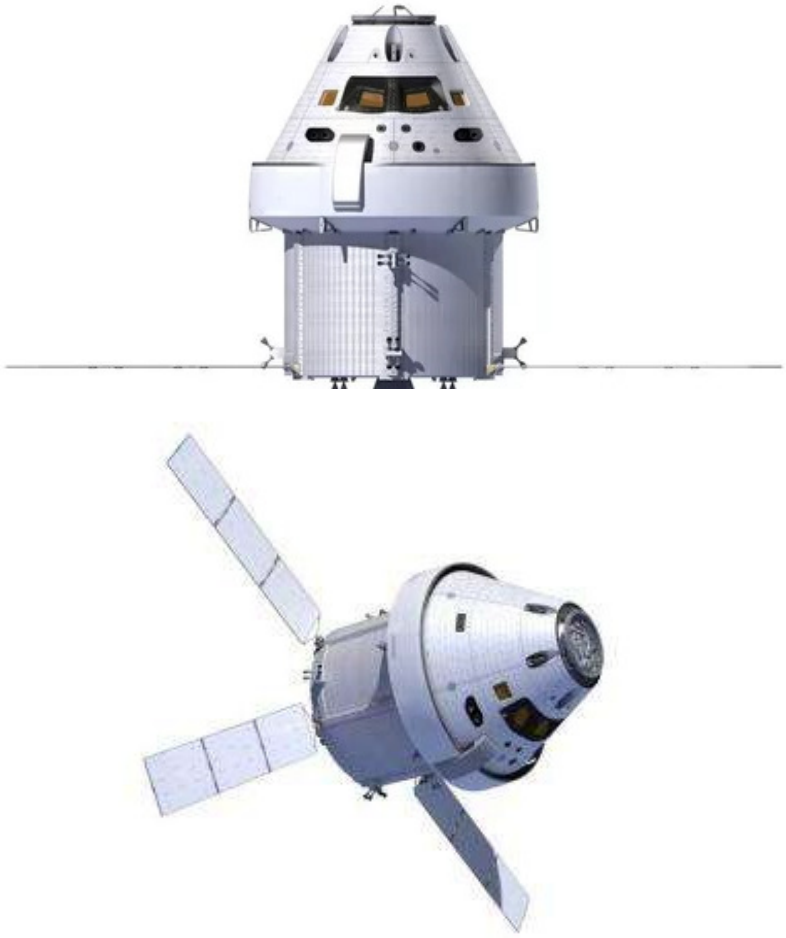
Orion MPCV

Manned Systems

Briefing

Orion MPCV (***M***ulti-***P***urpose ***C***rew ***V***ehicle) is a proposed American human-rated capsule designed to accommodate long-duration human spaceflight missions to the Moon, Mars, asteroids, and other deep space destinations.

The first uncrewed orbital test flight (Exploration Test Flight 1 or "EFT-1") of Orion was successfully completed on December 5, 2014. That mission was launched by a Delta IV-Heavy rocket and lasted just under four and a half hours. A second unscrewed Orion mission (Exploration Mission 2 or "EM-2") is scheduled to go up in 2019. Plans call for launching the first crewed Orion (EM-2) by April 2023. EM-2 had previously been set for 2021.



Orion CEV

The original Orion concept was known as the Crew Exploration Vehicle (CEV) which was part of NASA's Constellation program to develop a capability to return astronauts to the Moon and eventually transport them to Mars. That program foresaw launching a crewed Orion to ISS by 2016 to the Moon by 2020. Constellation, which also involved the development of a new human-rated expendable launch vehicle called Ares I and eventually a larger and more powerful Ares V, was cancelled due to cost considerations in 2010.

On December 9, 2004, NASA issued a Draft Statement of Work for the CEV. This was followed on January 21, 2005 by a Draft Request for Proposals (RFP) and in March 2005 with a final RFP. On July 12, 2005, NASA awarded two Phase I eight-month contracts worth $28 million each. The first contract went to Lockheed Martin and the second to the team of Northrop Grumman/Boeing. Under the contracts, the companies were tasked to perform sustained engineering in support of a July 2006 review of the engineering systems for the CEV, as well as continuing to develop designs for the vehicle and demonstrating the ability to manage costs, schedule, and risk. In January 2006, NASA issued Phase II of a RFP that added detailed design, development and production requirements for the CEV. The proposals were due on March 20, 2006. Both Boeing and Lockheed Martin submitted bids. On August 31, 2006, NASA awarded the seven-year prime contract to design and build the Orion CEV to the Lockheed Martin team.

Recent Developments

Structural testing of different Orion spacecraft hardware began in July to qualify them for uncrewed EM-1 and crewed EM-2

missions. The program, which includes modal, loads, shock, and acoustic testing, is being conducted at Lockheed Martin Space Systems' facilities in Waterton, CO.

Executive

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Specifications

Mass (overall):	25,848 kg
Crew Module:	10,387 kg
Service Module:	15,460 kg
Dimensions:	3.3 x 5 m
Mission lifetime:	0.5 yr
Passengers:	6

Subsystems

Airframe

Orion consists of four main structures—a Crew Module (CM), a Service Module (SM), two spacecraft adaptors, and the the Launch Abort System (LAS). Both the CM and SM are constructed of aluminum-lithium (AL-Li) alloy.

The CM is manufactured by *Lockheed Martin Space Systems Co*. of Houston, TX. The SM is built by *Airbus Defence and Space SAS* of Toulouse, France, which is why it is sometimes also referred to as the European Service Module (ESM). The spacecraft adaptors are built by *Lockheed Martin*. One of the adaptors attaches the CM and SM to each other and the second attaches the SM to the launch vehicle.

Launch Abort System

The LAS is designed to safely move the CM and SM away from the launch vehicle of an emergency or accident at the launch pad or during flight. The LAS has been developed by *Lockheed Martin*. The attitude control motor (ACM) for the LAS is provided by *Orbital ATK, Inc*. of Elkton, MD. The solid rocket jettison motors for the

LAS is supplied by *Aerojet Rocketdyne, Inc*. of Sacramento, CA.

Launch Systems

The designated launch vehicle for Orion is the Space Launch System (SLS), which is currently under development by the *NASA Marshall Space Flight Center* (MSFC) in Huntsville, AL.

Guidance & Control

Honeywell Aerospace of Phoenix, AZ is the prime contractor for Orion's navigation hardware and software design and development. The company produces the navigation avionics and the command and data handling system, the vehicle management computer.

Honeywell also supplies the inertial measurement unit (IMU), which includes a 3-axis gyroscope system for attitude control, while star trackers provide orientation. The star trackers are built by *Ball Aerospace and Technologies Corp*. of Boulder, CO.

The primary engine for Orion is an Orbital Maneuvering System (OMS) AJ10-190 hypergolic rocket engine adapted from the US Space Shuttle program. The OMS was designed and built by *Aerojet Rocketdyne, Inc*. of Sacramento, CA. Secondary power is provided by 12 MR-104G catalytic thrusters supplied by *Aerojet Rocketdyne* and 24 220 N reaction control engines provided by *ArianeGroup SAS* of Paris, France.

Power

Electrical power for Orion is generated by four solar arrays consisting of three panels each and a total of 15,000 solar cells. The arrays are attached to the SM. They are produced by *Airbus Defence and Space*. Backup electrical power is provided by Lithium-ion batteries produced by EaglePicher Technologies' *Yardney Technical Products, Inc*. of East Greenwich, RI. Each of the batteries weighs 44.8 kg and consists of a four-cell stack with eight NCP25-5 cells.

Thermal Protection

The Boeing Company of Huntington Beach, CA is responsible for production of the phenolic impregnated carbon ablator (PICA) heat shield, known as the Thermal Protection System (TPS). TPS will serve to protect Orion against extreme heat generated during re-entry into the Earth's atmosphere. *Fiber Materials, Inc*. of Biddeford, ME was Boeing's primary subcontractor on development of the shield, which employs a titanium skeleton covered with an AVCOAT ablative heat shield material supplied by *Textron, Inc*. of Providence, RI.

Thales Alenia Space SA of Turin, Italy is under contract to Airbus Defence and Space to develop and produce the thermomechanical systems for the SM, including structure and micrometeoroid protection, thermal control, and consumable storage and distribution.

Other Subsystems & Services

- Airborne Systems North America Of CA Inc. of Santa Ana, CA: parachute testing support
- Alter Technology Group of Seville, Spain: procurement and testing of electronic components for the Service Module
- Arcata Associates, Inc. of Littleton, CO: procurement support
- Fox Parachute Services, LLC of Belleville, WV: parachute testing support
- NASA Langley Research Center (LRC) in Hampton, VA: design of the stage adapter diaphragm
- Jacobs Engineering, Inc. of Pasadena, CA: qualification testing on the parachute system
- Space Power Facility at NASA Glenn Research Center's Plum Brook Station in Sandusky, OH: testing of Service Module
- Sgang Enterprises, Inc.'s Wren Industries division in Grand Junction, CO: closeout seal plates.
- UTC Aerospace Systems (formerly Hamilton Sundstrand, Inc.) of Windsor Locks, CT: fire detection and suppression system; carbon monoxide removal/humidity control system;

pressure control system; atmospheric monitoring system; cabin air ventilation; and potable/cooling water storage

Contract Briefs

Date	Source	Value	Details
Airbus Defence and Space			
02/16/17	ESA	€200,000,000	Contract to produce a second Service Module for the first crewed Orion MPCV mission.
Boeing			
09/00/06	NASA	$14,000,000	Sixteen-month, firm fixed-price and cost-plus-fixed-fee contract to design and develop a Thermal Protection System (TPS) for the Orion CEV.
Jacobs Engineering			
07/12/16	NASA	$40,300,000	Contract to perform manned flight qualification testing on the parachute system for the Orion MPCV.
Lockheed Martin			
07/12/05	NASA	$28,000,000	Eight-month contract to perform sustained engineering in support of a July 2006 review of the engineering systems for the Orion CEV.
08/31/06	NASA	$3,900,000,000	Prime contract to design and build the Orion CEV. Work will occur from September 8, 2006 through September 7, 2013.
Northrop Grumman/Boeing			
07/12/05	NASA	$28,000,000	Eight-month contract to perform sustained engineering in support of a July 2006 review of the engineering systems for the Orion CEV.
Sgang Enterprises, Wren Indsutries			
05/10/17	NASA	—	Contract to manufacture closeout seal plates for the Orion MPCV.
Thales Alenia Space			
09/17/15	Airbus	€90,000,000	Contract to develop and produce the thermomechanical systems for the Service Module (SM), including structure and micrometeoroid protection, thermal control, and consumable storage and distribution.
United Technologies, Hamilton Sundstrand			
09/01/06	Lockheed Martin	—	Contract to produce the fire detection and suppression system, carbon monoxide removal/humidity control system, pressure control system, atmospheric monitoring system, cabin air ventilation, and potable/cooling water storage through 2019.
Wyle Laboratories			
03/05/13	NASA	$1,760,000,000	Five-year contract to provide biomedical, medical and health services to support human spaceflight programs at the NASA Johnson Space Center in Houston, TX, including Orion.

Funding

RDT&E ($ Millions)	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17*
Orion CEV	1,174	1,748	1,650.0	—	—	—	—	—	—	—
Orion MPCV	—	—	—	1,196.0	1,200.0	1,138.0	1,197.0	1,194.0	1,270.0	1,350.0

** Request*

Costs

The estimated cost of developing the Orion CEV was originally $3.4 billion. By the time the Orion MPCV ready to be launched on its first crewed mission in 2023, NASA estimates it will have spent at least $16 billion.

Teal Group Evaluation

When the Obama administration decided to cancel the Constellation program in February 2010, we believed Orion was finished. But by April of that year, the administration had opted to save Orion and instead continue to develop of the capsule (although a scaled down version) with the idea that it could be used as a kind of "lifeboat" attached to the ISS in the event it were ever needed by astronauts to escape quickly from the station.

The current Orion MPCV program was announced by NASA in May 2011 and has been ongoing ever since. Thus far, the biggest highlight of this effort was the successful EFT-1 test mission in December 2014. But by then, about a decade of development work on Orion had been completed. It is important to remember that this is an old and expensive program that is going to be extremely old and expensive by the time the first Orion MPCV crewed mission goes up.

Orion MPCV will end up costing at least four times what NASA originally said it would. This is not unusual for space initiatives of this size, complexity, ambitiousness, and uncertainty, particularly those that involve the safe transportation human beings. However, it should signal some degree of caution about the future of this program. It is unclear to us that Orion MPCV, especially given its tie to the extremely expensive SLS rocket and NASA's rather vague vision for the SLS/Orion MPCV combo, is immune to cancellation.

Assuming NASA meets it latest target launch date for the first crewed Orion MPCV, by then the Orion will be nearly two decades old, and our experience is that space programs that take this long, become so expensive, and lack strong public enthusiasm and support rarely survive unless, like the ISS, they end up becoming more of a jobs program than about science or exploration.

We will continue to give NASA the benefit of the doubt on Orion MPCV, at least until other options begin to materialize—namely commercial crew capsules such as SpaceX's Dragon V2 and Boeing's CST-100 Starliner being developed for ISS crew transport missions. Both Dragon and Starliner are intended to make their first test launches in 2018.

It is worth noting that in September 2016, NASA issued a Request for Information (RFI) that signals that Lockheed Martin will be allowed to continue developing Orion MPCV through the first crew mission sometime around 2023, but that once the configuration of the "base vehicle" is completed NASA may seek to look for less expensive alternatives to Orion.

NASA may simply be responding to budgetary realities that dictate it may not be able to afford Orion for very long. The agency's budget for fiscal year 2017 is $19.5 billion. SLS and Orion MPCV alone consume about $3 billion per year. NASA may also be reacting to increasing concern within Congress about why the US government should be funding Orion when capsules like Dragon and Starliner could soon become available.

Launch Forecast

(payload units)	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Orion MPCV	—	—	—	1	—	—	—	—	1	—

