The Future of Nuclear War

The Dangerous Future of the Nuclear War:

Superbombs, Cheap Nukes and Geophysical Attacks

*Alexey Turchin*

Digital Immortality Now

Foundation Science for Life Extension

[alexeiturchin@gmail.com](mailto:alexeiturchin@gmail.com)

<https://philpapers.org/rec/TURTFO-14>

**Abstract**

In this article, I present a view on the future of nuclear war which takes into account the expected technological progress as well as global political changes.

There are three main directions in which technological progress in nuclear weapons may happen:

1) Very powerful, many gigaton weapons.

2) Cheaper nuclear bombs which are based on the use of the reactor-grade plutonium, laser isotope separation or are hypothetical pure fusion weapons. Also, advanced nanotechnology will provide the ability to quickly build large nuclear arsenals and AI could be used in designing, manufacturing and nuclear strategy planning.

3) Specialized nukes like nuclear-powered space lasers, hafnium bombs and nuclear-powered space ships as kinetic weapons.

Meanwhile, the nuclear war strategy also has changed as the bipolar world has ended and as new types of weapons are becoming available.

The first strategy change is that Doomsday weapons for blackmail will become attractive for weaker countries which can’t use ICBM to penetrate the anti-missile defense of the enemies.

Secondly, the cheaper nukes will become available to smaller actors, who may be involved in “worldwide guerilla”. Cheaper nukes and a larger number of actors also encourage regional nuclear wars, nuclear terrorism and anonymous or false-flag warfare. This will result in the disruption of social complexity and in the global food production shortages because of the effects on climate.

The third change of the strategy is the use of nukes not against primary military targets but on other objects, which could increase their effects: nuclear power plants, supervolcanos, EMP, tsunamis, taiga fires for global cooling, and even more hypothetical things like asteroid deflection to Earth.

All these unconventional means and strategies of nuclear war could become available somewhere in the 21st century and may cause or contribute to the civilizational collapse and even human extinction.

[Introduction 3](#_Toc103958697)

[Objections to the idea of the significant future of nuclear weapons 3](#_Toc103958698)

[Structure of the article 4](#_Toc103958699)

[Technological capabilities growth 4](#_Toc103958700)

[Larger nukes 4](#_Toc103958701)

[Cheaper nukes and proliferation 5](#_Toc103958702)

[Rector-grade plutonium weapons 5](#_Toc103958703)

[Nuclear proliferation via civil nuclear power 6](#_Toc103958704)

[Black market and general tech 7](#_Toc103958705)

[The decline of the global proliferation control and the rise of demand 7](#_Toc103958706)

[New ways to uranium enrichment: SILEX 8](#_Toc103958707)

[Thermonuclear reactors as a source of radioactive elements and fissile materials 8](#_Toc103958708)

[Pure fusion nuclear weapons 8](#_Toc103958709)

[4th generation nuclear weapons 9](#_Toc103958710)

[Laser-driven fusion as an ignition for a bomb 10](#_Toc103958711)

[From fusion reactors to pure fusion bombs 11](#_Toc103958712)

[Cold-fusion-based weapons? 11](#_Toc103958713)

[Muon-driven fusion 11](#_Toc103958714)

[New types of nuclear bombs 11](#_Toc103958715)

[Hafnium bombs 11](#_Toc103958716)

[Antimatter-based weapons 11](#_Toc103958717)

[Neutrino weapons 12](#_Toc103958718)

[Thorium 12](#_Toc103958719)

[Red mercury 12](#_Toc103958720)

[Black hole bombs 12](#_Toc103958721)

[Meson bomb 12](#_Toc103958722)

[Salted weapons 12](#_Toc103958723)

[Nuclear-powered weapons-delivery system 13](#_Toc103958724)

[New means of delivery 13](#_Toc103958725)

[Geophysical, EMP and climate-affecting nuclear weapons 13](#_Toc103958726)

[Electromagnetic pulse bombs cause a global collapse of electricity 13](#_Toc103958727)

[Supervolcanos 13](#_Toc103958728)

[Dams 13](#_Toc103958729)

[Landslides and tsunami 14](#_Toc103958730)

[Global chemical contamination 14](#_Toc103958731)

[Climate 14](#_Toc103958732)

[A nuclear attack on nuclear power stations 14](#_Toc103958733)

[Space nukes 16](#_Toc103958734)

[Nukes on orbit 16](#_Toc103958735)

[Anti-asteroid defense as an offensive weapon 16](#_Toc103958736)

[Nuclear-powered spaceships as weapons 16](#_Toc103958737)

[Core degasation as a Doomsday weapon 16](#_Toc103958738)

[Giant gas planets detonation 17](#_Toc103958739)

[Nuclear-powered lasers and energy jets 17](#_Toc103958740)

[3. Nuclear war and strategy changes 18](#_Toc103958741)

[Doomsday weapons as a last resort for a weaker side 18](#_Toc103958742)

[The doomsday weapon as a universal blackmail 18](#_Toc103958743)

[Mutually excluding Doomsday weapons 18](#_Toc103958744)

[Nuclear terrorism and anonymous war 19](#_Toc103958745)

[Nuclear guerilla 19](#_Toc103958746)

[Tripolar world 19](#_Toc103958747)

[The example of Russia 19](#_Toc103958748)

[A sloppy way to a larger nuclear war 19](#_Toc103958749)

[AI-empowered nuclear strategy 19](#_Toc103958750)

[Accidental nuclear war 19](#_Toc103958751)

[Anti-AI nuclear war 20](#_Toc103958752)

[Nuclear-biological war 20](#_Toc103958753)

[Other changes in the nuclear strategy and capabilities 20](#_Toc103958754)

[Collapse of social complexity and climate crisis from a regional nuclear war 20](#_Toc103958755)

[4. Existential risks from the future nuclear war 20](#_Toc103958756)

[Mitigation 21](#_Toc103958757)

[Literature 21](#_Toc103958758)

# Introduction

When we speak about global catastrophic risks connected with new technologies, we assume that in the decades from now these technologies will advance by many orders of magnitude. AI will become much stronger, nanobots will appear and biohackers will get access to better manufacturing capabilities. But the discussions about nuclear war assumed that this war will be the same as it was envisioned in the 20th century: a nuclear exchange between two superpowers, which, in the worst case, will cause a “nuclear winter” for several years, which could cause mass starvation of survivors, but not a human extinction. The highest number of deployed nukes was achieved in the 1980s and declined several times after that. So, it looks like the scale of possible nuclear war and thus its danger has declined.

However, if we assume that technological progress will continue also in the nuclear field, the same way as it happens in other fields, such a decline in nuclear numbers maybe only a temporary fluke.

It is reasonable to suggest that assumed exponential growth in AI and nanotech will be reflected in exponential growth in nuclear technologies, but we currently observe such growth only in civilian nuclear applications, like the number of approaches to fusion.

## Objections to the idea of the significant future of nuclear weapons

There are several objections which immediately appear in mind when we speak about the future of nuclear war, and which generally prevent us from digging deeper into the topic. I will shortly address these objections first:

1. *Drones and precise weapons*. One may object that there is no need in nuclear development as drones could inflict similar damage via precision strikes (Turchin & Denkenberger, 2018). But owning nukes was always seen as a symbol of ultimate military power, as they could be used to finally crush the opponent.
2. *Cold war.* Another objection is that we “knew everything” about nuclear energy since the peak of Cold war, and there is not much left to discover in the field. However, while many ideas existed even from the 1950s, like nuclear-powered nuclear torpedoes, they were starting to be implemented only recently. Also, there is an important article by Gsponer about the “4th generation of nuclear weapons” (Gsponer, 2005). Because the field is covered with secrecy, public knowledge may be obsolete for decades about what is actually possible. Also, the nuclear field was underfunded after Cold War and the global “ban” on tests. A new confrontation between the West and China with Russia will fuel more research in nuclear capabilities.

Also, it could be argued that the Cold War nuclear arsenals were the “peak”, which will never repeat itself, the same way as Egyptian pyramids appeared on early stages of architecture development, but were never repeated. But nuclear weapons has more practical significance than pyramids.

1. *Conventional weapons.* One more objection is that small tactical nukes can be replaced by powerful conventional explosives, or drone swarms, or space kinetic weapons. Large thermobaric bombs can reach 47 TNT equivalent like Russian “[Farther of all bombs](https://en.wikipedia.org/wiki/Father_of_All_Bombs)”. However, they play minor role in current war (like the war in Ukraine in 2022), probably because there is no much targets for them and large collateral damage. US has built only 17 MOAB (which has 11 TNT equivalent, never used in war) and 225 BLU-82 (6 TNT). All this implies that there is no need in small nukes, as in most cases they will can be replaced with conventional weapons, and there is not much need in them.
2. *Biological doomsday weapons.* Large nuclear doomsday weapons could be cheaply replaced by “biological doomsday” weapons like vials with smallpox or artificial multipandemic from different pathogens (Turchin et al., 2017).
3. *AGI soon.* If AI (or advance nanotech) will appear very soon, there will be no time for nuclear weapons development or use.

## Structure of the article

To analyze this, we firstly in Section 2 will discuss if technological development is possible in the nuclear field at all. One view is that such progress is impossible because almost all that could be achieved has already been done in the 20th century, and also because without nuclear tests there is no progress. There are two parts of such progress: the things which definitely could be done, and hypothetical things which may work or not, but there are many of them, so some will work. Then, in Section 3, we will look at how new technological capability will change the face of a possible nuclear war and nuclear strategy. Finally, in Section 4 we will look again over the results and will see how it all adds up to the risks of civilizational collapse and human extinction.

# Technological capabilities growth

The article “[Fourth Generation Nuclear Weapons: Military effectiveness and collateral effects](https://arxiv.org/abs/physics/0510071)” (2005) presents many aspects of the future of nuclear weapons.

## Larger nukes

The biggest nuke which was ever tested was the Tsar bomb with the yield of 58 Mt, but Teller [worked](http://blog.nuclearsecrecy.com/2012/09/12/in-search-of-a-bigger-boom/) on a 10 gigaton bomb, after which he has turned his genius to the construction of small warheads for submarines. In particular, his peers were afraid that he will succeed in the construction of such a bomb and wanted to turn his attention to safer things. So, they thought that such a bomb is technically possible, maybe as a several stages device.

As the Tsar bomb's weight was 20 tons and its full potential was 100 Mt, a 10 Gt bomb will likely weight 2000 tons. Such a weapon should be either stationary or transported by sea, maybe by a submarine. If we assume that building such a bomb has the same level of difficulty as building a nuclear reactor of the same size, its price will be around a few billion dollars. Most nuclear-capable countries will be able to build such bombs, and maybe even several if it fits their strategy.

A 100 MT bomb will kill almost everybody within 10 Km (and many in 20) distances according to Wellerstein’s [map](https://nuclearsecrecy.com/nukemap/). However, the effects of explosion decline according to a power law (in the map, 10 times increase of the explosion power results in a 2.3 times increase of the thermal burns radius). So, the 10 Gt explosion will be universally lethal for only 4-5 times longer distance, that is 40-50 km (or 100 km for more moderate damage). This is far from being an existential risk and is not practical for common warfare. The main effects of a very large bomb will be fallout and its influence on climate.

A 100 Mt bomb has a fallout area of 334.000 sq. km with radiation of 10 rad per hour, which produces a lethal dose in 24 hours. Simple extrapolation for a 10 GT bomb means that this will be around 30 mln. sq. km. (or 6 per cent of Earth's surface). However, larger bombs will have different patterns of fallout as more debris will go into the upper atmosphere and thus will stay there longer (it is good, as it will decay before hitting the ground back), but also it will be moved by the jet stream all over the world. In the end, even one such bomb could affect half of the hemisphere. We also don’t include yet the possibility that such a large bomb will be deliberately “salted” with covering capable to increase the production of dangerous isotopes, like cobalt-60, which will significantly increase fallout.

While the basic physics of creating large bombs was probably known from the 1950s, the manufacturing capabilities jumped since then. Firstly, there is now much more knowledge based on tests of smaller bombs. The availability of computer modelling means cheaper and more reliable designs. 3D printing, robotics and high precession production suggest that the manufacturing could be simpler.

We could suggest that the price of construction of a 10GT bomb will be comparable with the price of a large nuclear power plant, in order of magnitude of around 10 billion dollars. Another way to deduce the price is to compare it with the price of large projects like LHC or ITER, which cost tens of billions. Based on this price estimate, we could guess the size of the largest possible bomb which could be built given the current economy. It is unlikely that any country now will spend more than 100 billion on a single bomb. In a richer world in the future, with better manufacturing technologies, this could grow up to 1 trillion USD equivalent to the current purchasing power of USD. This means that current tech could create a 100 GT bomb, and future tech may produce 1000 GT, but this is the limit. 1000 GT bomb is only 0.001 of the explosion energy of the asteroid impact which killed dinosaurs, so the explosion itself maybe still not be enough to kill everybody, but its fallout may be able to do so.

If manufacturing nanotechnologies will be developed or autonomous robots will appear, even larger bombs will be possible.

## Cheaper nukes and proliferation

### Rector-grade plutonium weapons

Despite some doubts, it looks like the reactor-grade plutonium (that is one from the peaceful nuclear reactors) could be used for nuclear weapons production. There [was](http://www.ccnr.org/plute_bomb.html#:~:text=This%20test%20was%20conducted%20to,was%20declassified%20in%20July%201977.) a nuclear test with it.

The main difference between the rector-plutonium and the weapons-grade plutonium-239 is that the first is contaminated with plutonium-240 with a half-life of 6700 years and some other isotopes. Some of these isotopes are relatively short-living, like plutonium-241 with a half-life of 14 years, but these short-living isotopes make the reactor-grade plutonium highly radioactive and difficult to process. However, because of their short half-life, they will be almost gone in a few decades. After that, not so radioactive fuel (still contaminated with Pu-240) will be cheaper to process and the isotope separation technics could be used to lower the concentration of P-240. Because of this, old owners of reactor-grade plutonium could eventually have access to the good sources of almost weapons-grade plutonium. There are large stockpiles of such reactor-grade plutonium in the world. “Japan now has 45.5 tons of separated plutonium — 8.9 tons at home, and 36.6 tons in Britain and France, where spent fuel from Japanese nuclear plants has been reprocessed and stored because Japan lacks a plant to produce MOX fuel containing plutonium at home. The amount is enough to make about 6,000 atomic bombs.” [Link](https://apnews.com/article/cabinets-recycling-yoshihide-suga-energy-policy-japan-66218c8a44a498a1535380066da466e9#:~:text=Japan%20now%20has%2045.5%20tons,make%20about%206%2C000%20atomic%20bombs)

The development of robotics and laser separation methods will make the processing of the spent fuel cheaper, and thus weapons-grade plutonium could be produced from it.

[There are](https://www-pub.iaea.org/MTCD/Publications/PDF/te_1591_web.pdf) 530 tons of processed plutonium and 176 000 tons of spent fuel in the world, but only 1 per cent of the mass of the spent fuel is plutonium. So, the total is 1760 tons. Given the critical mass of P-239 as 2-4 kg for an implosion bomb, it is enough to produce 440 000-880 000 plutonium cores. As the nuclear industry continues to produce spent fuel and the industry size also grows, this number will grow several times by the end of the 21st century, maybe reaching several million possible nuclear weapons cores. If each is used as a starting point of a thermonuclear device with a 1MT yield, this corresponds to 1000GT of a possible nuclear arsenal at the end of the century. Plutonium is not decaying and will be always here, so it could be used as a weapon even thousands of years from now. There are ways to lower the needed critical mass of plutonium per core by mixing it with uranium or using higher pressure and some other tricks.

Adding here military stockpiles of enriched uranium and weapons-grade plutonium, we could conclude that there is enough material for more than **a million** nuclear weapons on the Earth, and it could grow several times by the end of the 21st century. Each such nuclear weapon could be used as a primary to a hydrogen bomb, salted and-or boosted with tritium.

A test of a bomb on reactor-grade plutonium [produced](http://www.ccnr.org/plute_bomb.html) less than 20kt yield in 1962. There are many other interesting materials on this site.

Alternatively, reactor-grade plutonium could be used unprocessed to make very weak nuclear weapons, basically, fizzle. “…the United Nations recently translated a book entitled "Nuclear Weapon Design" as follows: “Such an assembly [plutonium gun-type] designed by terrorists using reactor-grade plutonium would have an expected yield of a few times the fizzle yield, amounting to 1 kiloton or more and having catastrophic consequences. A mere fizzle yield would still be a very damaging explosion, with effects of blast, heat, and prompt radiation extending out to a radius of at least one-third of a mile.” [Link](https://www.israelnationalnews.com/Articles/Article.aspx/12641).

In 1944, the maximum speed of the projectile from the gun in the “Thin Man” nuclear weapon design was 910 meters per sec. This was not enough to produce a large explosion. Wikipedia [states](https://en.wikipedia.org/wiki/Fat_Man): “The distance required to accelerate the plutonium to speeds where predetonation would be less likely would need a gun barrel too long for any existing or planned bomber”. This means that with higher velocities, the problem of predetonation could be overcome. Maybe two guns should be pointed at each other, or they should be longer. Contemporary guns of the 21st century are able to produce a higher speed of the projectile. Contemporary tank guns have 1700 m per sec and scientific gas guns are up to 8500, [wiki](https://en.wikipedia.org/wiki/Muzzle_velocity). There could be many other ideas on how to overcome the problem of predetonation of reactor-grade plutonium. Obviously, they should be a state secret.

### Nuclear proliferation via civil nuclear power

While most nuclear power plants are not effective in producing weapons-grade plutonium, they could be converted into such producers, if the fuel will be used in a shorter cycle. They also produce reactor-grade plutonium which was discussed above.

More importantly, they become centres for the nuclear producing industry, which include the generation of scientists, fuel production and reprocessing facilities, which could be converted into the military nuclear program on short notice or cover such a program. However, most of the civil nuclear power is used by countries which already have access to nuclear weapons or NATO membership, but there are several exceptions.

ITER and other fusion reactors could be a proliferation risk as they create a strong neutron flux which could be used for uranium enrichment. (“[Nuclear Weapons Proliferation Implications of Thermonuclear-Fusion Energy Systems](https://arxiv.org/pdf/physics/0401110.pdf)” [)](https://arxiv.org/pdf/physics/0401110.pdf)) Also, this neutron flux creates a lot of radioactivity inside the tokamak building and fire or small explosion inside such a reactor could release a large amount of radioactive material.

### Black market and general tech

Access to markets allows outsourcing of many complex tasks by using standard equipment. The nuclear black market may also help. The larger is the number of smaller actors who own parts of the nuclear cycle, the more profitable will be the exchange of materials, technologies and scientists. For example, Iran can’t legally enrich uranium above 20 per cent, but no more. So, it could send some of its enriched uranium to North Korea which will perform final enrichment and will send part of it back as an HEU. Such trade would help both countries to escape international sanctions. Alternatively, sides could just buy and sell nuclear weapons, if there is a demand.

The limitation of access to uranium ore could be overcome by the technology of extraction of uranium from seawater. Genetically engineered bacteria could extract uranium from water in underwater farms: such technology was already [tested](https://www.forbes.com/sites/jamesconca/2016/07/01/uranium-seawater-extraction-makes-nuclear-power-completely-renewable/?sh=15c2b1e2159a) in Japan and has prices comparable with mining.

A small nuclear weapons project maybe not be that expensive. It requires a small pile-type nuclear reactor to produce an initial amount of plutonium. V.Khrustalev estimated that the price of such an initial project will be around 400 million dollars. In our time, small startups build space rockets, like Electron or Astra, and around 100-1000 people work on such startups, but in the middle of the 20th century, it was large projects available only to superpowers. Such democratization of complex technology is likely also possible for nuclear programs. Many companies are now working on small nuclear reactors.

### The decline of the global proliferation control and the rise of demand

Currently, the demand for nuclear weapons in the world is low. Most countries who wanted them, eventually got them, with a few exceptions of Syria, Iran, and Myanmar. Others either joined some nuclear agreements or chose non-nuclear status.

There is a group of countries that may want to have nuclear weapons, but don’t want to look bad in the eyes of their peers. These are countries which are at risk of war with neighbours or have strong military ambitions: Taiwan, Turkey, Egypt, Ukraine, Armenia, Azerbaijan, Brazil, Argentine, Japan, and Saudi Arabia. One of the reasons for the lower popularity of nuclear weapons is that owning nuclear weapons is protection from complete military defeat, but not against smaller military loss. The benefits of not owning nukes are high as attempts to get them will result in strong international sanctions, and such sanctions will prevent access to even more effective weapons like military drones.

There is no attractive example of using nukes to win a military conflict in the current world. This could change if a taboo on non-using nukes will fail and nuclear power will be used to win even a small regional war.

In a more chaotic world, global regulation of nuclear material will decline as well as the importance of trade with the international community, and smaller countries may choose to create nuclear arsenals for their protection.

### New ways to uranium enrichment: SILEX

Besides the access to uranium ore, the main difficulty in obtaining nukes is the complexity of uranium enrichment via centrifuges. Large plants are needed to be built and they should work for a long time to either produce nuclear fuel for reactors which will produce plutonium or high-enriched uranium for uranium bombs. But some reactor designs could work even on non-enriched uranium (like Chicago Pile-1).

[SILEX](https://www.tandfonline.com/doi/full/10.1080/08929882.2016.1184528) is a new technology for uranium enrichment based on laser separation of isotopes. It is recognized as a proliferation risk. Though commercialization of the technology experienced difficulties.

GMO-modified organisms presumably could also be used for uranium enrichment as many living organisms have a preference for some types of isotopes (but of lower nuclear masses, like carbon).

### Thermonuclear reactors as a source of radioactive elements and fissile materials

Most suggested thermonuclear reactors will produce neutron fluxes. Even most clean reaction p+B with boron has 1 per cent of parasitic reaction, which produces neutrons. These neutrons are absorbed by the wall of the chamber and make it radioactive. Some construction projects of ITER assumed the use of cobalt and this cobalt could become dangerous cobalt-60 after neutron absorption. If a fusion reactor will have a catastrophic failure, like a fire or a small explosion, large amounts of radioactivity will be released.

Fusion reactors could be used as neutron sources which will be used for the creation of plutonium from U-238.

## Pure fusion nuclear weapons

The dream of pure fusion weapons, which do not use fission nuclear bombs for reaction initiation, existed for a long time but didn’t produce workable weapons, at least in published sources. The use of chemical explosion and electric current could create some fusion, but its energy output will be only a few tons of TNT, not much than the weight of the bomb itself, so it is impractical. [Wiki](https://en.wikipedia.org/wiki/Pure_fusion_weapon): “It has been claimed that it is possible to conceive of a crude, deliverable, pure fusion weapon, using only present-day, unclassified technology. The weapon design [1] weighs approximately 3 tonnes and might have a total yield of approximately 3 tonnes of TNT. The proposed design uses a large explosively pumped flux compression generator to produce the high-power density required to ignite the fusion fuel. From the point of view of explosive damage, such a weapon would have no clear advantages over a conventional explosive, but the massive neutron flux could deliver a lethal dose of radiation to humans within a 500-meter radius (most of those fatalities would occur for months, rather than immediately).” The design is described in the article “[The question of pure fusion explosions under the CTBT](http://scienceandglobalsecurity.org/archive/sgs07jones.pdf).” In the article is also added that there are several ways to increase the yield: the shell from U-238 will increase the yield up to 3 times, and adding the second fusion stage will increase it even more.

There are two main (but still hypothetical) approaches to the pure fusion weapon. The first is accessible to only high-tech nuclear powers and requires the use of high-tech things tritium, antimatter, isomers, and powerful lasers – and the other approach, which is used only easy available isotopes for fusion and some combination of high currents, coils and guns, and thus could be replicated by poor countries or actors. Only the second is really significant. The advanced nuclear state could have many dangerous weapons even without pure fusion, so pure fusion will not change much, except lowering the nuclear use threshold.

Tritium is the easiest fuel but it is difficult to produce, and it requires nuclear power plants for manufacturing. Other fuels, based on lithium, deuterium or boron, could be assessable to smaller actors. Pure fusion weapons are a proliferation risk.

Paradoxically, the research in peaceful fusion could also provide the means to create a pure fusion bomb.

Even low-yield pure fission weapons are a significant source of deadly neutron radiation which could kill people at a distance of a few hundred meters or create radioactive contamination by interaction with surrounding matter.

There are many ideas on how to achieve pure fusion by combining laser, magnetic field, electric current and conventional explosives discussed here: “[High-Gain Magnetically Insulated Impact Fusion via Staged Explosive Acceleration to Hypervelocity](http://www.projectrho.com/public_html/rocket/supplement/Impact%20Fusion%20Write-Up.pdf)” The range of suggested in this article device is: “The device in Figure 2 is on the low end of possible yields, with a mass of 20 kg, a length of 45 cm, a diameter of 8 cm and a yield of 250 kg of TNT. Scaled up to the largest reasonably portable size, the same design would have a mass of 1600 kg, a length of 2.5m, a diameter of 40 cm and a yield of 2 kt of TNT.”

If such a pure fusion device requires precision in assembling the layers of explosives, it will be not available to smaller terrorists groups. If construction will be relatively simple, a terrorist could repeat it, the same way as they build Grad missiles and drones in Syria.

The article “[Fourth Generation Nuclear Weapons: Military effectiveness and collateral effects](https://arxiv.org/abs/physics/0510071)” (2005) is worth reading as it covers many ways to pure fusion weapons. Another important report is “[Dangerous Thermonuclear Quest: The Potential of Explosive Fusion Research for the Development of Pure Fusion Weapons](https://ieer.org/wp/wp-content/uploads/1998/07/DangerousThermonuclearQuest.pdf).”

[Wikipedia](https://en.wikipedia.org/wiki/Induced_gamma_emission#Nuclear_weaponry) on alternative designs of pure fusion weapons:

“Alternative fusion trigger. Some researchers have examined the use of antimatter[2] as an alternative fusion trigger, mainly in the context of antimatter-catalyzed nuclear pulse propulsion but also nuclear weapons.[3][4][5] Such a system, in a weapons context, would have many of the desired properties of a pure fusion weapon. However, the technical barriers to producing and containing the required quantities of antimatter appear formidable, well beyond present capabilities. Induced gamma emission is another approach that is currently being researched. Very high energy-density chemicals such as ballotechnics and others have also been suggested as a means of triggering a pure fusion weapon. Nuclear isomers have also been investigated for use in pure fusion weaponry. Hafnium and tantalum isomers can be induced to emit very strong gamma radiation. Gamma emission from these isomers may have enough energy to start a thermonuclear reaction, without requiring any fissile material”.

[Nanotechnology](https://www.cnbc.com/2017/03/17/mini-nukes-and-inspect-bot-weapons-being-primed-for-future-warfare.html) can theoretically be used to develop miniaturized laser-triggered pure fusion weapons that will be easier to produce than conventional nuclear weapons: “Del Monte explained that the mini-nuke weapon is activated when the nanoscale laser triggers a small thermonuclear fusion bomb using a tritium-deuterium fuel. Their size makes them difficult to screen, detect and also there’s “essentially no fallout” associated with them.”

More about the role of nanotech in nukes: “[From the lab to the battlefield? Nanotechnology and fourth generation nuclear weapons](https://arxiv.org/abs/physics/0509205)” (Gsponer, 2005b).

### 4th generation nuclear weapons

Gsponer calls 4th generation nuclear such weapons that will be pure fusion weapons with yields between 1-100 TNT:

“1. FGNWS can have yields in the 1 to 100 tons gap which today separates conventional form nuclear weapons.

2. Compared to previous generations, FGNWs have enhanced direct coupling to dense targets and reduced collateral effects, as well as the capability to drive powerful “jets” and “forged fragments.”

3. FGNWs are in line with the “increased precision” and “reduced collateral damage” trends of modern warfare.

4. Proponents will claim that FGNWs have a high potential to destroy “biological and chemical” weapons, as well as future “nanorobots...”

5. The military “sweetness” of FGNWs is such that they will eventually be built by all technologically-advanced countries, including non-nuclear weapons States such as Japan, Germany, Brazil, etc.”

They will be similar to neutron bombs: large neutron flux will kill personnel at higher distances than the explosion wave, but they will be even cleaner in terms of fallout.

They are also not prohibited by Comprehensive Test Ban Treaty. He also wrote:

“1. As the United States are likely to take the lead in the development and deployment of FGNWs, a nuclear arms race may result in which all advanced industrialized countries (e.g., Germany, Japan, France, China, etc.) could compete to become the second-largest military power in the XXIth century.

2. The development of FGNWs will most likely increase the attractiveness of previous generation nuclear weapons to technologically less-advanced countries.”

Pure fusion weapons require tritium, which is difficult to produce: an accelerator is needed. Thus, a small organization can’t get tritium-based pure fusion weapons, but they will be available only to countries with already established nuclear programs. Hydrogen-boron fuel is easier accessible but requires much higher energies for ignition, so the simplest designs will not work for it.

Another article on the topic: “[The Third Nuclear Age: How I Learned to Start Worrying about the Clean Bomb](https://apps.dtic.mil/sti/citations/AD1018896)”:

“Fourth generation fusion nuclear weapons FGNW represent a significant improvement in nuclear weapons technology and suggest the potential for small, clean, low-yield nuclear weapons. These weapons will be difficult to monitor, present significant challenges to treaty verification, begin to approximate conventional explosives with nuclear effects, and are a potential deterrence destabilizer. FGNW threaten to lower the barrier to use by removing the largest impediment one typically encounters in contemplating the use of nuclear weapons, the long-term effects of fallout. The possible end of the non-use nuclear taboo, clean detonation, and blurring of the conventional-nuclear lines threaten to produce a Third Nuclear Age: dawning of the regular use of nuclear weapons in a conflict. FGNW represent a vast increase in what Thomas Schelling referred to as the threat that leaves something to chance”.

### Laser-driven fusion as an ignition for a bomb

An [article](https://ufn.ru/ru/articles/1998/11/f/) in Russian describes a way to achieve fusion detonation using a chain of larger and larger pellets.

### From fusion reactors to pure fusion bombs

The more we know about simple fusion reactors, the closer we are to pure fusion bombs. This is because most simple reactor designs use the small explosion of DT pellets ignited by some combination of velocity, lasers and magnetic fields.

See an [overview](https://www.nextbigfuture.com/2022/04/first-light-fusion.html) of several startups.

### Cold-fusion-based weapons?

Cold fusion is the idea that protons and deuterons inside a metal crystal lattice will have lower electrostatic repulsion and will be capable to undergo fusion even at home temperature. There is no evidence that this design actually works or at least produces a large amount of energy. However, a hypothetical possibility may be considered that it could be used in pure fusion weapons if a piece of palladium with dissolved in it deuterium will be heated or compressed from all sides. So, paradoxically, “cold fusion” will be only one more step to hot fusion.

### Muon-driven fusion

Muons were [suggested](https://en.wikipedia.org/wiki/Muon-catalyzed_fusion) as a catalyzer of fusion. They do increase the probability of fusion, but they decay quickly and thus do not produce enough energy for the self-sustained reaction. Some research is going on the ways how to improve the yield of muons driven fusion. If a way will be found to generate more muons than is lost during the reaction, something like a chain reaction will happen, and a new type of bomb will appear.

## New types of nuclear bombs

### Hafnium bombs

[Wiki](https://en.wikipedia.org/wiki/Hafnium_controversy): “The hafnium controversy is a debate over the possibility of 'triggering' rapid energy releases, via gamma-ray emission, from a nuclear isomer of hafnium, 178m2Hf. The energy release is potentially 5 orders of magnitude (100,000 times) more energetic than a chemical reaction, but 2 orders of magnitude less than a nuclear fission reaction. In 1998, a group led by Carl Collins of the University of Texas at Dallas reported having successfully initiated such a trigger. Signal-to-noise ratios were small in those first experiments, and to date, no other group has been able to duplicate these results”.

Hafnium could be hypothetically used to trigger pure fusion weapons, as discussed in (Greene, 2017).

### Antimatter-based weapons

While antimatter provides the highest energy concentration, producing and storing antimatter safely will be difficult. However, small amounts of antimatter could be used to trigger pure fusion weapons.

“If presently available technology would be used to build a fully dedicated “antimatter factory,” rather than a general-purpose “research facility,” one could easily produce more than 1 microgram of antimatter per year right now [27]. As 1 microgram is sufficient to trigger one thermonuclear weapon, such a facility will only be a factor 365 away from the implicit goal that the US and Soviet governments set forth in the 1940s, namely to produce enough material for making one atomic bomb every day! As a matter of fact, the United States and other countries are still investigating the best technique for producing very large quantities of antimatter. One such technique is based on the idea of creating a “quark-gluon plasma” (Gsponer, 2005a).

“The most likely solution to this problem will probably require that antimatter be stored within a condensed material, in which special sites will function as micro- or nano-metric sized “traps” where particles of antimatter will be confined in a metastable state sufficiently away from ordinary matter.” “Such a condensed-matter solution will be much more suitable and rugged than currently used electromagnetic traps and in line with the contemporary emphasis on micro-electromechanical engineering and nanotechnology” (Ibid).

“During 2004 a number of newspaper articles referred to a US Air Force program related to the development of new types of explosives and high-energy fuels based on antimatter, which emphasized the use of positron (i.e., anti-electron) rather than antiproton annihilation energy.” (Ibid)

### Neutrino weapons

[Destruction of Nuclear Bombs Using Ultra-High Energy Neutrino Beam](https://arxiv.org/pdf/hep-ph/0305062.pdf)

To create the needed beam of neutrinos, which can penetrate Earth and melt nuclear weapons cores, an accelerator 1000 km in diameter is needed, and it will consume 50GW – this seems prohibitively expensive now but if more powerful magnets will appear, the accelerator could be made smaller.

Neutrino beam while passing through Earth will create a hadron shower in the same direction which will include neutrons, which can interact with fissile materials. Such a hadron shower will likely cause enough radiation damage to kill people.

### Thorium

Thorium can’t be used to make a bomb and has no critical mass, but could be used to increase the yield of the thermonuclear bomb as it is fertile material and could capture neutrons and breaks. Thorium tamper could produce around half of the fallout. [Link](https://www.quora.com/Can-thorium-be-used-to-make-nuclear-explosives%20Thorium). Thorium reactors could also [produce](https://whatisnuclear.com/thorium-myths.html#myth3) U-233 which is fissile and could be used in nukes.

### Red mercury

A hypothetical substance which can help in producing dangerous nuclear weapons and allegedly was on the black market after the demise of the Soviet Union. Most likely, a completely fake thing.

### Black hole bombs

“in the professional scientific literature comprises many concepts, including very hypothetical ones such as “quark” or “black hole” bombs”. (Gsponer in [Forth generation of nuclear weapons](https://arxiv.org/pdf/physics/0510071.pdf).)

### Meson bomb

The idea [was discussed](https://en.wikipedia.org/wiki/Meson_bomb) starting from the 1940s but seems not workable and was eventually used for disinformation. As I understand, the idea is that neutron gas can transition into quark plasma with the release of energy, and this possibly happens in some neutron stars.

In 2017 the [discussion](https://www.livescience.com/60847-charm-quark-fusion-subatomic-hydrogen-bomb.html) about the possible risks of quark bomb reappeared when it was found that the merging of two quarks releases 8 times more energy than fusion. But no chain reaction with quarks was ever discovered as we know.

## Salted weapons

These are weapons designed to create maximum radioactive fallout. The first such idea was the idea of the “cobalt bomb”, which has a cover of cobalt-59 which capture fusion neutrons and create dangerous long-living isotope cobalt-60. However, other types of salting are possible, which create isotopes which live shorter but create more intense fallout. For example, gold.

Neutron bomb could be also regarded as salted weapon but it doesn’t have any cover and instead it allows neutrons leave the zone of reaction.

Such weapons were regarded as third generation of nuclear weapons by Gsponer, and pure fusion ones as a fourth generation.

Two stages radiological attack: using different isotopes, with different half-lives, will result in the “most effective” extinction. Some isotopes are able to be deposited in bone tissue, lung, thyroid, some affect soil, water, surfaces, or are denser then air gases (radon). Plutonium hot nanoparticles could remain in tissues.

## Nuclear-powered weapons-delivery system

Burevestnik is a Russian cruise missile powered by a nuclear ram-jet which can travel in the air indefinitely long. The supersonic low-flying nuclear-powered bomber was a Cold war project. It will create damage by the supersonic boom.

Also, nuclear-powered planes or drones could stay longer in the air. They will create radioactive damage if are shot down.

## New means of delivery

Nuclear-powered torpedo Poseidon is an example of such a new mean of delivery. Drones ыcould also be a new way of delivery of small payloads.

## Geophysical, EMP and climate-affecting nuclear weapons

### Electromagnetic pulse bombs cause a global collapse of electricity

The idea of the global dangers of high-altitude nuclear explosions and electro-magnetic pulse (EMP) it causing is probably overestimated, but it obviously will cause damage to unprotected civilian electric networks. Electromagnetic effects of small explosions are amplified by the ionosphere and could knock down the electric grid at a distance of up to 1000 km, as happened during nuclear tests near Hawaii.

### Supervolcanos

There were persistent claims in Russian literature that Russian nukes are aimed at the San-Andreas fault and on the Yellowstone caldera with the goal to cause a large earthquake or supervolcanic eruption. The caldera’s cover has around 8 kilometres in thickness, and no current weapon could go through it. However, several megaton-class attacks in one place may weaken the caldera’s cover and it will explode because of its own internal pressure. Nobody knows for sure will it work and is it a cost-effective use of weapons.

If Yellowstone erupts, it will cover a significant part of the continental US with deep ash and produce long and strong sun-deeming effects, lowering the global temperature around 10C and causing a food crisis. Such a crisis could be survived if the food-roduction measures envisioned by ALLFED will be implemented.

There are at least 20 supervolcanos on Earth and if all of them will be targeted, the effect will be global.

### Dams

Another type of amplification of the effects of nuclear weapons is an attack on large dams or rivers.

The failure of dam cascade could have an even larger effect, e.g. Three Gorges dam and dams below the stream in China or the Volga cascade of dams in Russia. Millions of people live downstream and many nuclear stations will be inundated.

### Landslides and tsunami

A nuclear explosion could trigger a large underwater landslide (La Palma) which will cause a tsunami in the Atlantic. But the size of that tsunami seems to be overestimated as point-sourced tsunamis quickly decline with distance. Small chances of global consequences.

### Global chemical contamination

Nuclear weapons may be used to free large amounts of toxic chemicals from their natural deposit. The Black sea has large amounts of H2S dissolved in its depth which could be enough to poison almost all life on Earth, but the stratification of water prevents its release. A war on such a sea could include the use of nuclear depth charges against submarines, which will disturb stratification and start the self-sustaining process of degasation of H2S. The Black Sea currently has 13 mg/m3 of H2S, equal to a total of around 100 million tons. However, to cause global contamination, much larger amounts are needed, like several billions tons a year, according to models of past anoxic events (see Ward "Under Green sky").

### Climate

Nukes could be used to affect climate, that is, to create artificial nuclear winter. This idea was suggested in the 80s by Roland in “[Nuclear Winter and Other Scenarios](https://web.archive.org/web/20070113094523/http:/pynthan.com/vri/nwaos.htm)” He wrote that the USSR could nuke a large space of Siberian taiga (1 mln sq. km according to a calculation by Moiseev) and create artificial fires there which will affect global climate. As USSR was presumably better adapted to a colder climate, it could be used as an advantage in the case of war.

Nuclear explosions in coal mines could send large volumes of soot into the upper atmosphere.

Alternatively, undersea nuclear explosions on the Arctic shelf could cause an eruption of methane from methane clathrates, which is a strong greenhouse gas and will cause runaway global warming.

### A nuclear attack on nuclear power stations

There are around 440 active reactors in the world and the number is not changing since 1988. But energy demands suggest the possibility of a new nuclear renaissance and that much more nuclear power stations will be built.

The worst possible scenario could be imagined: during a war, nuclear-tipped ballistic and cruise missiles are launched at all known nuclear facilities (reactors and spent fuel storage facilities) in all countries. For example, North Korea has threatened to attack Japanese nuclear power reactors.

It was estimated that a 1 megaton bomb is needed to vaporize a nuclear power station and send whole its radioactive materials into the atmosphere. See an interesting discussion of this question [here](https://www.quora.com/What-would-happen-if-a-nuclear-warhead-hit-a-nuclear-powerplant?fbclid=IwAR0mBkDsmqQaXk9s7c7fpJWm1cC7bXIbbGL8LlYTG03Nb0p234OmKm2oI4M).

However, the main danger is the spent fuel pools which easily could catch fire if left unattended without water, and surely will be damaged after even the smallest nuclear attack. Almost every nuclear power station has such a pool. As an author on Quora [said](https://www.quora.com/What-would-happen-if-a-nuclear-warhead-hit-a-nuclear-powerplant): “To put the extremity of the possible release in perspective at Fukushima, the spent fuel in pool #4 had the potential to release 22 times the amount of radiation into the environment as compared to Chornobyl (#4 pool 568 megacuries vs Chornobyl 25 megacuries). The Fukushima spent fuel pools in total had the potential to release 66 times the radioactivity of Chornobyl and there are hundreds of such sites around the world.” If a pool in Fukushima catch fire, Tokio would have to be evacuated.

The biggest part of accumulated radioactivity is in the spent fuel storages. 240,000 tons of it exist in the world. The total radioactivity of it is 28 billion Tbk (2.8x1022 atom disintegration events per second), according to “[Estimation of Global Inventories of Radioactive Waste and Other Radioactive Materials](https://www-pub.iaea.org/MTCD/Publications/PDF/te_1591_web.pdf)”. The total radioactivity of global spent fuel is 40 000 times more than that of all military sources. Chornobyl accident [produced](https://pubmed.ncbi.nlm.nih.gov/10628087/) 2 x 1018 becquerels, or 10 000 times less than the total radioactivity of the spent fuel in the world.

An interesting article tries to estimate the consequences of the worst-case reactor incidents: "[Importance of severe accidents radiological releases and definition of large damage](http://web.archive.org/web/20110326062412/http:/ompldr.org/vN3d4YQ)." It shows that the complete destruction of a large reactor will cause only 45 direct fatalities but around 50 000 latent fatalities due to cancer. The total destruction of a reactor will release 30 times more nucleotides than Chornobyl did. If we want to get total global fatalities in case all nuclear power reactors will be destroyed, we need to multiply these fatalities estimates by 440 (number of the reactors) and then by 10 – this comes from spent fuel pools. This will give around 176 000 direct fatalities and 220 million latent fatalities from cancer. Not good, but not an extinction-level event.

If this spent fuel will be disseminated all over the world, it will give 5x107 Becquerel’s per sq. m. (EPA [norm](http://web.archive.org/web/20110326062412/http:/ompldr.org/vN3d4YQ) is 7400 Bk per sq. m. or 1000 times less.) It is not easy to directly convert this into exposition dose in rads. One claim is that topsoil always has 1 curie (=3.7x1010 Bk) per sq. mile of natural radium on the depth to 1 foot, according to this [document](https://books.google.kg/books?id=aoaSVcOAhpEC&pg=PA1579&lpg=PA1579&dq=strontium+square+meter+to+roentgen&source=bl&ots=1TyhtBNGpn&sig=ACfU3U1yHiBoeft_hcJ7gPiqbJd7pFiyyg&hl=ru&sa=X&ved=2ahUKEwj8i7fWtbn3AhXkpYsKHa0KBhsQ6AF6BAg0EAM#v=onepage&q=stront), which is around 104 per sq. meter, or 1000 times less than what would be produced by a global attack on spent fuel depots. If man natural radioactivity is around 15 mcR-hour and comes mostly from radium, now it will be 15 000 mcR-hour (or 120 R in a year), but it is the upper estimate, as there are other natural sources.

There are several [places](http://www.ecolo.org/documents/documents_in_english/ramsar-natural-radioactivity/ramsar.html) on the Earth which have high natural radioactivity, but people don’t constantly live there. Some people get 13 R-year in northern Iran because of radon-rich spings.

I saw an empirical formula: 1 curie per square meter gives 10 roentgens per hour – can’t find the link now. In our case, it will be around 0.001 curies per sq. m. and thus 10 000 microR. / h = 87 R/ year. Such a dose is deadly in a few years. This probably could be reduced by cleanup in houses, natural decay, and rains, but not in agriculture because of the accumulation of strontium in plants and meat. Internal radiation is 20 times more dangerous, so food production will be impossible or will result in a cancer epidemic. Strontium can accumulate in bones as it is similar to potassium. Note that much larger amounts of natural radium from natural uranium are dissolved in oceans but they are “shielded” by water.

Global storage of spent fuel will grow in time, while the activity of older fuel will decline. If the nuclear industry is set to grow and become the main source of energy, it needs to increase 10-100 times, and the amounts of fresh (10-years old or less) spent fuel will also grow.

While the chain reaction inside a nuclear bomb can’t “jump” into a nuclear reactor, a large stream of neutrons from the explosion will affect U-238 in the reactor, the same way as it happens in the uranium envelope of some thermonuclear bombs designs, including the famous Tsar bomb. Wiki: “As a result of the thermonuclear reaction, huge numbers of high-energy fast neutrons were formed in the main thermonuclear module, which, in turn, initiated the fast fission nuclear reaction in the nuclei of the surrounding uranium-238, which would have added another 50 Mt of energy to the explosion, so that the estimated energy release of Tsar Bomba was around 100 Mt”. This could contribute to the explosion power, but detailed calculations are needed.

Many highly populated areas will receive much higher doses as they a close to nuclear power stations which will result in acute radiation sickness. Civilization collapse or at least crisis is likely: famine, curtailed lifespan, societal collapse, mass die-off.

However, the military cost-effectiveness of such an attack is not clear, as a counter-value attack on population centres may incur similar damage.

## Space nukes

### Nukes on orbit

Nuclear weapons on the low-flying satellites could allow an instant attack. It could be either EMP or large explosions which will affect the surface by light and cause large scale fires. In the second case, large many megatons or even gigaton scale nukes are needed, but they weigh a lot (tens of tons) and require regular maintenance. Thus, sending them secretly will be difficult.

Smaller nuclear weapons could be on satellites and ensure first blinding strike capability. They can even descend on a ballistic trajectory to a target.

### Anti-asteroid defense as an offensive weapon

It was suggested to surround the Earth with several gigaton-class bombs and use them as a protection against possible incoming asteroids.

However, the best protection against asteroids is observation, which helps to eliminate the risk by knowing that there are no dangerous asteroids in the next century.

The space-based anti-asteroid nuclear weapons will be always a dual-use weapons, as they could be used against targets on Earth. Even if an earth-attack is a small probability event, it has a higher probability than the probability that such weapons will be helpful as an anti-asteroid defense in any given year.

Most asteroids which could be destroyed by such a weapon, are small and almost harmless (like the Chelyabinsk impactor). Larger asteroids (more than a few hundred meters in size), if they are attacked in the last hours before impact, will still fall on Earth as debris, so a nuclear attack on them is useless. Therefore, anti-asteroid defense is meaningful only if it is used against an asteroid which was discovered in advance, maybe, years before impact. But such an asteroid could be deflected by small orbit perturbations using a non-nuclear impactor. It means that nuclear protection of Earth from asteroids is useful only for a small range of asteroid sizes and times-before-impact of their discovery. The utility of such protection needs further calculation which also takes into account the size-frequency distribution of potential impactors and the existence of such objects as dark comets.

### Nuclear-powered spaceships as weapons

Nuclear-powered space rockets could become kinetic weapons against targets on Earth. The Orion interstellar spaceship project required 300 000 nuclear weapons for propulsion. The production of such a large number of weapons is a danger itself (they could be used for war before the construction will end) and the spacecraft could be turned into a space bomber.

Alternatively, after Orion reaches a high speed like 30 000 km-sec, it could become an ultimate kinetic weapon. An impact at such speed will be able to smash atoms and create additional nuclear reactions. The products of such nuclear reactions will be radioactive and will produce large global contamination. For example, the speed of hydrogen atoms inside the Sun’s core at 16 mln K temperature is only around 500 km-sec [check this calculation!!]

### Core degasation as a Doomsday weapon

[The nuclear-powered probe](https://link.springer.com/article/10.1007/s10512-005-0246-y) could be used to reach Earth's core: a very hot and heavy nuclear reactor could melt through the crust.

The dangers of such probe and of the core’s degasation were discussed by Circovic in “[Geoengineering gone awry](https://arxiv.org/abs/physics/0308058)” (Cirkovic & Cathcart, 2003). Such probe may cause degasation of the core, which will kill all life on Earth. Thus, such a probe could be used as a Doomsday weapon for global blackmail.

### Giant gas planets detonation

Another idea, which I had discussed [elsewhere](https://www.scribd.com/document/8299748/The-possibility-of-artificial-fusion-explosion-of-giant-planets-and-other-objects-of-Solar-system), is the use of nuclear weapons to start explosive nuclear reactions inside gas planets, which has an inner layer rich in lithium and deuterium.

In the article by Weaver and Wood [Necessary conditions for the initiation and propagation of nuclear-detonation waves in plane atmospheres](https://journals.aps.org/pra/abstract/10.1103/PhysRevA.20.316) about the possibility of ignition of oceans was concluded that in Earth's oceans deuterium has 20 times smaller concentration that is needed for self-sustained nuclear reaction, and secondly, that to start such reaction, a very large bomb is needed, because of complicated radiation absorption effects. However, inside giant gas planets, the conditions may be more favorable for such reactions, because of the higher pressure and higher concentration of deuterium (and lithium). While gas planets are remote, humanity already managed to put some encapsulated plutonium inside Jupiter and Saturn during the destructive diving of Galileo and Cassini spacecrafts.

The plutonium inside [thermogenerators](https://en.wikipedia.org/wiki/Cassini%E2%80%93Huygens#Plutonium_power_source) of these stations is Pu-238, and pressures inside giant planets could collapse a core of such material. The sources differ on the possibility to make a nuclear bomb from Pu-238. It is not [listed](https://en.wikipedia.org/wiki/Fissile_material) as fissile material, but it is listed to have a critical mass of 9-10 kg, [wiki](https://en.wikipedia.org/wiki/Critical_mass#cite_note-sti-7), [article](https://sti.srs.gov/fulltext/ms9900313/ms9900313.html). I do not claim here that the explosion was possible: I just want to show that it is not that far from our current capabilities.

In Quora is a good [answer](https://www.quora.com/Can-plutonium-238-become-critical-and-detonate): “Pu-238 is fissile, in principle capable of nuclear criticality. But it would make a poor nuclear explosive because its spontaneous fission neutron yield is high, virtually guaranteeing pretrigger “fizzle” yields during attempts to explosively compress it. It also has high specific activity, creating an abundance of decay heat that would preclude most practical nuclear uses, and lots of (a,n) neutrons if used as an oxide or other refractory compound.

In a remote future, the theoretical possibility to detonate a gas planet could be used as a “Death Star” class weapon. Such an explosion may release energy equal to Sin’s luminosity for 10 000 years in a few seconds. It is still far from a supernova explosion, but enough to destroy anything on the surfaces of all planets of the Solar system.

It is impossible to detonate the Sun as all easy fusionable elements (lithium and deuterium) have already burned out at the early stages of star formation.

## Nuclear-powered lasers and energy jets

In general, very large bombs are impractical, as they can damage both sides if used close to the front.

An alternative to bombs is beams or rays of energy which have much higher precision. It could be either nuclear-powered lasers or beams of neutrons.

Gsponer mentioned nuclear-powered jets of energy created by a directed nuclear explosion: “This leads to other possible applications, where the ablation pressure is used to accelerate a missile or a spacecraft (nuclear-driven rocket), or to squeeze a shaped charge liner (nuclear-driven plasma-jet).” (Gsponer, 2005).

Nuclear-powered lasers were researched in the SDI times, [project Excalibur](https://en.wikipedia.org/wiki/Project_Excalibur). Nuclear explosion energy is used to pump x-ray laser which could send a powerful energy ray on a long distance. A single bomb could pump many lasers which will target many targets like warheads. There was an article about possible global risks from the use of such lasers against targets on Earth, but it is now removed from the internet (“LASER WINTER: GROUND INCENDIARY CAPABILITY OF BALLISTIC MISSILE DEFENSE LASERS”). Another article is online “[Offensive Capabilities of Space-Based Lasers](https://www.jstor.org/stable/44481236?seq=1)”.

# 3. Nuclear war and strategy changes

All described above possible technological advances will affect nuclear strategy and the future types of nuclear war.

## Doomsday weapons as a last resort for a weaker side

Doomsday weapons were described by Khan in the book “[On thermonuclear war](https://www.slideshare.net/avturchin/doomsday-men-chapter-about-cobalt-bomb)” (read a relevant quote by the link). The idea is that a large-scale nuclear weapon with a cobalt cover will be created stationary on the own territory of a country and connected via a dead-man switch with sensors capable to detect enemies' nuclear attacks. The explosion of the doomsday bomb will end the life on Earth, thus killing the enemy. The book also inspired “Doctor Strangelove” movie.

So, the enemy will never risk attacking, as it would mean his own end too. It is similar to MAD (mutually-assured destruction) but also will affect all other countries. Doomsday weapon seems to be protected against the first strike as it presumably will be located deep underground and could be triggered by any attempt to disarm it via, say, deep-penetrating bombs. But thus, it needs to be in a constant trigger-happy state, which increases the risks of accidental catastrophe.

### The doomsday weapon as a universal blackmail

Therefore, the Doomsday weapon (DW) by its nature is a blackmail weapon, and the condition of its use is not necessary the other side’s nuclear attack, but virtually anything and well-played doomsday weapon gives a country (or even an organization or a person) a global power. So, it could be attractive as an instrument of the takeover of the world.

This suggests some interesting decision-theoretical considerations. For example, the threat needs to be credible and the DW creator should credibly prefer death to a world where he is not in the position of the global power, or he will not be believed. It may be bluffing, but it should be credible. In other words, the doomsday agent could be Islamic State, but not France, as we will not believe that France will go forward with such global execution. Leslie in “[The end of the world”](https://www.amazon.com/End-World-Science-Ethics-Extinction/dp/0415140439) (Leslie, 1996) argued for the creation of the doomsday weapons as this will lower the risk of nuclear war even more than MAD, but also suggest that they will be not “real”.

### Mutually excluding Doomsday weapons

However, here is assumed that there is only one credible Doomsday weapon in the world. The situation becomes more complicated if two countries will independently develop and present two Doomsday weapons, which, however, are hardwired to two different conditions. For example, both countries want global domination.

As Doomsday weapon blackmail works only if it is hardwired and can’t be turned off (the same way as in the game of chicken a driver throws off his wheel out of the window), the situation becomes unresolvable, if both Doomsday weapons are hardwired to go off. There is no logical solution which prevents at least one of them from exploding. In the same way, if both players in the game of chicken throw out their wheels, their impact becomes inevitable.

## Nuclear terrorism and anonymous war

Nuclear proliferation and multiple actors owning nuclear weapons make it difficult to recognize who used a single nuclear weapon. There also could be false flag nuclear attacks. Smaller pure nuclear weapons may be more effective than such terrorism weapons, as they could be delivered without a trace, e.g. in a (self-driving) car.

S. Lem wrote about the anonymization of warfare in “[Weapons system of the 21st century](https://readli.net/chitat-online/?b=202727&pg=1)” (Lem, 1986).

## Nuclear guerilla

Cheap and easily available nukes could be as often used as now Grad missiles are used during small local conflicts. The consequence will be an increase in the global radioactivity levels.

## Tripolar world

If China arises as a large nuclear power, the will be a tripolar world (Russia, US and China). Alternatively, there will be many regional nuclear pairs, like India-Pakistan, and some of them could have regional nuclear conflicts. However, a nuclear war in India may still have global consequences because of climate effects:

“Pakistan and India may have 400 to 500 nuclear weapons by 2025 with yields from tested 12- to 45-kt values to a few hundred kilotons. If India uses 100 strategic weapons to attack urban centres and Pakistan uses 150, fatalities could reach 50 to 125 million people, and nuclear-ignited fires could release 16 to 36 Tg of black carbon in smoke, depending on yield. The smoke will rise into the upper troposphere, be self-lofted into the stratosphere, and spread globally within weeks. Surface sunlight will decline by 20 to 35%, cooling the global surface by 2° to 5°C and reducing precipitation by 15 to 30%, with larger regional impacts. Recovery takes more than 10 years. Net primary productivity declines 15 to 30% on land and 5 to 15% in oceans threatening mass starvation and additional worldwide collateral fatalities.” [Rapidly expanding nuclear arsenals in Pakistan and India portend regional and global catastrophe](https://advances.sciencemag.org/content/5/10/eaay5478).

## The example of Russia

Russian fears of US ABM defense fueled the creation of larger nukes, that is, nuclear torpedoes Poseidon. They are one step closer to the stationary doomsday weapon as they presumably have a very large yield (up to 100 MT by some estimates) and are also salted.

## A sloppy way to a larger nuclear war

If there will be more nuclear actors, the chances of using a nuclear weapon will increase, and after it will be used, there will be normalization of their use. Eventually, almost all wars will be nuclear. Smaller and cheaper nukes increase these chances.

## AI-empowered nuclear strategy

AI as technology provides a superhuman capability in winning games. Nuclear strategy is also a type of game, so AI may be used to increase the advantage of owning nuclear weapons. A national state, which is both good in AI and nukes will have much more power over an AI-only state or nuclear-only state. In other words, nuclear power leverages advances in AI. But the strongest AI players now are also nuclear powers.

## Accidental nuclear war

S.Lem wrote: “Incredibly fast systems make mistakes incredibly fast” (Lem, 1986). Petrov’s incident was the dawn of AI-empowered errors in a nuclear world.

## Anti-AI nuclear war

Advance AI known as a superintelligence could be an ultimate weapon which can finally take over the world. If a country is going to create such AI, others may think about it as of ultimate existential threat, and thus start a preemptive nuclear attack against research centres, large computers, internet infrastructure and chip fabs.

Alternatively, if we realize that advanced non-friendly AI is unstoppable, global Luddism may be the only option.

## Nuclear-biological war

Advances in the nuclear field will be parallel not only to AI development but also to the development of advanced synthetic biology. It will also democratize and become cheaper, so many biohackers may be able to create their own biological viruses and release them in the wild. See more about it in our article “[Artificial Multipandemic as the Most Plausible and Dangerous Global Catastrophic Risk Connected with Bioweapons and Synthetic Biology](https://philpapers.org/rec/TURAMA-3)”.

## Other changes in the nuclear strategy and capabilities

Another aspect of this change is the use of nuclear propulsions for nuclear torpedoes ([Poseidon](https://en.wikipedia.org/wiki/Status-6_Oceanic_Multipurpose_System)), cruise missiles ([Burevestnik](https://en.wikipedia.org/wiki/9M730_Burevestnik)) and space missiles.

There is a black market for nuclear technologies, and the number of real actors could be higher than publically claimed.

Other factors affecting strategy are effective systems of missile defense, hypersonic strike capabilities, and blurring of the border between conventional and nuclear war. The drone swarms attack may be as effective as the first strike for disarming the nuclear arsenal of the opponent.

## Collapse of social complexity and climate crisis from a regional nuclear war

There are several “nuclear pair”: pair of countries which have their own mutual “cold war” and nuclear arm race. They are:

India-Pakistan

Israel-Iran

Iran-Saudi Arabia

Russia-Ukraine

China-Taiwan

North Korean-South Korea

A regional nuclear war may have much larger consequences because of climate effects and the disruption of complexity in over-connected world. This is described in the recent article: “[Depicting Nuclear Risk Accurately: The Likely Global Effects of Nuclear Weapons in the 21st Century](https://www.nti.org/atomic-pulse/depicting-nuclear-risk-accurately-the-likely-global-effects-of-nuclear-weapons-in-the-21st-century/?fbclid=IwAR32RBctvL7Mv5sH0hf0evf_OUuLtfYhLTnWH6V748K6w-4VauoaMWHF5jk)”.

# 4. Existential risks from the future nuclear war

After an overview of the nuclear capabilities and strategy in the future in sections 2 and 3, we may ask the main question: will future nuclear war be a bigger threat to humanity's existence, and what such a threat may look like?

There are two primary scenarios of how future nuclear war could end humanity: with a bang and a whisper: this is the use of doomsday weapons – and nuclear guerilla causing a slow decline.

In the first scenario, escalation and brinkmanship cause all-out war and the use of some kind of Doomsday weapon, or its close equivalents, like MAD, global attack on nuclear power stations, artificial climate change or attack by multiple cobalt bombs.

In the second scenario, the existence of a complex civilization becomes impossible, as large centres become often targets of nuclear terrorists, regional war happens one after another, climate deteriorates and crops decline.

But the decline in productivity doesn’t mean an immediate decline in the military capabilities as many types of weapons could survive longer than civilization itself, especially guns. Thus, returning to industrial manufacturing after the decline will be difficult. Soil radioactivity, climate change (runaway warming or the next ice age), antibiotic resistance, and all other dangerous leftovers will contribute to the decline of the complex society, but may not be enough to cause human extinction.

However, the next civilization of humans will have difficulties arising (no ores and oil), and if it does, it will succumb to nuclear wars again. After a few cycles, it will be equal to extinction.

## Mitigation

There are two closely connected ways to prevent dangers of the future nuclear war: global government and an effective monitoring system. “Global government” is any type of organization which lower the number of independent actors in the world, which in our case are actors capable to develop or-and owning nuclear weapons. It could be a UN, a set of international treaties or one superpower which takes over the world, or even superintelligent AI turning into Singleton.

Such “world government” can’t be effective without some global monitoring system. It is not just IAEA, but also systems of ubiquitous control powered by sensors, satellites and AI. Self-propelling nanosensors could be an important element of such a system. Moreover, the control should be coupled with the power and willingness to stop the illegal use of nuclear materials.

# **Literature**

Greene, P. (2017). Success-First Decision Theories. *Newcomb’s Problem. Cambridge University Press, Forthcoming*.

Gsponer, A. (2005). Fourth generation nuclear weapons: Military effectiveness and collateral effects. *ArXiv Preprint Physics/0510071*.

Lem, S. (1986). Weapon Systems of the Twenty-First Century or the Upside-Down Evolution. *Stanislaw Lem, Biblioteka XXI Wieku [Twenty-First Century Library], Krakow: Wydawnictwo Literackie*, 44–81.

Leslie, J. (1996). *The End of the World: The Science and Ethics of Human Extinction*. Routledge.

Turchin, A., & Denkenberger, D. (2018). Could slaughterbots wipe out humanity? Assessment of the global catastrophic risk posed by autonomous weapons. *Under Review in Journal of Military Ethics*. https://philpapers.org/rec/TURCSW

Turchin, A., Green, B., & Denkenberger, D. (2017). Multiple Simultaneous Pandemics as Most Dangerous Global Catastrophic Risk Connected with Bioweapons and Synthetic Biology. *Under Review in Health Security*.

THE THIRD NUCLEAR AGE: HOW I LEARNED TO START WORRYING ABOUT THE CLEAN BOMB

<https://apps.dtic.mil/dtic/tr/fulltext/u2/1018896.pdf>

<https://press.armywarcollege.edu/cgi/viewcontent.cgi?article=1006&context=monographs>

The idea of “[banana equivalent dose](https://en.wikipedia.org/wiki/Banana_equivalent_dose#:~:text=The%20radiation%20exposure%20from%20consuming,70%2C000%20BED%20(7%20mSv).)” is based on the estimation that “isotopically pure potassium-40 will give a committed dose equivalent of 5.02 nSv over 50 years per becquerel ingested by an average adult”. The technological progress in last 50 years resulted in the big innovations, lower prices and larger-scale manufacturing capabilities in many domains, and we expect that such supertechnologies as AI, nanotech and biotech will revolutionize the world in the 21st century and will create new existential risks. But when we discuss the global catastrophic risk of nuclear war, we still imagine such war in the ways that were typical in the 1970-80s: a nuclear strikes exchange between the two superpowers which targets cities and military installations. It is reasonable to suggest that exponential growth in new technologies will be reflected in the growth in nuclear technologies, but we currently observe such growth only in civilian nuclear applications, like the number of approaches to fusion and small nuclear reactors.