Scientists discover new way to prevent spacecraft errors

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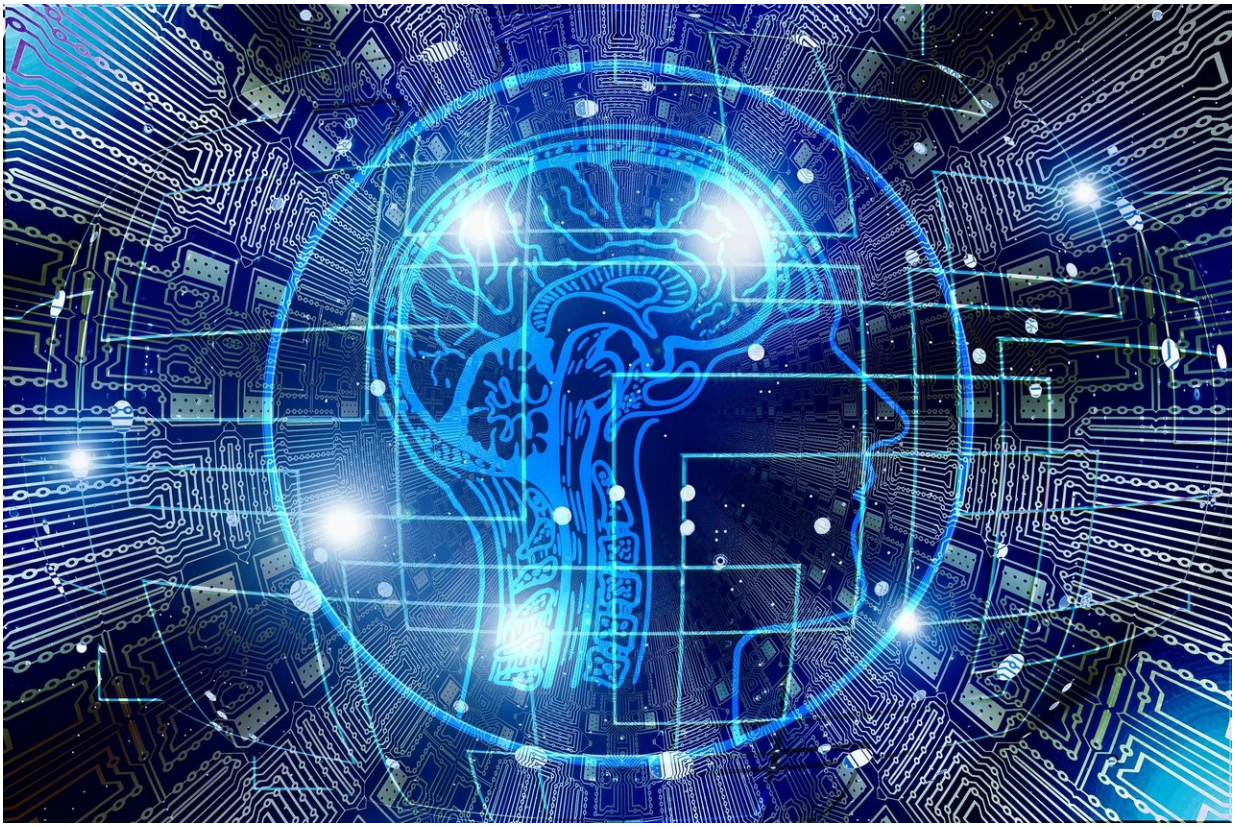

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Scientists from the National Research Nuclear University MEPhI (Russia) and the Scientific Research Institute of System Analysis of the Russian Academy of Sciences have recently developed components for

designing fault-tolerant asynchronous circuits, which can be used in space vehicles.

Microcircuits that are traditionally used in cars and computers are poorly suited to space vehicles due to low reliability when subject to space radiation. In space, high-energy ions cause device errors and failures. Thus, in developing ASICs (Application-Specific Integrated Circuits) for spacecraft, scientists need to create special methods for improving fault-tolerance (to put it simply, reliability).

"The thing about synchronous circuits is that their complexity, just like the number of elements on the circuit chip, is constantly increasing," said Maxim Gorbunov, assistant professor at MEPhI. "Sections of these circuits, which are located at a large distance, must be synchronized according to their clock rates (a CPU's clock cycles per second). Which means, if the signals produced by the clock generator do not come within the exact time intervals, the circuit simply stops working."

This is a complex engineering issue that includes the deterioration of microchip characteristics, Gorbunov said. That is why asynchronous circuits, which do not require clock rate synchronization, are considered to be so promising today.

"In asynchronous circuits switching occurs in parallel and without a delay; this makes these circuits more efficient and more energy intensive than their synchronous counterparts," Gorbunov explained. "The data reaches the processing unit as fast as the processor's data path allows, and is processed whenever the respective microcircuit chips are ready."

When it comes to the methodology of designing these circuits, it's far more problematic since there is no standard route for designing them. Despite the fact that the general idea for designing asynchronous circuits was proposed in the 1970s, most still primarily work with synchronous

circuits.

"We have explored the technical possibilities of synchronous circuits to their limits," Gorbunov said. "Today, design parameters (the minimal size of microcircuit elements) do not exceed ten nanometers. Asynchronous circuits with the same design parameters would operate faster than their synchronous counterparts, since they would not require synchronization."

Russian scientists therefore decided to come up with new elements for quicker and more reliable asynchronous microcircuits. The article, which was published in the journal *Acta Astronautica*, reports on fault-resistant Muller C-elements—the basic logic gates used in designing asynchronous circuits.

C-elements are logic devices with a built-in memory element. They are essentially building blocks with two inputs; when they coincide, the signal continues, but when they do not, the elements store the previous value in their memory.

"By applying the DICE (Dual Interlocked Cell) method, which is widely used in designing synchronous circuits, to three C-element designs, we obtained three new DICE C-element designs with improved fault tolerance," said another author on the article, Igor Danilov, head of the Radiation-Hard Fault-Tolerant VLSI Circuits Department at RAS Scientific Research Institute of System Development.

The researchers claim this new development can be used in designing asynchronous microcircuits with improved fault-tolerance for sophisticated space vehicles.

More information: I.A. Danilov et al. On board electronic devices safety provided by DICE-based Muller C-elements, *Acta Astronautica*

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