Updated: How Mars rover got its 'dream mode'

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The Curiosity rover now preparing to explore Gale Crater on Mars has an FPGA-based reptilian brain that keeps its systems going while main computers are in "dream mode".

WASHINGTON – The Curiosity rover now gearing up to explore a 96-mile-wide crater on Mars is by far the most complex machine ever to explore the surface of another planet. One big reason is the rover's avionics, which control everything from its 10 scientific instruments to communications, navigation, cameras and power management – which is where Curiosity's "dream mode" enters the picture.

Dream mode "is sort of the reptile brain for the rover," explained Jim Donaldson, the Mars Science Laboratory avionics chief engineer. Implemented in FPGAs, the rover's dream mode function monitors vital rover systems while its redundant main computers are in "sleep mode" to save power.

Donaldson said the biggest challenge engineers at NASA's Jet Propulsion Laboratory (JPL) faced in developing rover avionics was development and implementation of the FPGAs that have provided Curiosity with a quantum leap in functionality as it explores the Red Planet. From an engineering standpoint, Donaldson said the biggest challenge was scaling JPL's FPGA design practices to achieve the higher levels of complexity needed to put a largely autonomous rover inside Gale Crater, which is believed to harbor the conditions needed for microbial life.

JPL and its contractors eventually came up with a system of redundant avionics hardware implemented on about 1.2 million logic gates. That allows the rover's avionics to interface with all major scientific instruments, sensors and comms links along with the rover's drive train while also managing power in wake, sleep and dream modes.

Part of the Curiosity's power supply is visible at left. To the right of the power supply is the low-gain antenna and side of the paddle-shaped high-gain antenna for communications directly to Earth. The rim of Gale Crater is the lighter colored band across the horizon. *(Source: NASA/JPL-Caltech)*

(Click here to see an interactive display of Curiosity's science instruments and other key systems.)

Among NASA's Curiosity avionics contractors are Wind River (VxWorks real-time operating system) and Microsemi Semiconductor (RTAX-S and RTSX-SU FPGAs, high- and low-voltage power supplies, high reliability diodes and signal and power transistors).

As the architect of rover's avionics, Donaldson has a different view of the so-called "brain transplant" in which NASA engineers essentially switched Curiosity's main computers from flight mode to surface operations. "I prefer to call it an 'intellect upgrade' since [the rover's] brain remains the same," Donaldson said during a briefing on Tuesday (Aug. 14).

As mission managers prepare Curiosity for its first drive, they continue to take their time. Curiosity's mission is being measured in Martian days, or sols. Michael Watkins, the Mars Science Laboratory mission manager, said JPL's science team won't try to engage actuators to turn Curiosity's wheels until Sol 13 next week. The first drive is scheduled for about Sol 15. This will involve little more than a short drive, a turn, then backing up to see what was directly under Curiosity when it landed on Aug. 6.

"We start out crawling and then we walk," Watkins said.

The Curiosity science team said Friday (Aug. 17) that "we intend to hit the road" in the next several weeks on Curiosity's first long drive to a site called Glenelg. Mission managers described the area as "a natural intersection of three kinds of terrain." The rover could start heading for the foothills of Mount Sharp at the center of Gale Crater by the end of the year, they added.

Thanks to the rover's avionics, mission managers expect Curiosity to have sweet dreams between its

drives around Gale Crater. Quoting Alfred North Whitehead, Donaldson emphasized that Curiosity's avionics will allow mission managers to explore Mars as never before "by extending the number of important operations which we can perform without thinking of them."

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