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CST-100 STARLINER: Boeing's Commercial Crew Program

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Boeing, Manager Manufacturing Engineering

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Boeing’s Commercial Crew Program
Danom Buck, Manager
Manufacturing Engineering
Space Congress
May 24, 2016
United Launch Alliance Atlas V Rocket
- More than 60 successes and counting!
- Proven rocket significantly reduces system risk
- Human-rating of Space Launch Complex 41 at Cape Canaveral Air Force Station in progress

CST-100 Starliner Spacecraft
- Flight-proven systems, high-technology readiness level
- Firm configuration established

Mission Operations
- Integrated with the world’s experts on mission control: NASA Mission Operations Directorate
- Crew engagement through plan, train and fly phases

Ground Processing Operations
- Commercial Crew and Cargo Processing Facility modernized at NASA’s Kennedy Space Center
- Lean production based on Boeing’s commercial approach
- Integration testing and quality processes based on space shuttle and International Space Station approaches
Starliner Spacecraft

- Ascent Cover
- Forward Window
- Side Window
- Vacuum Vent
- Perforated Ring
- Radiators
- Thruster Doghouses
- Forward Heat shield
- Side Hatch
- CM/SM Umbilical
- LAS Pitch/Yaw Thrusters
- LAS Escape Thrusters
- LAS Abort System (LAS) Roll Thrusters
- MMOD Shields
- Solar Panels
- Cargo & Crew Provisions
- GLACIER

**SEATING FOR SEVEN**
(5 CREW + 2 CREW EQUIVALENT OF CARGO SHOWN)

**CLAM SHELL DESIGN**
allows for easy hardware installation

**FLEXIBLE CABIN DESIGN**
accommodates mix of crew and cargo
Atlas V Launch Vehicle

Legend
- **Black** = Heritage
- **Blue** = New Systems

- Environmental Seal
- Crew Access Arm and White Room
- Emergency Egress System
- Launch Vehicle Adapter
- Centaur Forward Adapter
- Common Centaur
- Centaur Aft Stub Adapter
- 400 Series Interstage Adapter
- Aft Transition Structure
- Heat Shield
- CST-100 Starliner
- Emergency Detection System and Software
- Dual Engine Centaur Two RL-10A-4-2
- Atlas Booster
- Solid Rocket Boosters (2)
- RD-180 Engine
- Atlas V Launch Vehicle

Mature System Design
Structural Test Article build-up in Commercial Crew and Cargo Processing Facility at Kennedy Space Center, Florida

Spacecraft 1 hardware progressing across supply base and arriving to Commercial Crew and Cargo Processing Facility at Kennedy Space Center, Florida
Starliner performs first contingency water drop qualification test at Langley Research Center, Virginia

NASA and Det 3 rehearse rescue and recovery operations with Starliner

Crew Access Arm and White Room undergoing testing through various lighting conditions in Oak Hill, Florida
Astronauts receive Atlas V familiarization training with United Launch Alliance in Decatur, Alabama

Astronaut Megan McArthur visits LIDAR manufacturer in Santa Barbara, California

Astronaut Ricky Arnold visits ECLSS manufacturer in Connecticut

Astronauts run through simulations on Crew Part-Task Trainers built in St. Louis
## What's Next? Qualification Test Campaign

<table>
<thead>
<tr>
<th>Test</th>
<th>Location</th>
<th>Primary Purpose</th>
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</table>
| Structure Verification Testing                  | NASA Kennedy Space Center, Florida & Huntington Beach, California | • CST-100 structure verification  
  • Modal survey  
  • Structures loading for critical load conditions  
  • Structural integrity  
  • Ordnance-actuated device shock levels  
  • Separation system performance  
  • FEM validation |
| Service Module Hot Fire Test                    | NASA White Sands Test Facility, New Mexico    | • Demonstrate integrated propulsion system performance and system dynamics         |
| Ground Verification Testing / Environmental Qualification Testing | NASA Kennedy Space Center, Florida & El Segundo, California | • Perform vehicle-level environmental verification testing and system-level non-chamber qualification:  
  • Verify system performance verification  
  • Electromagnetic compatibility  
  • Thermal vacuum and acoustic environments |
# What’s Next? Qualification Test Campaign

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| Full-Scale Crew Module Drop Tests              | Dugway Proving Ground, Utah & NASA Langley Research Center, Virginia | • Verify spacecraft landing impact attenuation performance  
• Verify parachute system performance, forward heat shield separation and base heat shield jettison across various nominal and off-nominal conditions |
<p>| Integrated System Verification Test (ISVT)     | Multiple                                | • Demonstrate the integrated spacecraft / space station performance                                                                          |
| End-to-End (E2E)                               | Multiple                                | • Complete crew transportation system end-to-end connectivity and integration across the segments and external interfaces                         |
| Pad Abort Test (PAT)                           | NASA White Sands Test Facility, New Mexico | • Demonstrate the abort system performance                                                                                                    |
| Orbital &amp; Crew Flight Tests (OFT, CFT)        | Multiple                                | • Demonstrate complete crew transportation system orbital mission – uncrewed flight test and crewed flight test to space station               |</p>
<table>
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<th><strong>Test Articles</strong></th>
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<tr>
<td>Structural Test Article Crew Module – Structure Verification Testing; Training Article</td>
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<td>Structural Test Article Service Module – Structure Verification Testing</td>
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<tr>
<td>Service Module – Hot Fire Testing</td>
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<tr>
<td>* <strong>Test Articles in flow in C3PF at Kennedy Space Center</strong> *</td>
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<th><strong>Spacecraft 1</strong></th>
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<tr>
<td>Crew Module – Ground Verification Testing; Pad Abort Test</td>
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<tr>
<td>Service Module – Ground Verification Testing; Pad Abort Test</td>
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<tr>
<td>* <strong>Spacecraft 1 hardware in C3PF at Kennedy Space Center with more on the way</strong> *</td>
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<tr>
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<tbody>
<tr>
<td>Crew Module – Environmental Qualification Testing; Crew Flight Test; PCM-2</td>
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<tr>
<td>Service Module – Environmental Qualification Testing; Crew Flight Test</td>
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<tr>
<td>* <strong>Spacecraft 2 hardware in production via supply base</strong> *</td>
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<th><strong>Spacecraft 3</strong></th>
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<tr>
<td>Crew Module – Orbital Flight Test; PCM-1</td>
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<tr>
<td>Service Module – Orbital Flight Test</td>
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<tr>
<td>* <strong>Progressing through unit and subsystem build via supply base</strong> *</td>
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