NASA's NavCube could support an X-ray communications demonstration in space—a NASA first

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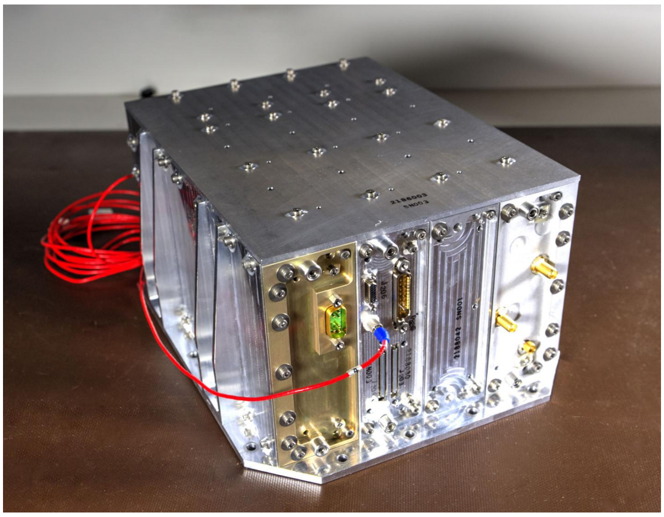


NavCube, the product of a merger between the Goddard-developed SpaceCube 2.0 and Navigator GPS technologies, could play a vital role helping to demonstrate X-ray communications in space -- a potential NASA first. Credit: NASA/W. Hrybyk

Two proven technologies have been combined to create a promising new technology that could meet future navigational challenges in deep space. It also may help demonstrate—for the first time—X-ray communications in space, a capability that would allow the transmission of gigabits per second throughout the solar system.

The new technology, called NavCube, combines NASA's SpaceCube, a reconfigurable and fast flight computing platform, with the Navigator Global Positioning System (GPS) flight receiver. Navigator GPS uses the GPS signal to enable on-board autonomous positioning, navigation, and timing even in weak-signal areas. Considered one of the enabling technologies on the agency's flagship Magnetospheric Multi-Scale (MMS) mission, Navigator GPS recently was included in the Guiness World Records for the highest-altitude GPS fix.

"NavCube is more flexible than previous Navigators because of its ample computational resources. Also, because we added the ability to process modernized GPS signals, NavCube has the potential to significantly enhance performance at low, and especially, high altitudes, potentially even to the area of space near the moon and lunar orbits," said Luke Winternitz, Navigator's chief architect.

"This new product is a poster child for our research and development efforts," added Peter Hughes, the chief technology officer at NASA's Goddard Space Flight Center in Greenbelt, Maryland, whose organization funded the development of all three technologies and named the NavCube team as this year's winner of his organization's "Innovators of the Year" award. "Both SpaceCube and Navigator already proved their value to NASA. Now the combination of the two gives NASA another tool. Also, the possibility that it might help demonstrate X-ray communications in space—a technology in which we also have interest—is particularly exciting."

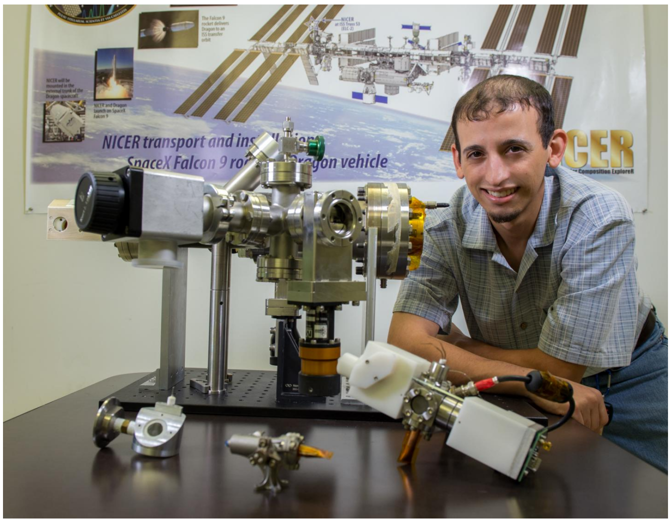
This promising technology is slated to fly as one of several experiments on an external pallet to be deployed on the International Space Station in 2018. One NavCube unit will demonstrate its navigation and processing capabilities afforded by the merger of its technological parents, while the other could potentially provide precise timing data for an experiment demonstrating X-ray communications, or XCOM.

"A Match Made in Heaven"

As part of the potential XCOM demonstration, NavCube will drive the electronics for a device called the Modulated X-ray Source, or MXS, which generates rapid-fire X-ray pulses, turning on and off many times per second. These rapid-fire pulsations can be used to encode digital bits for transmitting data. It was developed as a testbed to validate NASA's Neutron-star Interior Composition Explorer, or NICER, which primarily will study neutron stars and their rapidly spinning next-of-kin, pulsars, when it launches as an attached space station payload in 2017.

XCOM is one of two technology demonstrations that NICER Principal Investigators Keith Gendreau and Zaven Arzoumanian want to demonstrate with NICER. To demonstrate one-way XCOM, the team will install MXS on the experiment pallet where it will transmit data via X-rays to NICER's receivers positioned 166 feet away on the opposite side of the space station truss.

NavCube's job is to run MXS's on-and-off switch, said Jason Mitchell, an engineer at Goddard who helped advance the MXS. Because NavCube combines SpaceCube's high-speed computing with Navigator's ability to track GPS signals, the team also wants to experiment with X-ray ranging, a technique for measuring distances between two objects.



Goddard's Steve Kenyon is the mechanical and packaging "wizard" for the MXS and XCOM hardware. The equipment shown are various incarnations of the hardware needed to demonstrate X-ray communications

in space. Credit: NASA/W.Hrybyk

"NavCube provided the best solution for running this experiment," Mitchell said. "The combination of these powerful technologies was a marriage made in heaven."

Although most of the technology is ready, the team still is seeking additional funding to complete a space-ready MXS, including its housing and high-voltage power supply. "We have most of the hardware, but need a little more support to complete the XCOM package," said Jenny Donaldson, who is leading the development of the NavCube payload. "This is a great opportunity to demonstrate NavCube and, if all things go as planned, X-ray communications," she said.

Rich Heritage

NavCube traces its lineage to two already proven technologies: SpaceCube 2.0 and Navigator GPS. SpaceCube 2.0, one in a family of onboard processors, is 10 to 100 times faster than more traditional flight processors. Having flown many times before, including on previous experiment pallets, SpaceCube now enjoys a growing list of customers, including future high-profile robotic-servicing missions.

The Navigator GPS Flight receiver was purposely designed to detect, acquire, and track faint GPS signals for NASA's MMS mission. Navigator now is providing positioning information to the four spacecraft that must fly in a particular, high-earth flight formation to gather scientific data. Since MMS's launch, Navigator has set records—an achievement recently acknowledged by the Guinness World Records for providing the highest-altitude GPS fix. At the highest point of the MMS orbit, Navigator has tracked as many as 12 GPS satellites. The team originally expected to detect no more than two or three GPS satellites.

Barry Geldzahler, chief scientist and chief technologist for NASA's Space Communication and Navigation (SCaN) Program, who also provided additional funding for this project, saw the benefits this technology could bring to NASA early on.

"We knew that processing speed from SpaceCube and the tracking capability of Navigator could be a powerful combination," said Geldzahler. "The next task was to figure out how to make it smaller and increase the sensitivity for more flexible mission applications."

"At the time, we needed a more robust, re-programmable and extensible processing platform," added Monther Hasouneh, NavCube's hardware lead. "SpaceCube was already there. Furthermore, we figured that missions using SpaceCube 2.0 as a science data processor also could benefit from having a GPS receiver as a low-cost add-on," he added.

Hasouneh and his team ported the Navigator software and firmware into the SpaceCube reprogrammable platform and developed a compatible GPS radio-frequency card—and in doing so, reduced Navigator's size. The team also added new GPS signal capabilities and enhanced Navigator's sensitivity to make it appropriate for a broader range of applications.

Provided by NASA's Goddard Space Flight Center