NASAfacts

Commercial Crew Development Round 2

NASA's Commercial Crew Program (CCP) is investing in multiple American companies that are designing and developing transportation capabilities to and from low Earth orbit and the International Space Station (ISS).

Through the development and certification processes, NASA is laying the foundation for future commercial transportation capabilities. Ultimately, the goal is to lead to safe, reliable, affordable and more routine access to space so that commercial partners can market transportation services to the U.S. government and other customers.

After a transportation capability is certified, NASA would be able to purchase transportation services to meet its ISS crew rotation and emergency return obligations.

Through Commercial Crew Development Round 2 (CCDev2), NASA awarded $270 million in 2011 for the development of commercial rockets and spacecraft. This development round will be completed in mid- to late-2012.

The industry partners with whom NASA signed funded Space Act Agreements (SAAs) are Blue Origin, The Boeing Co., Sierra Nevada Corp. and Space Exploration Technologies (SpaceX).

The agency also signed unfunded agreements to establish a framework of collaboration with additional aerospace companies. As part of those agreements, NASA is reviewing and providing expert feedback to Alliant Techsystems Inc. (ATK), United Launch Alliance (ULA) and Excalibur Almaz Inc. (EAI) on overall concepts and designs, systems requirements, launch vehicle compatibility, testing and integration plans, and operational and facilities plans.

To find out more about the beginning of a new era in space exploration and NASA's Commercial Crew Program, visit **www.nasa.gov/commercialcrew**.

ATK
Liberty

NASA INVESTMENT: Unfunded
PROFILE: Solid rocket boosters, Ariane 5 core stage, Vulcain 2 engine
CAPABILITY: 44,500 pounds to low Earth orbit

NASA and Alliant Techsystems Inc. (ATK) of Promontory, Utah, signed a Space Act Agreement (SAA) in September 2011 for the company's Liberty Launch Vehicle. Under the unfunded agreement, NASA's Commercial Crew Program (CCP) and ATK are exchanging technical information to aid in the development of Liberty as a commercial crew transportation provider.

Liberty's design combines the company's solid rocket boosters (SRBs) as the first stage and Astrium's Ariane 5 core stage and Vulcain 2 engine as the upper stage. The Ariane 5 rocket motors would form a two-stage launch vehicle with a single engine per stage. Astrium is a subsidiary of the European space company EADS.

Liberty's five-segment solid rocket first stage is derived from the Space Shuttle Program's four-segment solid rocket boosters. The Liberty first stage booster is capable of producing 3.6 million pounds of thrust at liftoff, roughly the same power as 63 four-engine 747 jets taking off. The five-segment first stage stands 154 feet tall. Combined with a modified Ariane 5 core stage as its upper stage, Liberty would be capable of carrying up to 44,500 pounds to low Earth orbit. Service and crew modules would be integrated to the top of Liberty in order to carry cargo and astronauts.

Other Liberty team members include United Space Alliance (USA) of Houston for launch vehicle integration and ground operations support and L-3 Communications of Cincinnati for first-stage avionics.

For more on ATK and Liberty, visit **www.atk.com**.

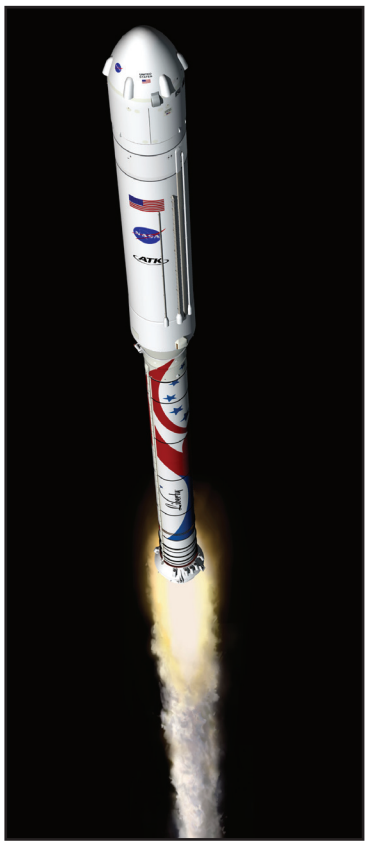

Image courtesy of ATK

Boeing
CST-100

NASA and The Boeing Company of Houston signed a funded Space Act Agreement (SAA) in March 2011 for the company's CST-100. Under the $92.3 million agreement, NASA's Commercial Crew Program (CCP) and Boeing are working to advance the company's Commercial Space Transportation System (CST). Optional milestones also were approved, valued at $20.6 million.

The CST-100 is a reusable, capsule-shaped spacecraft designed to take up to seven people, or a combination of people and cargo, to low Earth orbit, including the International Space Station (ISS).

The company has designed its spacecraft to be compatible with a variety of expendable launch vehicles and has selected United Launch Alliance's Atlas V rocket for initial CST-100 test flights.

Boeing also partnered with Pratt and Whitney Rocketdyne of Hartford, Conn., for the development of the spacecraft's Launch Abort Engine (LAE). The LAE combines Attitude Control Propulsion System thrusters from heritage spaceflight programs with a Bantam abort engine design and storable propellant engineering capabilities.

For more on Boeing and the CST-100, visit **www.boeing.com**.

NASA INVESTMENT: $92.3 million, plus $20.6 million in optional milestones
PROFILE: Crew module and service module
LANDING: Dry surface
CAPABILITY: Seven astronauts or equivalent crew and cargo

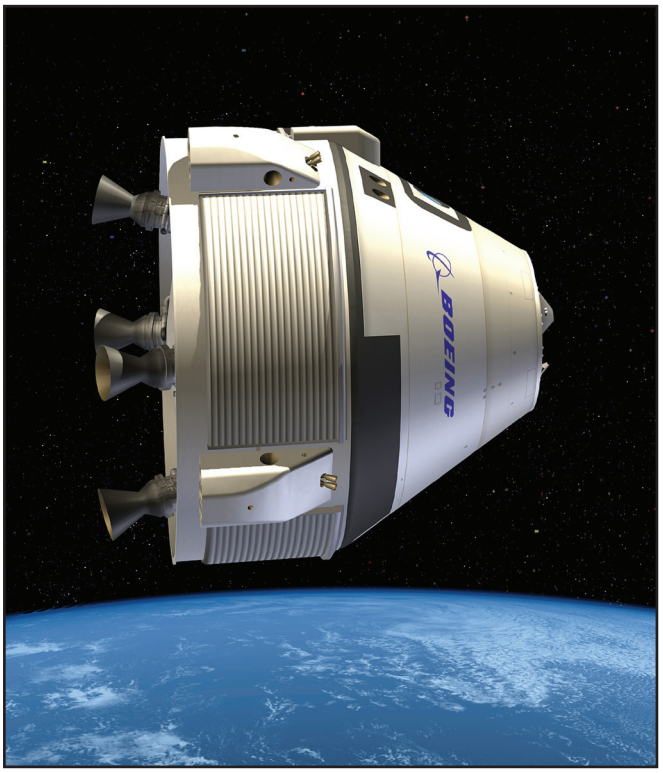

Image courtesy of Boeing

Blue Origin
Space Vehicle

Image courtesy of Blue Origin

NASA INVESTMENT: $22 million
PROFILE: Biconical spacecraft
LAUNCH: Atlas V rocket initially, then reusable booster stage
CAPABILITY: Four astronauts

NASA and Blue Origin of Kent, Wash., signed a funded Space Act Agreement (SAA) in March 2011 for the company's Space Vehicle. Under the $22 million agreement, NASA's Commercial Crew Program (CCP) and Blue Origin are working to advance the company's orbital concepts into a system capable of transporting four astronauts to low Earth orbit.

The Space Vehicle is designed to launch first on a United Launch Alliance Atlas V rocket and then on Blue Origin's reusable booster stage. The Space Vehicle would be capable of transporting four NASA crew members, wearing pressure suits, to the International Space Station. Missions would launch from Space Launch Complex-41 at Cape Canaveral Air Force Station, adjacent to NASA's Kennedy Space Center in Florida, and land at a Blue Origin facility in west Texas.

Blue Origin is performing wind tunnel testing at Lockheed Martin's High Speed Wind Tunnel Facility in Dallas to verify the spacecraft's aerodynamics. The company also is testing a pusher escape system that would rescue a crew if an emergency were to occur during launch or ascent, as well as the thrust chamber assembly (TCA) for the BE-3 100,000-pound thrust liquid oxygen, liquid hydrogen rocket engine that eventually would power the launch vehicle's reusable booster system.

For more on Blue Origin and the Space Vehicle, visit **www.blueorigin.com**.

Excalibur Almaz
Human Spacecraft

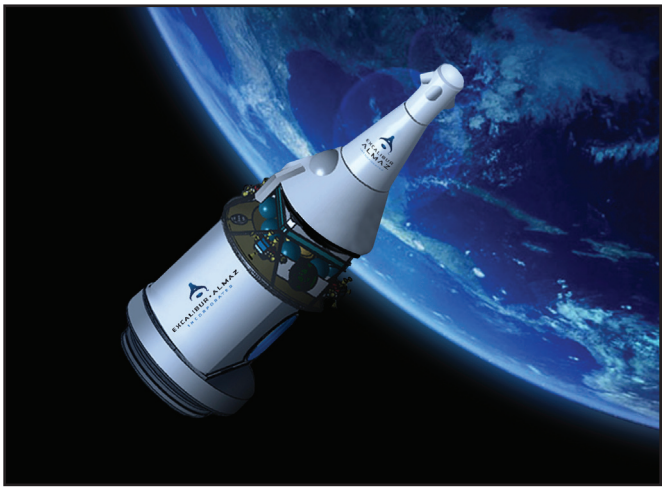

Image courtesy of Excalibur Almaz Inc.

NASA INVESTMENT: Unfunded
PROFILE: Human Spacecraft, which includes a capsule, launch abort system and expendable service module
LANDING: Ground landing
CAPABILITY: Three astronauts and/or cargo

NASA and Excalibur Almaz Inc. (EAI) of Houston signed a Space Act Agreement (SAA) in October 2011 for the company's Human Spacecraft. Under the unfunded agreement, NASA's Commercial Crew Program (CCP) and EAI are working to refurbish and upgrade the company's existing capsules with modern flight capabilities to launch humans to low Earth orbit.

During the partnership, NASA and EAI are conducting reviews of the Human Spacecraft's overall design, systems requirements, launch vehicle compatibility, testing plans, and operational and facilities plans. The company's heritage capsules, tested decades earlier, now will be upgraded with new internal systems and a service module to accommodate three crewmates during trips to low Earth orbit.

Astrium is providing EAI with propulsion subsystems, guidance and navigation and control components. Paragon Space Development Corp. of Houston is providing the Environmental Control and Life Support Systems (ECLSS). Lockheed Martin of Houston is performing systems engineering and integration while United Space Alliance of Houston is providing flight and ground operations support.

For more on Excalibur Almaz Inc. and the Human Spacecraft, visit **www.excaliburalmazinc.com**.

Sierra Nevada
Dream Chaser

NASA and Sierra Nevada Corp. (SNC) of Louisville, Colo., signed a funded Space Act Agreement (SAA) in March 2011 for the company's Dream Chaser spacecraft. Under the $80 million agreement, NASA's Commercial Crew Program (CCP) and Sierra Nevada are working to advance the company's reusable lifting-body spacecraft. Optional milestones also were approved, valued at $26.5 million.

The Dream Chaser is derived from NASA's HL-20, which somewhat resembles NASA's space shuttles and boasts years of development, analysis and wind tunnel testing by the agency's Langley Research Center in Hampton, Va.

Plans for the spacecraft include launching vertically and free-flight capabilities in low Earth orbit to dock with the International Space Station. Dream Chaser currently is the only Commercial Crew Development Round 2 (CCDev2) vehicle being developed with wings and the ability to land on a conventional runway.

Under the SAA, the company is developing non-toxic and storable propellants and assessing the vehicle's flight control surfaces and associated mechanisms required for flight.

Milestones under the agreement include a captive-carry completed May 29 and free-flight test of a full-scale prototype to test the vehicle's approach and landing performance. A simulator consisting of a physical cockpit layout and integrated simulation hardware and software also will assist Dream Chaser engineers in evaluating the vehicle's characteristics during the piloted phases of flight.

NASA INVESTMENT: $80 million, plus $25.6 million in optional milestones
PROFILE: Piloted lifting-body spacecraft
LANDING: Runway
CAPABILITY: Up to seven astronauts and cargo

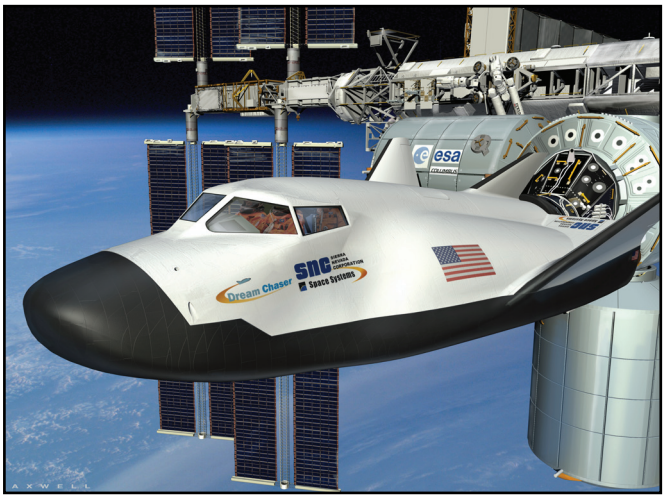

Image courtesy of Sierra Nevada Corp.

The all-composite structure was designed by the SNC team and built in conjunction with SNC Dream Chaser team organizations AdamWorks of Centennial, Colo., Applied Composite Technology of Gunnison, Utah, and Scaled Composites of Mojave, Calif.

For more on Sierra Nevada and Dream Chaser, visit **www.sncorp.com**.

SpaceX
Dragon

NASA and Space Exploration Technologies (SpaceX), of Hawthorne, Calif., signed a funded Space Act Agreement (SAA) in April 2011 for the company's Dragon capsule. Under the $75 million agreement, NASA's Commercial Crew Program (CCP) and SpaceX are working to outfit Dragon with life support systems and a launch abort system.

The reusable spacecraft is designed to launch atop the company's Falcon 9 rocket and would be capable of carrying up to seven astronauts to low Earth orbit. After a mission, the spacecraft would return to Earth's atmosphere with a parachute landing in the ocean. The company also is working on ground landing capabilities for the future.

The Dragon capsule currently is contracted to fly cargo-only missions to the space station for NASA's Commercial Resupply Services (CRS) Program. In 2010, the capsule became the first commercially developed spacecraft to return from Earth's orbit during a demonstration flight for the agency's Commercial Orbital Transportation Services (COTS) program.

Under the SAA, SpaceX is performing crew accommodation checks of its capsule and testing its SuperDraco engines. Eight SuperDracos would be built into the sidewalls of Dragon to carry astronauts to safety should an emergency occur during launch or ascent.

For more on SpaceX and Dragon, visit **www.spacex.com**.

NASA INVESTMENT: $75 million
PROFILE: Free-flying, reusable spacecraft
LANDING: Ocean initially, then ground
CAPABILITY: Seven astronauts

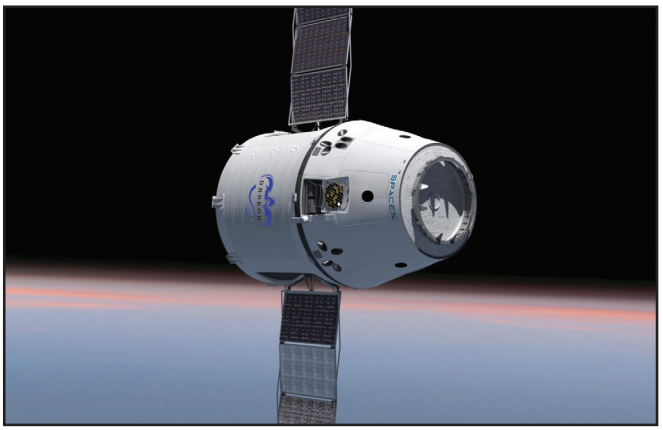

Image courtesy of SpaceX

ULA
Atlas V

NASA and United Launch Alliance (ULA) of Centennial, Colo., signed a Space Act Agreement (SAA) in July 2011 regarding the company's Atlas V rocket. Under the unfunded agreement, ULA is sharing its work to human-rate the Atlas V with NASA's Commercial Crew Program (CCP). The agency already relies on the Atlas V to launch complex scientific and robotic missions to space.

ULA is giving NASA an extensive look into its safety-critical launch vehicle systems, including the details of failure modes and effects analyses data from previous NASA missions, such as New Horizons, Juno and the Mars Science Laboratory.

Three of the four funded Commercial Crew Development Round 2 (CCDev2) partners have selected Atlas V as their launch vehicle including Sierra Nevada with its Dream Chaser, The Boeing Co. with its CST-100 spacecraft and Blue Origin for its Space Vehicle.

For more on ULA and the Atlas V, visit **www.ulalaunch.com**.

NASA INVESTMENT: Unfunded
PROFILE: Atlas core stage, Centaur upper stage and option for up to five solid rocket boosters
PROPULSION: More than 860,000 pounds of thrust from core stage at liftoff
CAPABILITY: Flexibility to launch different crew spacecraft

Image courtesy of United Launch Alliance

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