3D printing poses limited nuclear proliferation risks

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The limited implications of 3D printing for nuclear proliferation have been well established in open sources. *Robert Kelley* examines the case of centrifuge rotor construction techniques in greater detail

Key Points

- There are only a small number of components within nuclear weapons and gas centrifuges for which 3D printing could provide an attractive alternative to other forms of manufacturing or enable the construction of export-controlled components.
- Technical barriers and the small-build threshold of a clandestine nuclear weapons programme mean that potential proliferators are more likely to rely on a small, skilled workforce using traditional construction methods.
- Popular articles suggesting that gas centrifuges for uranium enrichment are easy to manufacture from 3D-printed maraging steel are not correct; 3D-printed maraging steel is a difficult and poor substitute for aluminium or fibre composite rotors.

The implications of 3D printing for nuclear weapons proliferation have been examined in open sources since at least 2015. Broadly, these analyses concur that there is only a small set of cases where 3D printing techniques currently present a nuclear proliferation risk, or may do so in the foreseeable future.

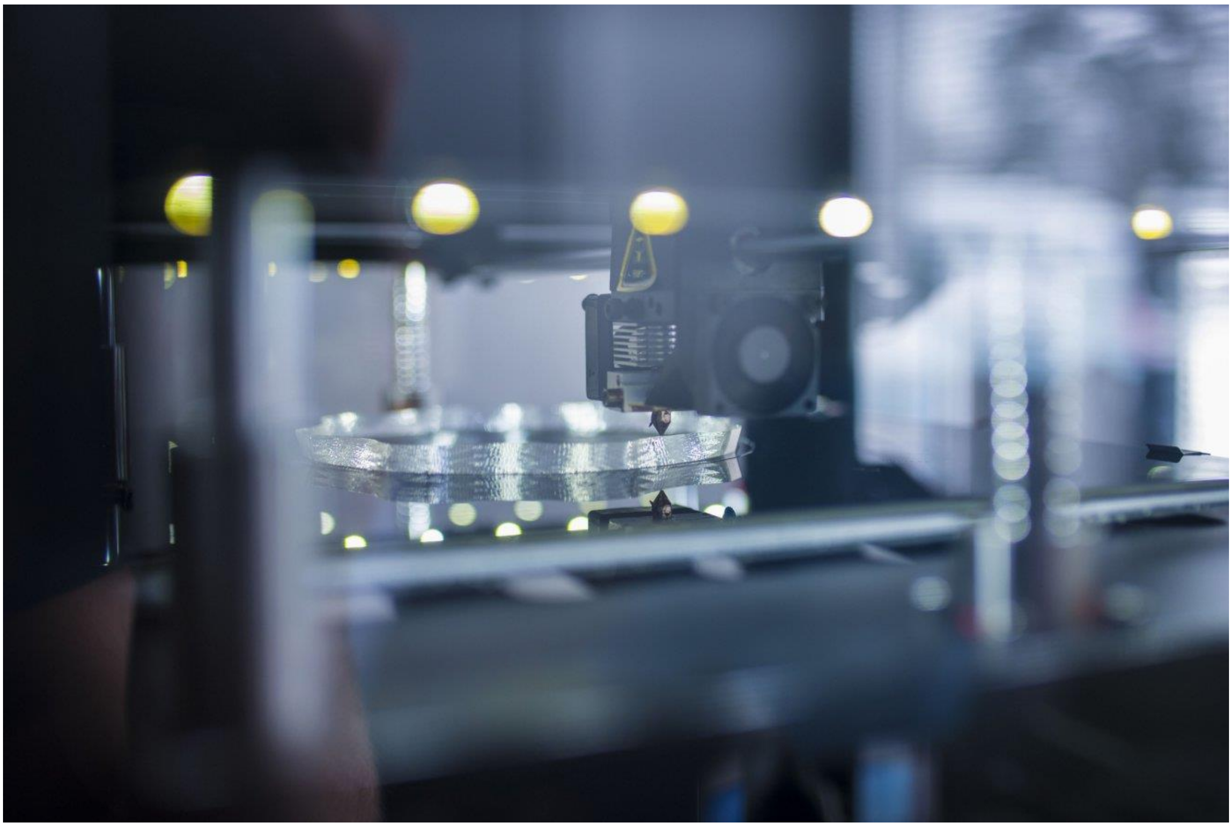
Suggestions that a complete nuclear weapon or centrifuge could be 3D printed in one pass are almost certainly overblown for many practical reasons. According to previous research by the author (published in a February 2017 paper for the EU Non-Proliferation Consortium, *Is three-dimensional printing a nuclear proliferation tool?* '), claims about groups being able to 3D print nuclear weapons in one pass could be "quickly refuted", as 3D-printing techniques had "not been developed to anywhere near the level needed … and probably never will be".

That paper and others, such as an August 2015 paper by Grant Christopher of King's College London titled *3D Printing: A Challenge to Nuclear Export Controls* , have examined the different components of nuclear weapons and gas centrifuges that could be produced using 3D printing. In light of the ongoing development of the technology, *Jane's* has updated its assessment of the effect of 3D printing on nuclear non-proliferation, with a particular focus on centrifuge rotor manufacturing.

<u>Implosion weapons</u>

A plutonium implosion weapon uses an inner core of plutonium. This is a highly radiotoxic and chemically reactive metal. However, 3D printers are already printing highly reactive metals and dealing with toxic materials, so those limitations are not a barrier, per se, to 3D printing of plutonium.

Plutonium has the most complex metallurgical structure of any element. It is very difficult to alloy, cast, and machine, but the solutions for conventional manufacturing have been openly published for decades. However, the process development for 3D printing plutonium would take far longer than using existing knowledge. Moreover, it would not offer any new capability and would consume huge resources.



A close-up shot of a 3D printer printing an object. Although 3D printing could revolutionise some forms of manufacturing, the implications for the construction of nuclear weapons and infrastructure are limited. (AzmanL/Getty Images)

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A similar argument applies to 3D printing of uranium metal, although it is far less toxic and reactive. Moreover, *Jane's* assesses that 3D printing would provide no advantages for the construction of heavy and obsolete gun-type uranium weapons.

The core of a nuclear weapon is often surrounded by a light metal such as beryllium to reflect neutrons into the explosion. The reflector also provides mechanical support, corrosion resistance, and containment of radiotoxic plutonium. Beryllium is a difficult material to work with; objects cannot be cast in furnaces and are normally manufactured by powder metallurgy processes (in which metals powders are shaped under high temperatures and pressure to form a chemical bond).

Beryllium powder for 3D printing is difficult to obtain. However, mixtures of beryllium and aluminium powders are readily available on the market. They would be much easier to 3D print than pure beryllium, and process development would not be extensive. As such, 3D printing the beryllium/aluminium component could be an attractive alternative enabling technology for a proliferator.

The final key components are the high explosive lenses that crush the core to supercriticality and nuclear explosion. Crude devices can use explosives such as melt-cast TNT or Composition B. 3D printing would not aid casting processes. More modern, powerful high explosives such as RDX or HMX are normally pressed at high pressures with a binder. This is dangerous and requires a very large isostatic press. Acquiring the press is a barrier because of export controls. The pressed parts are then machined, which is another dangerous process.

3D printing could assist in producing the high explosive parts in the future. However, *Jane's* assesses that this is unlikely to be practical before the 2030s. Proper explosive powder would be required, but the binder might not be necessary. This process may take many years to reach maturity, but 3D printing of explosive lenses that may have complex shapes and intricate details could eventually become an enabling technology for a proliferator, bypassing existing export controls.

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