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The Mysterious Explosion of a Russian Nuclear Missile Engine

by Lt. Col. (res.) Dr. Raphael Ofek

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EXECUTIVE SUMMARY: The fatal explosion that occurred recently during testing of the Russian Burevestnik nuclear cruise missile raises many questions. Could it have been avoided? Was it a fundamental failure of the ambitious armaments plan declared by President Putin in 2018? Whatever the answers to these questions, the renewed trend toward an unconventional armaments race could deteriorate into a second Cold War.

On August 8, during a test of the nuclear-powered engine of the 9M730 Burevestnik cruise missile (*petrel* in Russian; nicknamed the SSC-X-9 Skyfall in the West), held on a floating platform in the White Sea near the Nyonoksa missile test site in the far north of Russia, a mysterious explosion occurred that killed eight people. The blast raised questions about the status of a new generation of five advanced weapons introduced by Putin in 2018, of which Burevestnik, described by the Russian president as supersonic and of unlimited range, occupied pride of place.

Five of the eight people killed in the explosion were Rosatom (Russian State Atomic Energy Corporation) employees, and three more employees were injured. According to the company's announcement, the disaster occurred while testing an "isotopic energy source for a liquid propulsion system."

Shortly after the explosion, the weather monitoring agency Roshydromet reported a significant spike in radiation 40 km from the blast site. Also, in the city of Severodvinsk, which is near the explosion site in the Archangelsk district, the radiation level was reported to have jumped to 16 times the normal level. This led the alarmed residents to rush to stock up on iodine, which reduces the effects of radiation exposure.

The initial response of the Russian authorities to the incident was befuddling (if reminiscent of their conduct in the wake of the Chernobyl disaster). Following the blast, residents of the village of Nyonoksa, which is close to the beach and adjacent to the blast site, were told to evacuate immediately – but the order was soon rescinded. Information about the blast was difficult to obtain. When a Rosatom spokeswoman was asked if there was concern about radiation emissions as a result of the blast, she said the agency had nothing to add to the statements of the Russian Defense Ministry and the regional authorities – but the Defense Ministry had given out only a few details. Only later did the Rosatom Corporation release a video interviewing senior scientists at the nuclear center.

The dissipated radiation that followed the blast clearly indicated that the exploded missile engine was nuclear. Furthermore, the Russian authorities have admitted that five of the people killed were nuclear experts.

American arms control expert Jeffrey Lewis and his staff discovered, using an Automatic Identification System (AIS) designed to detect ships far from shore as well as satellite photos, that the ship Serebryanka had docked over a month before the blast in a closed area a few nautical miles off the Nyonoksa military test site. Serebryanka is a nuclear fuel ship for Barents Sea nuclear ice-breakers, and is usually docked at its base port of Murmansk. It remained docked off the Nyonoksa test site for about 30 hours after the August 8 blast, apparently to help cleanse the area of radioactive materials.

According to the DIA (US Army Intelligence), 13 tests of the Burevestnik or its systems have been conducted since 2016, including the August 8 disaster. Only two can be classified as having been relatively successful. In a November 2017 test, a missile was launched from a site in Novaya Zemlya and all missile systems were tested during flight. But the flight lasted only about two minutes, during which the missile went 35 km and then crashed into the Barents Sea. Another test of the missile's nuclear reactor was carried out in January 2019; according to the Russian news agency TASS, it was a success.

Missile development by the superpowers has been going on for a long time. In the early 1960s, at the height of the Cold War, the Pentagon conducted Project Pluto, which had the aim of developing a nuclear-powered supersonic cruise missile designed to carry several warheads. This project was similar to the Russian Burevestnik program. Progress in the development of ICBMs (intercontinental ballistic missiles) made Project Pluto superfluous in the Pentagon's view, and it was abolished in 1964.

A schematic diagram of the Burevestnik missile released by the Russian Defense Ministry shows that the missile is fired from its launch pad using a liquid-fueled booster rocket. After the missile rapidly accelerates, its engine begins to operate. The engine is based on ramjet technology that allows the missile to reach supersonic speeds of up to Mach 20.

The nuclear jet engine sucks air through its nozzle and then compresses and heats it to a very high temperature through the nuclear reactor inside the engine, which is shaped like a hollow cylinder. The air is then emitted sharply outward from the rear, providing the missile with the thrust to move forward.

Rosatom said the failed experiment of August 8 was testing an "isotopic energy source for a rocket engine fueled with liquid fuel." This negates the possibility that the source of energy applied to the Burevestnik missile is the metallic plutonium-238 isotope, as does the steep jump in the level of radioactivity in the areas near the explosion site. This is because plutonium-238 is not fissionable and therefore cannot be used as fuel for a nuclear reactor. Although this isotope is an alpha radiation emitter, it has very short-range radiation that is stopped after 5 cm of air.

With that said, the isotope's potent alpha emission renders it usable as a radioisotope thermoelectric generator (RTG). Indeed, it was used by the US space program as an energy source. It can therefore be stated with certainty that the "isotopic source of energy" referred to by Rosatom was a nuclear reactor. The advantage of a nuclear reactor is that it allows a cruise missile to move through the air for a very long time, giving it an essentially unlimited flight range.

However, the jump in radioactivity in the air near the blast site reduces the likelihood that the nuclear reactor installed in the Burevestnik missile is fueled with enriched uranium, or even highly enriched. It is therefore reasonable to conjecture that the nuclear fuel of the reactor is plutonium-239, which, in addition to being toxic, is radioactive. It is also more suitable for refueling a miniature reactor because its critical mass is five times lower than that of uranium-235, which makes it possible to reduce the reactor's dimensions.

Moreover, it is possible that the plutonium fuel in the reactor was not metallic but in a saline state, which would further reduce the amount of plutonium needed to fuel it. This hypothesis might explain Rosatom's reference to "an isotopic source of energy for a liquid-fueled rocket engine." Rosatom conducts many activities related to the development of molten salt reactors (MSR). These are nuclear fission reactors in which the primary reactor coolant and/or nuclear fuel is a molten salt mixture, and they use plutonium-239 as fuel.

The August 8 rocket engine explosion appears to have been caused by a rapid jump in reactor criticality beyond the permitted level. Nuclear missiles use a liquid-fueled booster rocket to accelerate to a speed that will enable their reactors to operate. There is thus a high probability of failure during the launch phase due to an obstacle hindering synchronization between the rocket's acceleration and the nuclear reactor system, or – either alternatively or in addition – a failure of the reactor's criticality control system.

Taking an overall view, it appears we now have a resurgence of an unconventional armaments race between the big powers, at least for purposes of deterrence – a situation that could deteriorate into a second Cold War.

Lt. Col. (res.) Dr. Raphael Ofek, a BESA Center Research Associate, is an expert in the field of nuclear physics and technology who served as a senior analyst in the Israeli intelligence community.