

Crawler-Transporters

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A pair of behemoth machines called crawler-transporters have carried the load of taking rockets and spacecraft to the launch pad for nearly 60 years at NASA's Kennedy Space Center in Florida.

Each larger than the size of a baseball infield and powered by locomotive and large electrical power generator engines, the crawler-transporters stand ready to keep up the work for the next generation of launch vehicles that will lift astronauts into space.

The crawlers are unique in the world, having been built in 1965 to move the massive Saturn V rocket from Kennedy's Vehicle Assembly Building (VAB) to Launch Complex 39. After the Moon landing and Skylab programs ended, the crawlers continued their work, taking space shuttles to their launch pads for 30 years.

With the shuttle fleet retired in 2011, the crawlers were envisioned as critical elements of future launch operations at Kennedy. One, the Crawler-Transporter 2, was strengthened to handle the Space Launch System (SLS), a rocket and launch tower combination heavier than even the Saturn V Moon rockets the crawlers were designed for.

Able to raise and lower its sides and corners independently, the crawlers are designed to roll underneath a mobile launcher (ML), pick it up, and steadily carry it 4.2 miles to Launch Pad 39B. Because each pad is built atop a sloping pyramid, the crawler uses its hydraulic suspension to keep the platform level all the way to the top where it sets the platform in place so the vehicle can lift off safely.

Crawler-Transporter 2

Kennedy upgraded one of its two massive crawler transporters as the agency prepared for its journey to the Moon and Mars through the Artemis missions. Crawler-transporter 2 (CT-2) is more than 50 years old, but with the modifications conducted by the Exploration Ground Systems (EGS) Program, CT-2 is expected to be in service for many years to come.

The overall size of CT-2 is 131 feet long and 114 feet wide. The crawler's speed while carrying a launch vehicle and spacecraft is limited by analysis that determines what rate provides the smoothest ride. The crawler was designed to travel two miles per hour unloaded but has not been tested to speed. To date, CT-2 has traveled 2470.5 miles.



Crawler-transporter 2 (CT-2) moves slowly along the crawlerway on its way back to the Vehicle Assembly Building (in view in the background) at NASA's Kennedy Space Center in Florida. Water sprayed by a truck in front to reduce dust creates a small rainbow. The crawler took a trip to the Pad A/B split to test upgrades that will allow the giant vehicle to handle the load of the agency's Space Launch System rocket and Orion spacecraft atop the mobile launcher. Photo credit: NASA/Leif Heimbolt

Engineers tested the modifications on CT-2 incrementally to prepare for the first integrated test flight of SLS and NASA's Orion spacecraft, known as Artemis I. NASA also tested different rollout variations. The 20-year-life modifications roll tested the new 1500-kilowatt generators, parking and service brakes, control system modifications, diesel engine refurbishments, vent hoods, exhaust, and other Phase I upgrades.

Modifications to the crawler included redesigned and upgraded roller bearings, removal and replacement of the existing bearings with a new assembly that can carry a greater load, and an improved lubrication system. These redesigns have given the crawler a longer operational life and enable the giant vehicle to carry the heavier loads with the SLS rocket. CT-2's uprated load carrying capacity is 18 million pounds, 50% higher than the original design.

CT-2's modifications proved successful as it carried mobile launcher 1 (ML1) with SLS and Orion atop from the VAB to Launch Pad 39B ahead of the launch of Artemis I. The crawler has four reinforced pickup points on its surface that secure into place underneath ML1 to carry it to the pad. Pinch blocks are located at three of the four pickup points to secure the load being carried. The crawler does not interface with the rocket, enabling it to carry future vehicles with no additional modifications needed.

Once the CT-2 makes its eight-hour trek to the pad with engineers and technicians aboard, ML1 and SLS are lowered onto pad mount mechanisms. After platforms are lowered and power transfers are complete, the CT-2 rolls back down the pad slope and park just outside the pad perimeter gate. CT-2 waits there until a few days prior to launch in case a rollback is required. Then it rolls to the Mobile Service Structure park site to be protected during launch.

Crawler-Transporter Facts

Height

Minimum (JEL cylinders retracted)..... 20 feet
Maximum (JEL cylinders extended) 26 feet

Size

Overall131 feet long, 114 feet wide
The mobile launcher contacts the crawler at four points, arranged in a 90-foot square (same as the base line on a professional baseball field)

Cylinders

JEL Hydraulic20-inch bore diameter
CT-1, 23-inch bore max diameter CT-2 (16 each)
Steering Hydraulic..... 14.5-inch diameter (16 each)
Guide Tube (4 each) 40-inch diameter

Weight

CT-2Approximately 6.65 million pounds (or the weight of about 15 Statues of Liberty or 1,000 pickup trucks).

Speed

Loaded 1 mph
Unloaded 2 mph

Loads Capacity

Mobile Launch Platform and
Space Shuttle 12.6 million pounds
Mobile Launcher Platform9.87 million pounds
ML-1Approximately 11.3 million pounds
Artemis I SLS and Orion...Approximately 5.75 million pounds
Load CapacityAble to transport 18 million pounds
(or the weight of more than 20 fully loaded 777 airplanes)

Trucks

Traction Motors 375 hp each (16 each/4 per truck)
Belts 8 each (2 per truck)

Hydraulic System

Reservoir Capacity2,500 gallons
Steering 4 pumps, 34.4 GPM @ 1200 RPM, per pump
Steering Pressure5,000 PSI maximum
Jacking, Equalizing, Leveling (JEL) 8 pumps,
60 GPM Max, 15-20 GPM nominal @ 1200 RPM per pump
JEL Pressure3,000 PSI Maximum

Electrical Systems

DC Power System

16 locomotive traction motors 375 hp
Diesel EnginesAlco, 16 cylinders
(2 @ 2,750 hp each, for DC)
Generators (DC)..... 4 @ 1,000 kW each

AC Power System

Runs all onboard systems
Diesel EnginesCummins Power, 16 cylinders,
2 @ 2,220 hp each, for A/C power
Generators (AC)..... 2 @ 1,500 kW each

Capacity

Diesel Fuel Capacity.....5,000 gallons
Fuel Consumption 1 gallon per 32 feet
(approximately 165 gallons per mile)
Drive System Gear Ratio 168:1

From Apollo to Artemis

March 1963: Fabrication began on the crawler-transporters in Ohio.

Nov. 1964: Assembly of the first crawler-transporter was completed on Merritt Island, Fla.

Nov. 1964: The crawlerway was ready for testing.

Jan. 23, 1965: The crawler moved under its own power for the first time.

June 22, 1965: The crawler picked up its first load, a mobile launcher.

Jan. 28, 1966: The crawler successfully transported a mobile launcher approximately one mile to the VAB.

Early 1966: Both crawlers became operational.

Aug. 26, 1967: The first Saturn V rocket was moved to the launch pad for the uncrewed Apollo 4 mission.

Oct. 9, 1968: A Saturn V rocket was moved to the launch pad for Apollo 8, the first crewed Saturn V mission.

Feb. 27, 1973: The crawler carried the first Saturn IB to the launch pad for the Skylab 2 mission.

May 1, 1979: A crawler transported space shuttle Enterprise, with external tank and two inert solid rocket boosters, to Launch Pad A for fit check.

Dec. 29, 1980: A crawler moved space shuttle Columbia out to Launch Pad 39A for STS-1 mission.

April 6, 2005: After modifying the crawler, it moved space shuttle Discovery to Launch Pad 39B for its STS-114 return-to-flight mission.

Nov. 16 – 30, 2011: Moved the SLS mobile launcher from the park site beside the VAB to Launch Pad 39B and back.

March 23, 2016: CT-2 began its trek from the VAB out to Launch Pad 39B to test recently completed upgrades and modifications that were completed on the crawler to ensure it will be ready to support the mobile launcher and SLS.

March 29, 2016: The upgraded CT-2 returned from a trek to Launch Pad 39B after testing of upgrades and modifications.

March 22, 2017: CT-2, with the space shuttle-era mobile launcher platform 1 atop, moved along the crawlerway for a load test.

May 31, 2018: CT-2 moved under the mobile launcher and picked it up. The lifting procedures were practiced three times to validate interface locations and confirm the weight of the mobile launcher.

Aug. 31 – Sept. 8, 2018: CT-2 moved the mobile launcher for SLS along the crawlerway to Launch Pad 39B to perform a fit check between the pad and its subsystems. After several days of testing at the pad, CT-2 moved the modified mobile launcher into High Bay 3 of the VAB.

May 1, 2019: CT-2 took a practice run from the VAB along the crawlerway, carrying the space shuttle-era mobile launcher platform 3, or MLP-3, on top.

June 28, 2019: CT-2 carried the mobile launcher from the VAB along the crawlerway to Launch Pad 39B for Verification and Validation (V&V) testing of ML and pad systems.

Aug. 30 – Sept. 10, 2019: CT-2 carried the mobile launcher along the crawlerway from Pad 39B to the VAB for protection from Hurricane Dorian and then back to the pad after the all clear was issued.

Dec. 19, 2019: CT-2 carried the mobile launcher along the crawlerway to the VAB after completion of V&V testing.

Oct. 6 – 27, 2020: CT-2 carried the mobile launcher from High Bay 3 in the VAB to Pad 39B for a systems check-out and top-to-bottom washdown. After completion of the systems checkout, CT-2 carried the mobile launcher back to High Bay 3.

March 17 – Apr. 26, 2022: CT-2 carried the SLS with the Orion spacecraft atop on the mobile launcher from the VAB to Pad 39B for the Artemis I wet dress rehearsal tests ahead of launch. Following the wet dress rehearsal attempts, CT-2 carried the mobile launcher back to the VAB.

June 6 – July 2, 2022: CT-2 carried the SLS with the Orion spacecraft atop on the mobile launcher from the VAB to Pad 39B for a second time to complete the Artemis I wet dress rehearsal. After a successful wet dress rehearsal test, CT-2 carried the mobile launcher back to the VAB.

Aug. 16 – Sept. 27, 2022: CT-2 carried the SLS with the Orion spacecraft atop on the mobile launcher from the VAB

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to Pad 39B for launch of Artemis I. After two aborted launch attempts and a cryogenic demo test, CT-2 carried the mobile launcher back to High Bay 3 ahead of Hurricane Ian.

Nov. 3 – Dec. 9, 2022: CT-2 carried SLS with the Orion spacecraft atop on the mobile launcher from the VAB to Pad 39B for launch of Artemis I, which took place on Nov. 16. CT-2 carried the mobile launcher back to the VAB and later on to a parking location at Kennedy, where modifications and upgrades will be made on both ahead of the Artemis II crewed mission.

March 29, 2023: Guinness World Records presented a certificate to teams with the Exploration Ground Systems Program and Kennedy leadership officially designating Crawler-Transporter 2 as “the heaviest self-powered vehicle.”



Above: Crawlerway rock is visible as NASA's upgraded crawler-transporter 2 (CT-2) returns to the Vehicle Assembly Building (VAB) at the agency's Kennedy Space Center in Florida from its trek to Launch Pad 39B. CT2's recently completed upgrades and modifications were tested to ensure the vehicle will be ready to support NASA's journey to Mars. Photo credit: NASA/Ben Smegelsky

Left: Exploration Ground Systems' mobile launcher makes its last solo trek along the crawlerway atop crawler-transporter 2 to Kennedy Space Center's Launch Complex 39B in Florida on June 27, 2019. Photo credit: NASA/Ben Smegelsky



Bottom right: NASA's mobile launcher atop crawler-transporter 2 arrives at Launch Pad 39B on Aug. 31, 2018, at the agency's Kennedy Space Center in Florida for a fit check and systems testing. The 380-foot-tall mobile launcher is equipped with the crew access arm and several umbilicals that will provide power, environmental control, pneumatics, communication and electrical connections to NASA's Space Launch System and Orion spacecraft. Photo credit: NASA/Jamie Peer

National Aeronautics and Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

www.nasa.gov