) (4)
- (b) (4)
- (b) (4)
- (b) (4)
- (b) (4)
- Retention system / D-ring will be flight-like for both parachutes

## Status:

- Testing planned for week of 1/8/24 at Yuma Proving Ground (YPG)
- Instrumentation will allow for parachute loads measurement, loads measurement of the retention system and timing of the D-ring release
- (b) (4)

## Forward Work:

- Parachute delivery to Yuma for integration currently scheduled for November 2023

## Airdrop Test Conops





# NASA Quick Look GAO for Commercial Crew Program

Steve Stich  
Manager, Commercial Crew Program  
July 27, 2022

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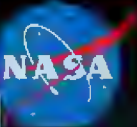




# CFT Parachute Forward Work (1 of 3)

| Open Work                           | CFT Parachute Actions (Actionee)  | ECD   | Comments   |
|-------------------------------------|---|---|--|
| 1) OFT2 Post Flight Inspections     | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)<br>4. (b) (4), (b) (6)<br>5. (b) (4), (b) (6) | 1. Complete<br>2. Complete<br>3. Complete<br>4. 7/18 ECD<br>5. End July or early August | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)<br>5. (b) (4) |
| 2) VCN Submittal                    | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)<br>4. (b) (4), (b) (6)<br>5. (b) (4), (b) (6) | 1. Complete<br>2. Complete<br>3. Thursday's<br>4. Friday's<br>5. 8/26                   | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)<br>5. (b) (4) |
| 3) Asymmetry and Loads Model Update | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)   | 1. Complete<br>2. 7/22 target<br>3. ASAP  | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)                             |
| 4) Drogue Packing Update            | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)<br>4. (b) (4), (b) (6)<br>5. (b) (4), (b) (6) | 1. Complete<br>2. 8/9<br>3. 8/16-9/21<br>4. 8/2<br>5. Sept                              | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)<br>5. (b) (4) |
| 5) OFT-1 FHSP UA Closeout           | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)<br>4. (b) (4), (b) (6)<br>5. (b) (4), (b) (6) | 1. Complete<br>2. Complete<br>3. Mid July<br>4. Complete<br>5. U/R                      | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)<br>5. (b) (4) |

# CFT Parachute Forward Work (2 of 3)



| Open Work                   | CFT Parachute Actions (Actionee)  | ECD  | Comments   |
|-----------------------------|---|--|--|
| 6) PAT Inspections          | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)  | 1. Complete<br>2. Complete   | 1. (b) (4)<br>2. (b) (4)   |
| 7) High Q                   | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)<br>4. (b) (4), (b) (6)<br>5. (b) (4), (b) (6)<br>6. (b) (4), (b) (6)<br>7. (b) (4), (b) (6) | 1. Complete<br>2. Complete<br>3. 7/27 ECD<br>4. 8/2<br>5. 8/15 NLT<br>6. U/R<br>7. 7/15 need | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)<br>5. (b) (4)<br>6. (b) (4)<br>7. (b) (4) |
| 8) Repack Rationale         | 1. (b) (4), (b) (6)<br>2. (b) (4), (b) (6)<br>3. (b) (4), (b) (6)<br>4. (b) (4), (b) (6)<br>5. (b) (4), (b) (6)   | 1. Complete<br>2. 7/22 Target<br>3. 8/26 Target<br>4. 9/30 Target<br>5. 9/30 Target          | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)<br>5. (b) (4)                             |
| 9) Parachute Hazard Reports | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)  | 1. Complete<br>2. Complete<br>3. U/R<br>4. Meeting 7/12                                      | 1. (b) (4)<br>2. (b) (4)<br>3. (b) (4)<br>4. (b) (4)   |





# CFT Parachute Forward Work (3 of 3)



| Open Work                        | CFT Parachute Actions (Actionee)  | ECD   | Comments  |
|----------------------------------|---|---|---|
| 10) Spacecraft Production        | <ol style="list-style-type: none"> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> </ol> | <ol style="list-style-type: none"> <li>Complete</li> <li>NLT 7/15</li> <li>Target 7/19</li> <li>Target 7/22</li> <li>U/R</li> </ol> | <ol style="list-style-type: none"> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> </ol> |
| 11) Postflight Review & Template | <ol style="list-style-type: none"> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> </ol>                  | <ol style="list-style-type: none"> <li>Sept. TBR</li> <li>Oct. TBR</li> <li>Sept. TBR</li> <li>Nov. TBR</li> </ol>                  | <ol style="list-style-type: none"> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> </ol>                  |
| 12) OFT 2 IR results             | <ol style="list-style-type: none"> <li>(b) (4)</li> </ol>   | <ol style="list-style-type: none"> <li>U/R</li> </ol>   | <ol style="list-style-type: none"> <li>(b) (4)</li> </ol>   |

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Please Contact:  
David Allega  
david.b.allega@nasa.gov

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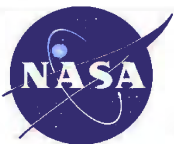
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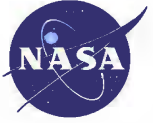
# CUI



# **SPACE OPERATIONS MISSION DIRECTORATE (SOMD)**

Major Program Review

August 25, 2022



# Major Program Review

Commercial Space Division (CSD)  
Commercial Crew Program (CCP) Overview  
Phil McAlister, CSD Division Director



# CCP Technical Top Issues

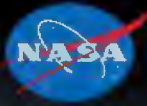
|                         |   |  |   |   |
|-------------------------|---|--|---|---|
| Minimal issues; on plan | Y | Known issues, but mitigations in development or in place to meet plans | R | Known issues, and plans unlikely to be met without impact to other areas and/or additional external resources |
|-------------------------|---|--|---|---|

|   | Q1 | Q2 | Current | Trend |  | Trend Status |             |             |  |
|---|----|----|---------|-------|--|--------------|-------------|-------------|--|
|   |    |    |         |       |  | ↑ Improving  | → No Change | ↓ Declining |  |
| <b>Boeing:</b><br>Service Module (SM) Prop System manifold isolation valves | R  | R  | Y       | ↑     | <b>Issue:</b> During launch count for OFT-2, testing of the Service Module (SM) Prop System manifold isolation valves resulted in 13 of 24 oxidizer valves failing to cycle open<br><b>Mitigation:</b> <ul style="list-style-type: none"> <li>Boeing developed troubleshooting procedures to recover valve functionality.</li> <li>Boeing developed fault tree and 7 investigation teams to integrate findings and learning to support root cause identification and flight rationale</li> <li>NASA has membership on each of the investigation teams throughout this process</li> <li>Numerous remediation steps identified to limit moisture intrusion for the oxidizer valves</li> <li>Addition of a valve purge system to preclude moisture intrusion for flight</li> <li>Boeing working with vendor to modify valve to eliminating corrosion risk</li> </ul> <b>Status:</b> <ul style="list-style-type: none"> <li>Root cause is corrosion from oxidizer &amp; external moisture</li> <li>Off-Vehicle Testing at White Sands, NM replicate valve stiction and remediation, with additional testing being performed at MSFC</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>(b) (4)</li> <li>Potential additional valve-cycling to confirm health prior to pad roll-out</li> <li>Successfully accomplished OFT-2 flight objectives</li> </ul> |              |             |             |  |
| <b>Boeing:</b><br>Main parachutes   | R  | Y  | Y       | →     | <b>Issue:</b> Main parachutes do not have required factors of safety when accounting for asymmetry loading, which is non-uniform inflation that results in unequal suspension line loading.<br><b>Mitigation:</b> <ul style="list-style-type: none"> <li>NASA/Boeing testing collected data characterizing/modeling the asymmetry of the Boeing parachute system</li> <li>NASA/Boeing agreed on utilization of pendulum testing conditions including a mass drop to generate highly loaded conditions where asymmetry data was missing</li> <li>Working margin improvements to be incorporated in PCM1 and subs parachute builds</li> </ul> <b>Status:</b> <ul style="list-style-type: none"> <li>Additional testing successful in defining high load asymmetry reducing the impact on margins</li> <li>New margins calculated allow CCP to move forward without the need for significant redesign for CFT single flight use</li> <li>Procuring new build main parachutes for PCM-1 and subsequent flights and finalizing closure plan for remaining technical issues</li> </ul>   |              |             |             |  |

OFT-2 successfully completed all 252 flight test objectives and 15 Mission Operations Demonstrations. The test flight-provided valuable data to help improve trends technical issues.

CCP assessment of Top Issues

For NASA Internal use Only



# Boeing Starliner Top Issues Review

December 2, 2022

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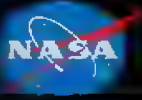
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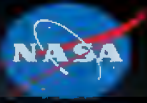
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# In Flight Anomaly Summary



| Title | Open / Closed | Description | Progress / Status | Expected Disposition Date |
|-------|---------------|-------------|-------------------|---------------------------|
|-------|---------------|-------------|-------------------|---------------------------|

(b)(3)

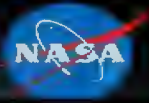


# Backup



# CFT Top Issue Summary Table (1 of 2)

| Trend       |             | Mitigation  |                                  |
|-------------|-------------|-------------|----------------------------------|
| ↑ Improving | ↓ Degrading | ➡ No change | 🔴 Mitigation plan in development |
|             |             |             | 🟡 Mitigation steps in-work       |
|             |             |             | 🟢 Executing to Plan              |



| Issue  | Summary  | Closure Plan or Next Step for CFT   | Trend | Prior/Now |
|--|--|---|-------|-----------|
| <b>OFT-2 Anomaly Investigation</b>                   | 13 of 24 SM oxidizer isolation valves failed to open prior to OFT-2 launch. Root cause might drive CFT SM re-work.   | Successful remediation during OFT2 flight. Same approach planned for CFT. Boeing working PCM-2 design changes   | ➡     | 🟢 🟢       |
| Parachutes   | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts  | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs (at risk). Over-Q test completed 11/15. VCN delivery plan in work. Attempting to partner on closure plan for FHS over-Q test gap.   | ➡     | 🟡 🟡       |
| LAE Fault Tolerance                                  | LAE pre-valve and main valves are OFT to leakage during pre-launch and ascent and 1FT while in free flight and docked; potential ISS contamination   | HALO design review complete. Analysis of leak detection sensors I/W. Schedule assessment of sensor system installation shows low risk to closure by CFT. LCC/FLT rule needs to be partnered.  | ↑     | 🟡 🟢       |
| <b>Landing Loads &amp; Landing System Complexity</b> | Potential for excessive landing loads (both hardware and crew injury) due to (1) Potential Medium Pendulum motion or yaw angles during descent can cause load exceedances (2) Boeing approach to landing margins do not allow easy assessment of increased loads (3) Boeing loads analysis campaign schedule being assisted with NASA computational assets to bring in completion date to the left | Initial results of Boeing Loads Analysis show Starliner may be able to support an 8 knot CFT landing wind placard. Analysis campaign expected to be complete NET mid-Dec and completion of Landing Loads IV&V and HHP occupant protection analyses expected NET 2/24/23. Hardware modifications are expected for PCM-1. | ➡     | 🟡 🟡       |
| Service Module Modal Correlation                     | The CM Starliner FEM is fully correlated, but the full stack (CM+SM) model is not correlated. Modal test originally completed with heavyweight SM, but full model correlation was not obtained making transition to lightweight SM difficult analytically. CFT will fly lightweight SM.  | Modal testing with lightweight SM completed. Correlation efforts I/W. Should complete in December.  | ↑     | 🟡 🟢       |
| Abort Loads Analysis                                 | Risk that both primary and secondary structure (tanks, batteries, crew seats, e.g.) cannot withstand abort loads. This risk is due to differences in statistical binning of load cases which can cause un-conservative loads for which structure is evaluated.   | All data has been received. Boeing has agreed to assess all primary structure components with load indicator increases > 5%. Engineering judgement assessment is that impacts will be small. Boeing stress assessment ECD of late November  | ➡     | 🟢 🟢       |
| <b>Hazard Report Process</b>                         | Need to increase efficiency and integration of safety, engineering, and operations to enable success of Phase III HRs for CFT  | CFT tactical plans continue to be updated as deliveries have slipped. Dual STRBs in operation. Boeing SW PR process improved. Parachute HR being reworked. Estimating final STRB in February.   | ➡     | 🟢 🟢       |

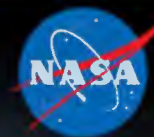
12/2/2022

**Bold** indicates issue joint with ISS

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# Boeing CFT Top Issues

Dan Bell

Associate Administrator Briefing  
25 February 2022

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# CFT Top Issue Summary Table (1 of 2)

| Trend       |             | Mitigation                       |                            |
|-------------|-------------|----------------------------------|----------------------------|
| ↑ Improving | ↓ Degrading | ■ Mitigation plan in development | ■ Mitigation steps in-work |
| → No change |             | ■ Executing to Plan              |                            |



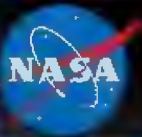
| Issue  | Summary  | Closure Plan or Next Step for CFT  | Trend | Prior/Now |
|--|--|--|-------|-----------|
| <b>OFT-2 Anomaly Investigation</b>                   | 13 of 24 SM oxidizer isolation valves failed to open prior to OFT-2 launch. Root cause might drive CFT SM re-work.   | Wait for conclusion of OFT-2 Anomaly Investigation Team and implement required mitigations for CFT.  | ↑     | ■ ■       |
| Parachutes   | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts  | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs. Finalizing closure plan for remaining technical issues  | ↑     | ■ ■       |
| LAE Fault Tolerance                                  | LAE pre-valve and main valves are OFT to leakage during pre-launch and ascent and 1FT while in free flight and docked; potential ISS contamination   | TIM complete. Initial tasks identifying options for forward path mitigation of potential leakage are in work   | ↑     | ■ ■       |
| <b>Landing Loads &amp; Landing System Complexity</b> | Potential for excessive landing loads (both hardware and crew injury) due to (1) Potential Limit Cycle or Medium Pendulum motion during descent can cause load exceedances (2) Boeing approach to landing margins do not allow easy assessment of increased loads            | Perform parachute testing to define pendulum model Boeing/NASA working to concur to initial conditions Analysis to be conducted when pendulum tests are complete Feasibility assessment in work for Gantry test if required. | ↑     | ■ ■       |
| Lightweight Service Module Model Correlation         | The CM Starliner FEM is fully correlated, but the full stack (CM+SM) model is not correlated. Modal test completed with heavyweight SM, but full model correlation was not obtained making transition to lightweight SM difficult analytically. CFT will fly lightweight SM. | Meeting held 2/4 to discuss testing forward paths; Boeing agree gap exists Evaluating SM2 for modal testing options  | →     | ■ ■       |
| Abort Loads Analysis                                 | Risk that both primary and secondary structure (tanks, batteries, crew seats, e.g.) cannot withstand abort loads. This risk is due to differences in statistical binning of load cases which can cause un-conservative loads for which structure is evaluated.               | Closure plan for CFT is for Boeing to assess primary structure load indicators with exceedances greater than 5%  | ↑     | ■ ■       |
| <b>Hazard Report Process</b>                         | Need to increase efficiency and integration of safety, engineering, and operations to enable success of Phase III HRs for CFT  | CFT tactical plans complete; CFT kickoff held 8/25; CCP/ISS agreed to hold parallel boards   | →     | ■ ■       |

**Bold** indicates issue joint with ISS



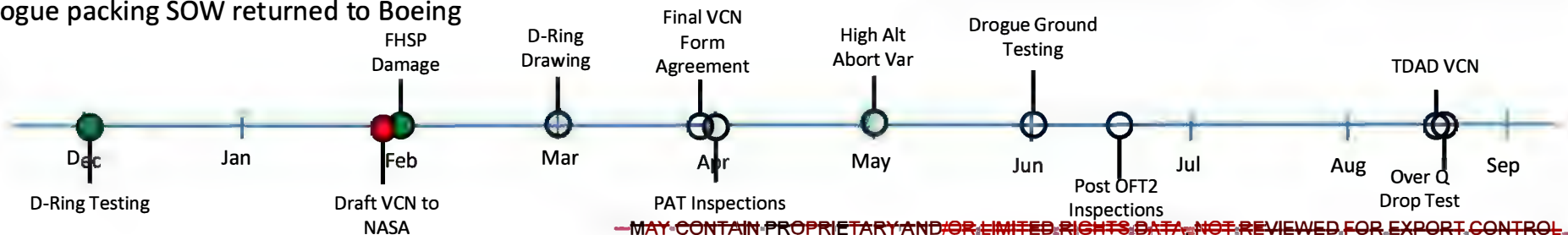
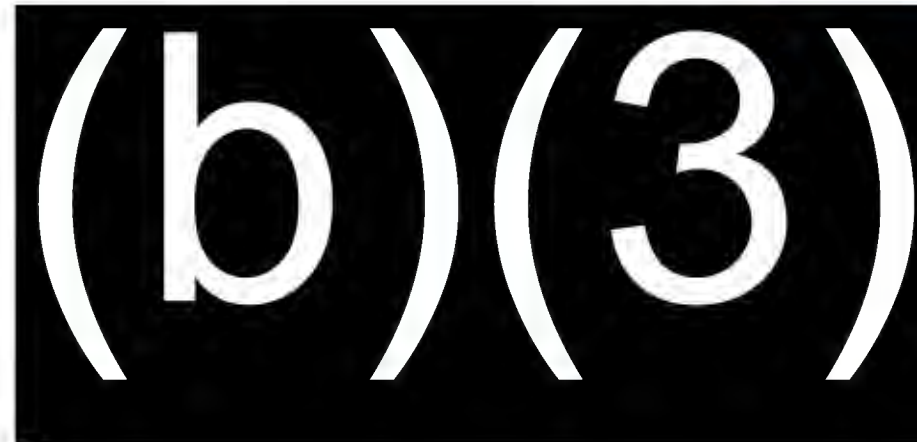
# Main Parachute Loading and FHS Drogue Chute Debris

|                |               |
|----------------|---------------|
| Boeing POC     | NASA POC      |
| Louis Atchison | Jim McMichael |



| Issue      | Summary   | Closure Plan or Next Step for CFT   | Trend | Mitigation |
|------------|---|---|-------|------------|
| Parachutes | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts | Single flight use of Starliner main parachutes for CFT+ waiver<br>Procuring new build main parachutes for PCM-1 and subs.<br>Finalizing closure plan for remaining technical issues | ↑     | ■          |

- FHS parachute technical discussion Complete
  - Boeing investigation complete, damaged FHSP to be provided to NASA
  - NASA will perform additional testing for CFT risk acceptance
- PAT parachute inspections in Yuma complete
  - Drogue parachutes currently can not be located, will need to be inspected at a future date
- High Alt. Abort variance discussed at the AIWG on 1/26/22
  - Cases above Mach 0.8 do not impact abort performance
  - PCB on 3/10
- Dart movement from WSMR to Yuma completed Feb 18<sup>th</sup>
- VCN compliance matrix/VCN deliveries deliveries delayed
- Drogue packing SOW returned to Boeing







# Boeing CFT Top Issues AA Briefing

Dan Bell  
July 13, 2022

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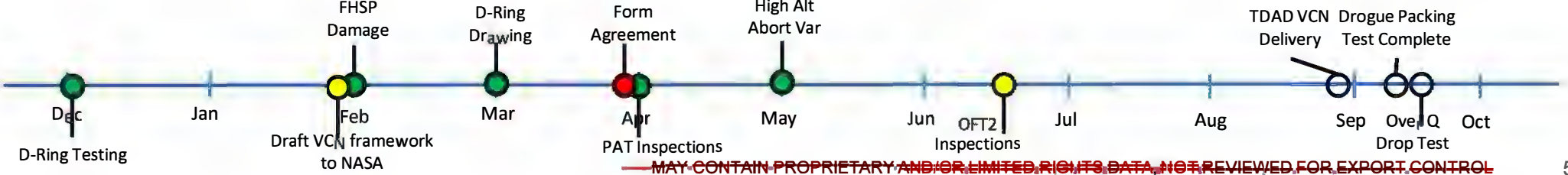
# OFT / CFT / PCM Parachute Design and Cert

|                |          |
|----------------|----------|
| Boeing POC     | NASA POC |
| Louis Atchison | Mark Dub |



| Issue      | Summary   | Closure Plan or Next Step for CFT  | Trend | Mitigation |
|------------|---|--|-------|------------|
| Parachutes | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs (at risk due to supply chain issues). Attempting to partner on closure plan for remaining technical issues | ➔     | ■          |

- OFT-1 FHSP Chute damage investigation completed. Unexplained anomaly. Flight rationale in work.
- Over-Q test work progressing - Path to closure on Drogues/Mains. Investigating previous FHSP test data to determine if path to closure on FHSP.
  - Boeing has identified OFT-1 chutes for delivery, require refurb and update, Expecting delivery of chutes 8/7, test targeting 9/13
- Drogue package change: ground pneumatic test and flight test (Over-q test) in work.
- CFT main installed at risk, pending data on 3x repack and responses to PAA Finding Letters (3)
  - Boeing running subscale packing test to quantify knockdown. Expect path to close.
- OFT-2 Parachute Inspection
  - Boeing putting Airborne on contract to do inspection – date TBD
- Began meeting weekly on VCN (philosophical until VCN delivery) and HR (identifying gaps in Controls), Boeing now plans VCN delivery NLT 8/26 with possible incremental deliveries. Based on initial VCN meetings, expect lengthy path to closure due to extensive disconnects, such as asymmetry modeling.
- PCM 1+ SOW design down selecting final design solution -PCB 5/18 approved baseline changes for FOS > 1.6 for NEW CHUTES
  - Boeing continues to evaluate new outer radial material for REUSE
    - Outer radial change would require additional full scale flight tests
- PCM-1 Main Chute plan, Boeing communicated inability to provide new design for Aug 2023 launch date
  - Boeing developing updated support plan



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# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Manager, Commercial Crew Program**  
**January 26, 2022**

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# CFT Top Issue Summary Table (1 of 2)

| Trend       |             | Mitigation                       |                            |
|-------------|-------------|----------------------------------|----------------------------|
| ↑ Improving | ↓ Degrading | ■ Mitigation plan in development | ■ Mitigation steps in-work |
| ↔ No change |             | ■ Executing to Plan              |                            |



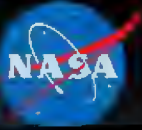
| Issue  | Summary  | Closure Plan or Next Step for CFT   | Trend | Prior/Now |
|--|--|---|-------|-----------|
| <b>OFT-2 Anomaly Investigation</b>                   | 13 of 24 SM oxidizer isolation valves failed to open prior to OFT-2 launch. Root cause might drive CFT SM re-work.   | Wait for conclusion of OFT-2 Anomaly Investigation Team and implement required mitigations for CFT  | ↑     | ■ ■       |
| Parachutes   | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts  | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs. Finalizing closure plan for remaining technical issues   | ↑     | ■ ■       |
| LAE Fault Tolerance                                  | LAE pre-valve and main valves are OFT to leakage during pre-launch and ascent and 1FT while in free flight and docked; potential ISS contamination   | TIM complete. Initial tasks identifying options for forward path mitigation of potential leakage are in work  | ↑     | ■ ■       |
| <b>Landing Loads &amp; Landing System Complexity</b> | Potential for excessive landing loads (both hardware and crew injury) due to (1) Potential Limit Cycle or Medium Pendulum motion during descent can cause load exceedances (2) Boeing approach to landing margins do not allow easy assessment of increased loads            | Perform parachute testing to define pendulum model Boeing/NASA working to concur to initial conditions Analysis to be conducted when pendulum tests are complete Feasibility assessment in work for Gantry test if required.  | ↑     | ■ ■       |
| Lightweight Service Module Model Correlation         | The CM Starliner FEM is fully correlated, but the full stack (CM+SM) model is not correlated. Modal test completed with heavyweight SM, but full model correlation was not obtained making transition to lightweight SM difficult analytically. CFT will fly lightweight SM. | Abort trade studies in work by NASA to define risk and provide justification for modal test; results expected Sept 2021. Meeting held 9/17 with Boeing to discuss analysis and/or testing forward paths; Boeing agrees gap exists. Evaluating SM-2 or SM6 for test. | ↑     | ■ ■       |
| Abort Loads Analysis                                 | Risk that both primary and secondary structure (tanks, batteries, crew seats, e.g.) cannot withstand abort loads. This risk is due to differences in statistical binning of load cases which can cause un-conservative loads for which structure is evaluated.               | Closure plan for CFT is for Boeing to assess primary structure load indicators with exceedances greater than 5%   | ↑     | ■ ■       |
| <b>Hazard Report Process</b>                         | Need to increase efficiency and integration of safety, engineering, and operations to enable success of Phase III HRs for CFT  | CFT tactical plans complete; CFT kickoff held 8/25; CCP/ISS agreed to hold parallel boards  | →     | ■ ■       |

**Bold** indicates issue joint with ISS





# Boeing Main Parachute Status (1 of 2)



| Issue      | Summary   | Closure Plan or Next Step for CFT   | Trend | Mitigation |
|------------|---|---|-------|------------|
| Parachutes | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts | Single flight use of Starliner main parachutes for CFT+ waiver<br>Procuring new build main parachutes for PCM-1 and subs.<br>Finalizing closure plan for remaining technical issues | ↑     | Yellow box |

## Background

- Significant improvement on understanding of Boeing parachute margins
- Multiple tests conducted to measure asymmetry targeting high riser loads
  - Additional asymmetry data collection allowed refinement of models
- Boeing/NASA TIM allowed alignment of assumptions for the margins assessment
- Technical teams agree that with the current margins, **no major redesign of the Boeing main parachute is required.**  
**Approved at PCB on September 16, 2021.**
  - Boeing parachutes will be only used for a single use
  - New parachute builds will explore higher strength materials and minor joint modification opportunities to reduce/eliminate the remaining negative margins



(b)(3)

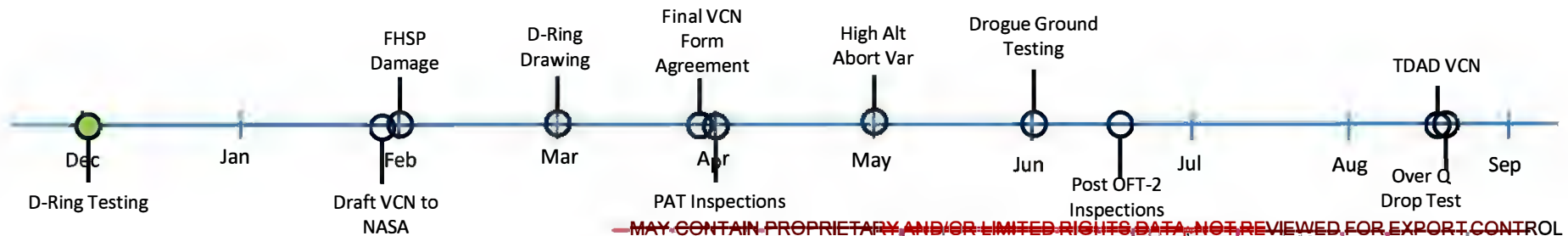
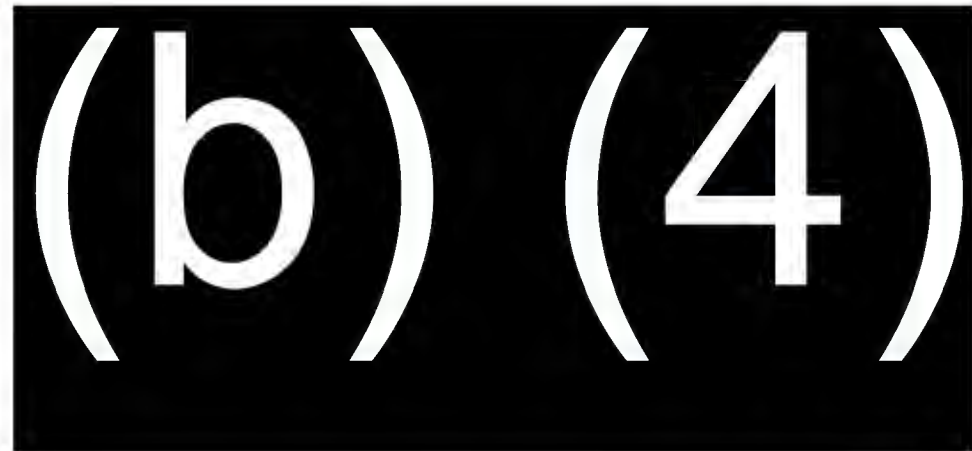


# Main Parachute Path to Certification (2 of 2)



- Boeing and NASA have developed plans and schedules to complete the remaining work required for CFT
  - Risk evaluation is being performed on a drogue mortar qualification deviation
  - Planning is in work for final qualification testing for a drogue parachute packing change
  - Agreement to conduct a High Q drop test using a Dart test article – complete parachute standard test requirements - planning in work
- Important delivery of draft VCN required **end of Jan** to assure full scope of work is understood for closure

## Parachute Certification Milestones



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# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Manager, Commercial Crew Program**  
**July 20, 2022**

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## CFT Top Issue Summary Table (1 of 2)



| Issue  | Summary  | Closure Plan or Next Step for CFT  |
|--|--|--|
| <b>OFT-2 Anomaly Investigation</b>                   | 13 of 24 SM oxidizer isolation valves failed to open prior to OFT-2 launch. Root cause might drive CFT SM re-work.   | Successful remediation during OFT2 flight. Same approach planned for CFT. Boeing working design changes with Mfg   |
| Parachutes   | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts  | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs (at risk due to supply chain issues). Attempting to partner on closure plan for remaining technical issues         |
| LAE Fault Tolerance                                  | LAE pre-valve and main valves are OFT to leakage during pre-launch and ascent and 1FT while in free flight and docked; potential ISS contamination   | Conceptual designs complete. Testing of leak detection sensors to begin July 18 and run through July 30. Schedule assessment of Leak Overboard option shows significant risk to closure by CFT. Down select briefing to program 7/5. |
| <b>Landing Loads &amp; Landing System Complexity</b> | Potential for excessive landing loads (both hardware and crew injury) due to (1) Potential Medium Pendulum motion or yaw angles during descent can cause load exceedances (2) Boeing approach to landing margins do not allow easy assessment of increased loads (3) Boeing loads analysis campaign schedule being assisted with NASA computational assets to bring in completion date to the left | Parachute modelling update based on NMPAT testing is complete and analysis in work. Additional conditions including yaw being incorporated in analysis prior to CFT<br>Assessment in work for Gantry test if required.               |
| Service Module Modal Correlation                     | The CM Starliner FEM is fully correlated, but the full stack (CM+SM) model is not correlated. Modal test completed with heavyweight SM, but full model correlation was not obtained making transition to lightweight SM difficult analytically. CFT will fly lightweight SM.   | SM2 to ship to WSTF on 7/7<br>Modal testing planned in September with first review of results within 2 months of test  |
| Abort Loads Analysis                                 | Risk that both primary and secondary structure (tanks, batteries, crew seats, e.g.) cannot withstand abort loads. This risk is due to differences in statistical binning of load cases which can cause un-conservative loads for which structure is evaluated.   | Closure plan for CFT is for Boeing to assess primary structure load indicators with exceedances greater than 5%  |
| <b>Hazard Report Process</b>                         | Need to increase efficiency and integration of safety, engineering, and operations to enable success of Phase III HRs for CFT  | CFT tactical plans complete. Dual STRBs in operation. Boeing SW PR process improved. Boeing VTL improved. SW Safety Assessments aligned to HR deliveries.  |

**Bold** indicates issue joint with ISS

# OFT / CFT / PCM Parachute Design and Cert



| Issue      | Summary   | Closure Plan or Next Step for CFT  |
|------------|---|--|
| Parachutes | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs (at risk due to supply chain issues). Attempting to partner on closure plan for remaining technical issues |

- OFT-1 FHSP Chute damage investigation completed. Unexplained anomaly. Flight rationale in work.
- Over-Q test work progressing - Path to closure on Drogues/Mains. Investigating previous FHSP test data to determine if path to closure on FHSP.
  - Boeing has identified OFT-1 chutes for delivery, require refurb and update, Expecting delivery of chutes 8/7, test targeting 9/13
- Drogue package change: ground pneumatic test and flight test (Over-q test) in work.
- CFT main installed at risk, pending data on 3x repack and responses to PAA Finding Letters (3)
  - Boeing running subscale packing test to quantify knockdown. Expect path to close.
- OFT-2 Parachute Inspection
  - Boeing putting Airborne on contract to do inspection – date TBD
- Began meeting weekly on VCN (philosophical until VCN delivery) and HR (identifying gaps in Controls), Boeing now plans VCN delivery NLT 8/26 with possible incremental deliveries. Based on initial VCN meetings, expect lengthy path to closure due to extensive disconnects, such as asymmetry modeling.
- PCM 1+ SOW design down selecting final design solution -PCB 5/18 approved baseline changes for FOS > 1.6 for NEW CHUTES
  - Boeing continues to evaluate new outer radial material for REUSE
    - Outer radial change would require additional full scale flight tests
- PCM-1 Main Chute plan, Boeing communicated inability to provide new design for Aug 2023 launch date
  - Boeing developing updated support plan



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# Commercial Crew Program Status to ASAP

**Steve Stich**  
**Manager, Commercial Crew Program**  
**October 25, 2022**

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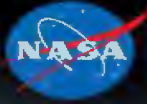
# OFT / CFT / PCM Parachute Design and Cert



| Issue      | Summary   | Closure Plan or Next Step for CFT  |
|------------|---|--|
| Parachutes | Main parachutes do not have required factors of safety when accounting for asymmetry loading. Parachute loads not expected to meet the factors of safety with the current con-ops for 1a aborts | Single flight use of Starliner main parachutes for CFT and procuring new build main parachutes for PCM-1 and subs (at risk due to supply chain issues). Attempting to partner on closure plan for remaining technical issues |

- **OFT-1 FHSP Chute damage investigation completed. Unexplained anomaly. Flight rationale in work.**
- **Over-Q test work progressing - Path to closure on NPCQT-01 (Drogues/Mains Over-Q Test) targeting NET 11/14.**
  - Investigation of previous FHSP test data to determine if path to closure on FHSP is complete and NASA has determined test data did not demonstrate FHSP deployment in Over-Q conditions. Test proposal at PCB 10/28.
- **Drogue package change: ground and flight test (NPCQT-01) in work. Bench strip test completed 9/9, Pneumatic Mortar test NET November.**
- **CFT main installed at risk, pending data on 3x repack and responses to PAA Finding Letters (3):**
  - Boeing running subscale packing test to quantify knockdown. Boeing advised 10/11/22 test completion at risk prior to February 2023 CFT launch date.
- **OFT-2 Parachute Inspection – Postflight OEM inspection complete. No significant damage was reported in-process. Final report delivered 10/18/22.**
- **Began meeting weekly on VCN (philosophical until VCN delivery) and HR (identifying gaps in Hazard Controls). Boeing recently added resources to support VCN delivery: Was 9/30/22. Revised planning in work. Planned delivery now November 2022 with possible incremental deliveries earlier. Based on initial VCN meetings and analogous certification experience, expecting ~6-month review cycle for closure.**
- **PCM-1+ SOW design downselecting final design solution. PCB-22-187 approved baseline changes for FOS > 1.6 for NEW (first-flight) parachutes PCM-1+.**
  - Boeing continues to evaluate new outer radial material for REUSE; change would require additional full scale flight tests.
- **PCM-1 Main Chute production: Boeing communicated inability to provide new design for Aug 2023 launch date due to supply chain issues.**
  - Earliest available shipset for PCM-1 from vendor on-dock at Boeing NET 9/30/2023. Parachutes required on-dock NET L-minus 6 months to install.





# Commercial Crew Program Status to GAO for Quick Look Book (#105212)

**Steve Stich**  
**Manager, Commercial Crew Program**  
**January 19, 2022**

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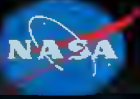
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# Boeing Parachute Status



## Asymmetry Parachute Testing

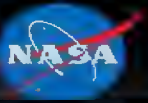
- (b)(3)  
[Redacted]
- (b)(3)  
[Redacted]
- (b)(3)  
[Redacted]
- **Prior material capabilities used in margin calculations were based on a factors of material spec capability, and joint efficiency**
  - CCP has introduced utilizing A-basis material calculations for the parachute joints measuring actual statistical capability
  - Parachute capabilities were measured on ground test and flight parachutes to include environmental exposures

**CCP test efforts are leading to a more accurate understanding of margin for CCP crews, but have also expanded the knowledge basis for successful design and certification of future NASA program parachute systems**

| Test Number | Asymmetry | Pendulum |
|-------------|-----------|----------|
| NMPAT 01    | X         |          |
| NMPAT 02    | X         |          |
| NMPAT 03    | X         |          |
| NMPAT 04    | X         |          |
| NMPAT 05    | X         |          |
| NMPAT 06    | X         |          |
| NMPAT 07    | X         | X        |
| NMPAT 08    | X         | X        |
| NMPAT 09    | X         | X        |
| NMPAT 10    | X         | X        |
| NMPAT 11    | X         | X        |



# Boeing Parachute Status



## Boeing Main Parachute Status

### Application of data collected for Boeing Margins

- Significant improvement on understanding of Boeing parachute margins
- Multiple tests conducted to measure asymmetry targeting high riser loads
  - Additional asymmetry data collection allowed refinement of models
- Boeing/NASA TIM allowed alignment of assumptions for the margins assessment
  - Some differences remain in the analysis approach, but Boeing margins essentially align with those calculated by the NASA parachute team
- NASA technical teams agree that with the current margins, **no major redesign of the Boeing main parachute is required. Approved at PCB on September 15, 2021.**
  - Boeing parachutes will be only used for a single use
  - New parachute builds will explore higher strength materials and minor joint modification opportunities to reduce/eliminate the remaining negative margins



(b)(3)

(b)(3)

**Significant progress has been made on the understanding of the parachute margins. No major redesign of the main parachutes will be required.**



# Boeing Parachute Status – Forward Path



## Additional Technical Work to be Completed Prior to CFT

- **NASA/Boeing evaluating the remaining work required for certification**

- **CFT Main Parachute Modifications and Joint Qualification**

- NASA Identified a high-confidence redesign option for the Boeing Mains arming lanyard joint that has been tested in recent NMPAT tests
- Airborne will retrofit the design into the CFT mains (removing the 2K lines) and perform joint testing on their final implementation to verify performance

- **Boeing High Altitude Abort Variance**

- Addresses gap between potential abort altitude and drop tests
- NASA team is reviewing supporting data provided by Boeing

- **FHS Chute Damage incurred on OFT-1 (Night Landing)**

- Possible causes - Jettisoned HW recontact or unknown debris
- CCP has funded WB-57 landing imagery for OFT-2

- **Drogue Packing Procedure Modification**

- Damage on PCRT-3 test due to RLC hang up on skirt band, D-Bag liner
- Evaluating scope of Ground Testing that will confirm effectiveness of procedure change, remaining risk acceptance (no system level tests)

- **Dynamic pressure requirement compliance**

- (b)(3)
- Will require an overload test, or risk acceptance for the rare (abort + drogue failure) case

- **Main Chute Restraint System Changes (Bent D-ring) Complete**

- CFT restraint system must be replaced to eliminate issues
- Eliminates possibility of D-ring yielding enough to prevent the release of D-bag and creating a pilot parachute in tow with no main out
- Partnered Ground test campaign will verify changes, remaining risk acceptance (no system level tests)

(b)(3)

(b)(3)



# Boeing Parachute Status – Forward Path



## Remaining Parachute Drop Test Campaign

- **Highly successful NMPAT test campaign generating both Asymmetry and Pendulum data**
  - NASA team including a mass drop in pendulum tests 7-11 allowing secondary objective asymmetry data to be collected
  - Reducing uncertainty/improving margins
- **Pendulum tests conducted have not generated limit cycle pendulum**
  - Tests represent real vehicle mass
  - Low wind conditions during the drops
  - Remaining 2 tests held to winter (Dec-Jan) to assure envelope of available winds are tested
- **Single additional drop test to address the higher Q limit identified for aborts may be required to close out Boeing Parachute certification**





## IV&V CFT Schedule

**Kim Ess**  
**Integrated Performance**

**07/13/22**

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# Parachute Analysis



- **Requirement R.CTS.291**
  - Trailing Deployable Aerodynamic Decelerator Design
    - The integrated space vehicle shall meet the intent of JSC 65985, Requirements for Human Spaceflight for the Trailing Deployable Aerodynamic Decelerator (TDAD) during the design and development of parachute and other similar systems.
- **Past tests varied number of mains, drogues, dynamic pressure range, suspension lines, suspended weight, to provide input to models**
  - Commercial Crew Parachute Airdrop Test (CCPAT) Project / NASA Main Parachute Asymmetry Test (NMPAT)
- **NMPAT informs the pendulum and landing loads IV&V effort**
- **Pendulum IV&V effort complete and in review**
- **Other IV&V tasks for Parachutes**
  - Margins analysis of the parachutes
  - Analysis of suspension line loads
  - Creation of inflation parameter dispersion models (EDL, Aborts)





# CUI

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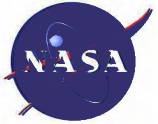
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# CUI



# Major Program Review

**Commercial Space Division (CSD)**

**Commercial Crew Program (CCP) Overview**

**Phil McAlister, CSD Division Director**



# CCP Dashboard

**Trend Status**

Improving
 No Change
 Declining

**Legend**

- Minimal Issues, on plan
- Issues, mitigation in work or in place to meet plans
- Issues, plans unlikely to be met without impact and/or additional resources

**MAJOR CHANGES SINCE LAST MPR**

- Additional Post Certification Missions (PCM) acquired from SpaceX. CCtCap contract now includes PCM 7, 8, & 9.

**COST PERFORMANCE** ●

**(b) (4)**

**SCHEDULE PERFORMANCE** ●

- Boeing certification currently scheduled for 2023
- CREW 4 on track for April 2022 launch.
- OFT-2 anticipated in May 2022

**TOP RISKS**

|  | Nov                                   | Feb                                   |
|--|---------------------------------------|---------------------------------------|
| Increased risk of crew injury during landing due to under-predicted occupant responses | <span style="color: red;">●</span>    | <span style="color: red;">●</span>    |
| Availability of DoD Search and Rescue Assets   | <span style="color: yellow;">●</span> | <span style="color: yellow;">●</span> |
| Reimbursement of DoD Military Personnel Appropriation (MPA) Days                       | <span style="color: white;">○</span>  | <span style="color: yellow;">●</span> |

**WATCH ITEMS**

**(b) (4)**

**CONTRACT EVM STATUS (QTRLY)**

- Not Applicable

**TECHNICAL PERFORMANCE** ●

- The OFT-2 flight currently is on hold pending resolution of an oxidizer valve issue within Starliner's Service Module.

**CONTRACTOR PERFORMANCE**

- Contractor performance nominal

**UPCOMING EVENTS**

|                                  |                  |
|----------------------------------|------------------|
| SpaceX CREW-4 LRR                | Apr 21           |
| SpaceX CREW-4 Launch             | Apr 23           |
| Boeing OFT-2 FTRR                | May 6            |
| Boeing OFT-2 LRR                 | May 17 (U/R)     |
| Boeing OFT-2 Launch (not public) | NET May 19 (U/R) |



# CCP/Boeing: Red Issues



PROGRAM OVERALL

## Technical Performance

Issue: (b)(3)

### Mitigation:

- Asymmetry TIM conducted allowing convergence of analytical approaches and assumptions
- NASA/Boeing agreed on utilization of pendulum testing conditions including a mass drop to generate highly loaded conditions where asymmetry data was missing

### Status:

- Additional testing successful in defining high load asymmetry reducing the impact on margins
- New margins calculated allow CCP to move forward without the need for significant redesign **for CFT single flight use**
- **Procuring new build main parachutes for PCM-1 and subsequent flights and finalizing closure plan for remaining technical issues**