Interview: Academician Anatoly Koroteyev

An Inside Look at Russia's Nuclear Power Propulsion System

Academician Anatoly S. Koroteyev is General Director of the Keldysh Research Center, one of Russia's leading centers for space engineering. A full member of the Russian Academy of Sciences since 1994, he has been officially honored by the Russian government for his work on space propulsion and power technologies, as well as being well known for developing plans for manned expeditions to Mars. He sits on the Russian Academy of Sciences Council on Space, is a member of the International Academy of Astronautics, and served as President of the Tsiolkovsky Russian Academy of Cosmonautics in 2005-2011.

Academician Koroteyev participated in the September 2012 International Specialized Symposium: "Space & Global Security of Humanity" in Yevpatoria, Ukraine (see page 28). He gave this interview to 21st Century Science and Technology *on December 3, 2012 in the form of written responses to questions from staff writer Benjamin Deniston. The interview has been translated from Russian.*

21st Century: The Keldysh Center is working on developing a spacecraft using a megawatt-class nuclear power propulsion system (NPPS), and a prototype is expected to be completed in 2018. What other agencies are involved in this project, and what is the role of your Center? What has the progress been in this work?

Koroteyev: Under a Russian Federation Presidential Directive dated June 22, 2010, the Keldysh Research Center is the lead organization for the project to develop a spacecraft that uses a nuclear power propulsion system (NPPS). The additional participants in the project represent a high level of cooperation among Russian organizations, chiefly Roscosmos and Rosatom [the state agencies for space exploration and nuclear power, respectively], with several of their subdivisions playing a special role: the Energiya Rocket and Space Corporation, the Chemical Machine-building Design Bureau, the N.A. Dollezhal Scientific Research and Design Institute, the Russian Scientific Center – Kurchatov Institute [Russia's premiere nuclear research lab], and others.

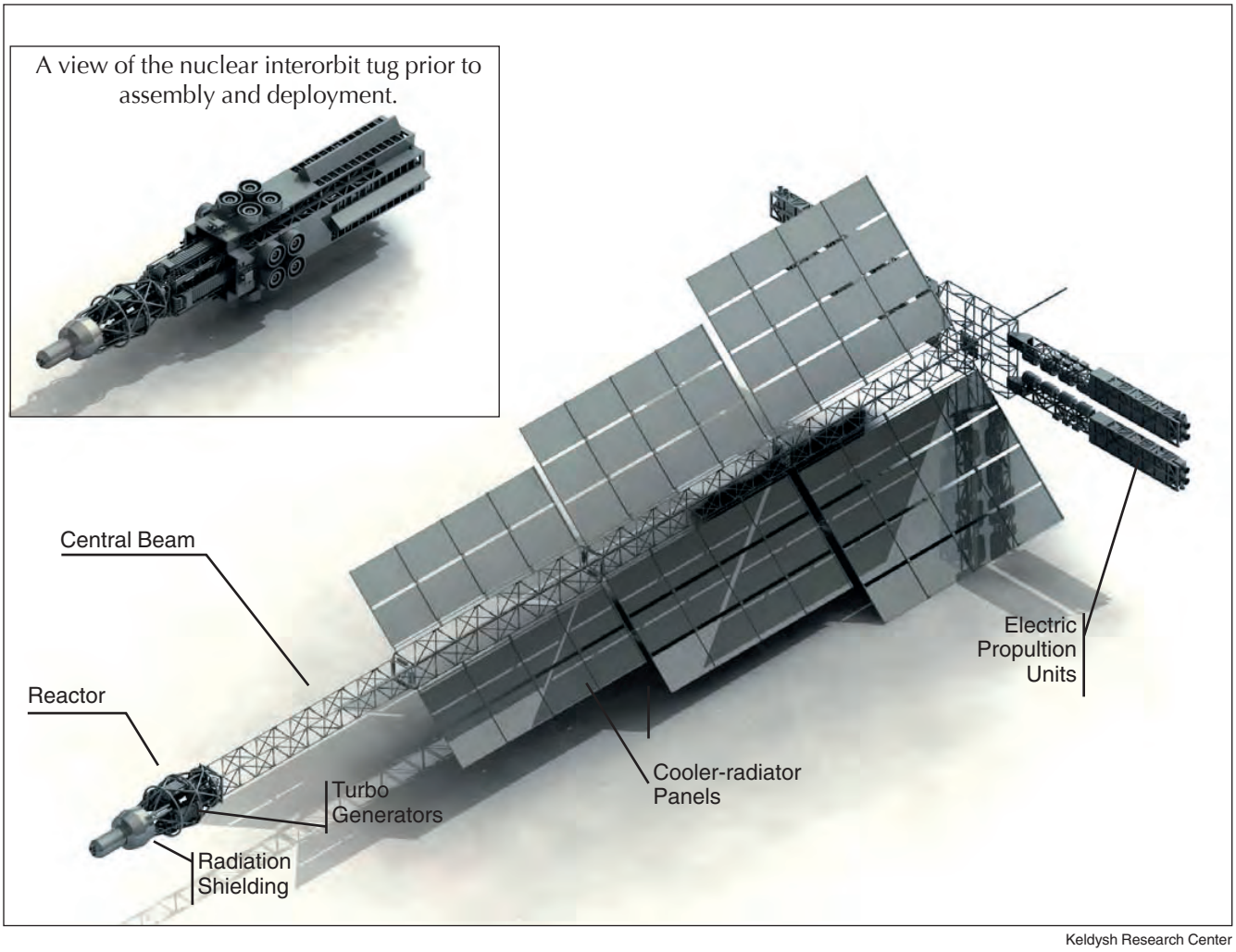
To date, a great deal of theoretical, experimental, and design work has been done, resulting in a draft design for a space transport using an NPPS. This work has enabled us to determine a prospective design for the spacecraft and its main features, and establish their feasibility.

Many people firmly believe that developing nuclear reactors for use in space is long overdue, and there are many potential applications, including improved communications, remote sensing, and propulsion systems. What do you think are the most exciting and beneficial applications for nuclear reactors in space?

I agree with the view that the introduction of nuclear power in space technologies is seriously behind schedule, and that is one of the reasons for the decline of the worldwide rate of growth in space exploration during the past 20 to 30 years. NPPS transport systems open up qualitatively new potentialities in space, in particular for improved information systems and the possibility of protecting the Earth from asteroids. They also open the way toward achieving compact power units for use in space, including on other planetary bodies, as well as for expeditions into deep space.

Because of the development of variable-trajectory spacecraft, it is becoming possible to do efficient space debris clean-up and to supply electricity to other spacecraft. In a number of emergency situations, it would be possible to redirect spacecraft onto their intended trajectories.

This will bring space communications and remote Earth sensing to a new level, which would not have been achievable using spacecraft based on solar or chemical energy sources.



Keldysh Research Center

A graphic design of the nuclear interorbit tug, powered by the Nuclear Power Propulsion System (NPPS).

At the 2012 International Specialized Symposium: "Space & Global Security of Humanity" in Yevpatoria, Ukraine, you spoke of using the NPPS for defending the Earth from asteroid impacts. What advantages will the megawatt-class NPPS provide over existing solar-electric or chemical propulsion systems for defending the Earth?

The NPPS opens up the possibility of using so-called gravitational tractors to divert the trajectory of an asteroid to a fly-by at a safe distance from Earth.

Over the past few years we have heard statements from President Vladimir Putin, Roscosmos Chief Vladimir Popovkin, Deputy Premier Dmitry Rogozin, and others about Russia's plans to develop permanent infrastructure on the Moon and in space, including possibly returning man to the Moon. How will the development of the NPPS contribute to these goals?

By using nuclear power, we can create infrastructure with sufficient energy supplies for successful planetary expeditions, something that could not be achieved by relying on solar energy alone.

In the United States, our difficulties in developing nuclear power in space have been chiefly political. We had a nuclear thermal rocket program which was shut down in 1972, despite showing immense promise. According to the recent studies I have seen, nuclear thermal rockets can provide significantly more thrust than nuclear electric systems, thus providing quicker travel times. Are there any programs at the Keldysh Center or elsewhere in Russia to develop nuclear thermal systems as well?

Plans do exist for the use of nuclear systems in which thermal energy is directly transformed into propulsion. Indeed, this would make it possible to achieve greater thrust values than is possible with electric engines. But it requires solving a number of complex challenges, re-

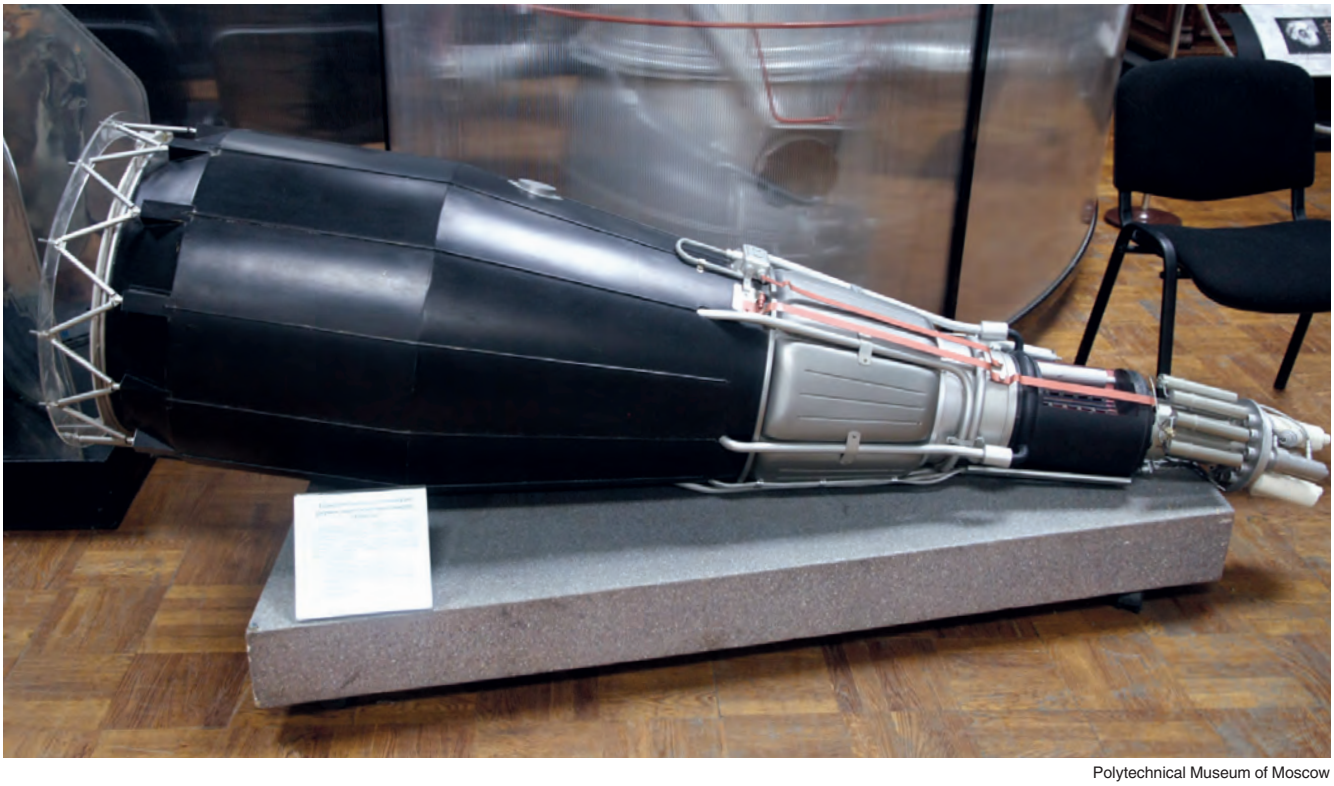
lated to ensuring the reliability of such engines. Higher temperatures are involved in the reactor, especially when heating a propellant that is chemically highly reactive, such as hydrogen.

For the challenge of manned deep-space flight, such as manned missions to Mars, prolonged exposure to radiation and the effects of prolonged zero-gravity can be detrimental to human health. For serious, large-scale Mars exploration, the energy densities of fission appear to be lower than needed. Only the energy densities of thermonuclear fusion could provide enough constant acceleration/deceleration to simulate Earth gravity, possibly alleviating the biological effects of microgravity. This would also reduce the travel time to Mars to weeks, or even days, meaning less exposure time to harmful radiation. Are you aware of any programs, either at the Keldysh Center or elsewhere, to make this next great leap into the domain of thermonuclear fusion systems for space travel?

I think that it is premature to talk seriously about using thermonuclear energy in space: even on Earth, an effective way to utilize thermonuclear energy has not yet been put forward, although work in this area has been going on for over half a century.

Despite the fact that, to my knowledge, Russia is the only nation actively developing the exciting new technology of nuclear propulsion, I have seen little coverage of this in the western media. Are there any other ongoing programs at the frontiers of space research and exploration, either at the Keldysh Center, or in Russia generally, which you would like to bring to the attention of our readers?

Our view is that the issue of using nuclear power in space should become more international in the commercial respect, and I think that the development of such cooperation would be welcomed in both the West and the "East." Perhaps a first step toward better acquainting Western specialists with Russia's work on this problem would be to publish in the USA some kind of an overview of Russian publications in the area of nuclear power in space, which would provide a clearer understanding of the status of this question in our country.



Polytechnical Museum of Moscow

This scale model of a Russian TOPAZ space nuclear reactor is in the Polytechnical Museum of Moscow. Russian scientists ground-tested the first TOPAZ reactor in 1971, which operated for 1,300 hours. It used 26 pounds of nuclear fuel, delivered 5 kilowatts of power, using thermionic direct conversion, and weighed 710 pounds. The first TOPAZ reactor was flown successfully in 1987 on two experimental Plazma satellites. The program was abandoned by Mikhail Gorbachev in 1988.