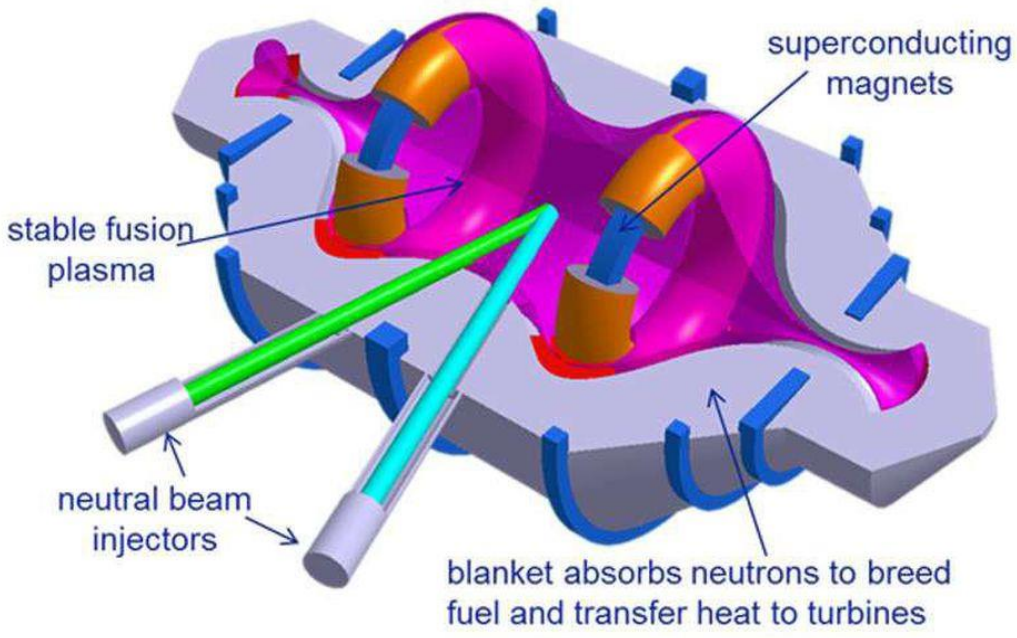
The Fork in the Road to Electric Power From Fusion

Lockheed Martin compact fusion reactor (CFR)

Peter Lobner, 1 February 2021

When first announced in 2014, Lockheed claimed that its Skunk Works® team in Palmdale, CA would test a compact fusion reactor (CFR) in less than a year, build a prototype in five years, and deploy the system in 10 years. Lockheed Martin claimed that their CFR would be one-tenth the size of a tokamak with the same power output. The Lockheed Martin CFR website is here: https://www.lockheedmartin.com/en-us/products/compact-fusion.html

The CFR is a compact, D-T burning, magnetically encapsulated linear ring cusp that relies on high beta cusp confinement. Beta is the ratio of plasma pressure to magnetic pressure; conventional tokamaks like ITER have low beta (5%), while the CFR may have a beta of 1.0 or more. A pair of superconducting magnet coils define the limits of the fusion reaction chamber. Neutral beam injectors provide plasma heating for startup. The T4 prototype was expected to run in steady state for about 10 seconds after the injectors were turned off. The production machine would run continuously.



General arrangement of the Lockheed Martin CFR.
Source: Lockheed Martin

The system is regulated by a self-tuning feedback mechanism, whereby the farther out the plasma expands, the stronger the magnetic field is encounters to push back to contain it. The basic magnetic field geometry inside the CFR is shown in the following diagrams.

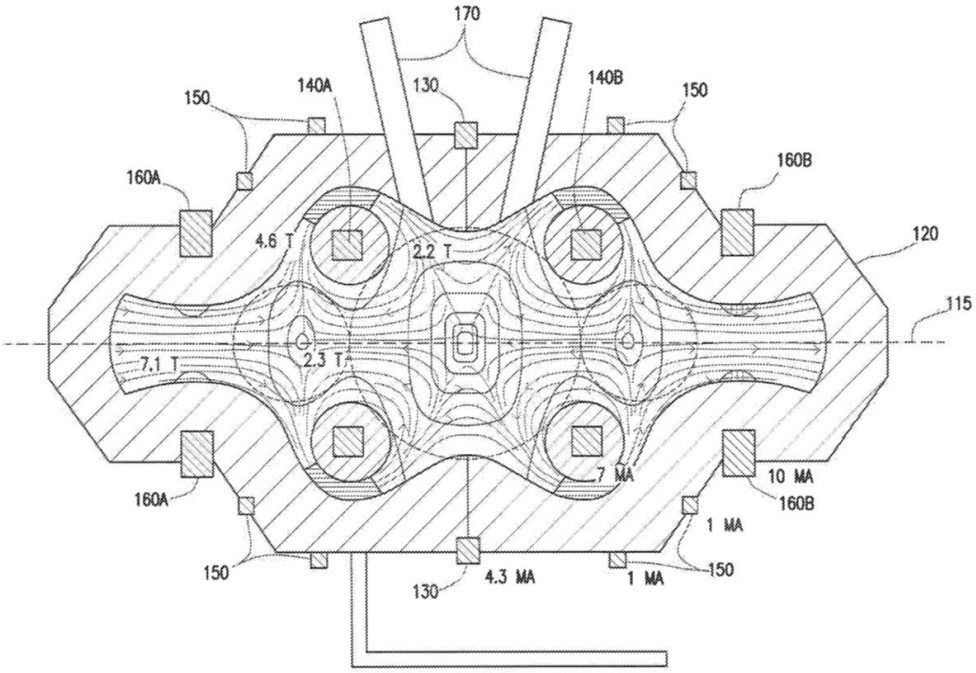
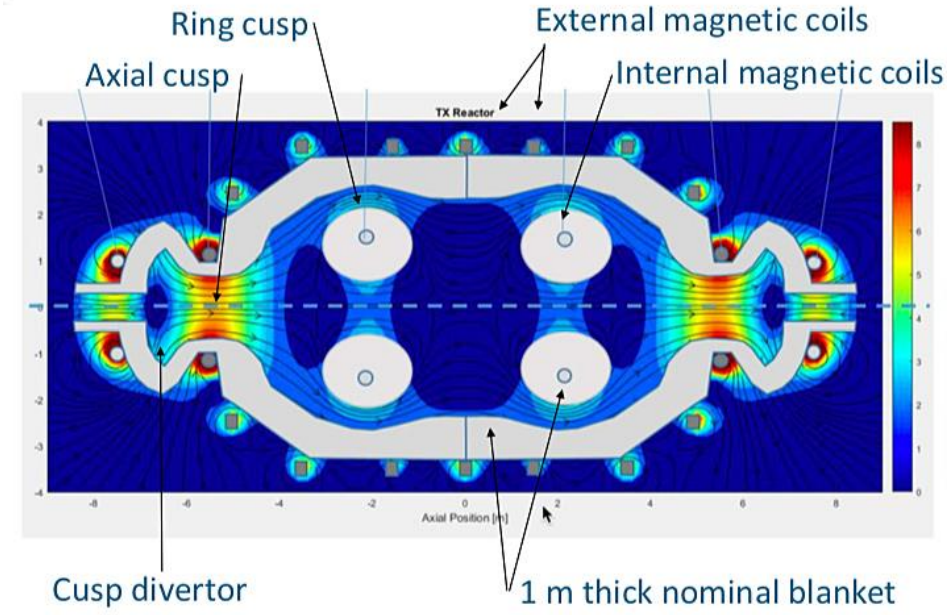


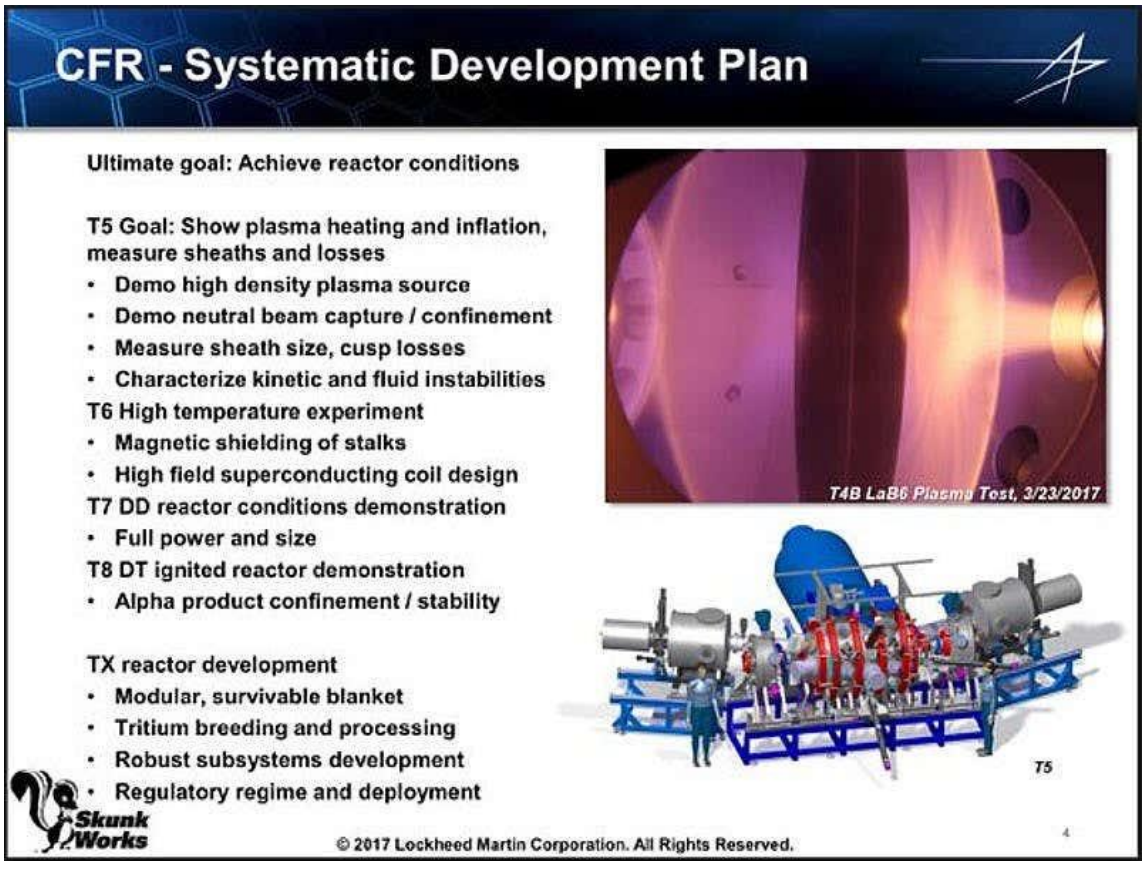
FIG. 6

Magnetic fields in the compact fusion reactor.
Sources: (above) Patent US2018/0047462A1, (below) LM



In 2014, the T4 reactor was being designed to produce 100 MWe and be small enough to fit on a truck, in a 23 x 43 foot (7 x 13.1 m) container that weighed about 20 tons (18.1 metric tons).

By December 2017, the CFR prototype was known as the T4B. It measured 6.6 ft (2 m) long x 3.3 ft (1 m) in diameter and weighed about 20 tons (18.1 metric tons). The T4B was designed to produce one megawatt of energy. At that time, the commercial reactor design concept, the TX, measured 59 ft (18 m) long, 23 ft (7 m) in diameter, and weighed about 2,000 tons (1,814 metric tons). The TX was expected to produce 200 MWe of electric power. Lockheed Martin expected that the weight of the TX could be reduced to about 200 tons (181 metric tons).



Source: Lockheed Martin via TheDrive

Following T4B, the construction of the next design iteration, T5, was reported in July 2019. This will be a significantly larger and more powerful machine than T4 and is no longer designed to fit on a truck. Lockheed Martin's path to a commercial fusion reactor includes three

more iterations (known as T6, T7 and T8) before they may be ready to commit to build, test and license the TX reactor for commercial operation. There is no announced timeline for these milestones.

Funding

Lockheed-Martin is a large publicly traded corporation (stock symbol LMT). Their compact fusion reactor program likely is funded from an internal research & development account. Lockheed Martin has not received DOE funding targeted for the development of low-cost, compact fusion power plants.

For more information

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- Stuart Nathan, "New details on compact fusion reveal scale of challenge," The Engineer, 22 October 2014: https://www.theengineer.co.uk/new-details-on-compact-fusion-reveal-scale-of-challenge/
- "Lockheed Martin Compact Fusion Reactor Concept, Confinement Model and T4B Experiment," Lockheed Martin, 2016: https://web.archive.org/web/20171225092237/http://fusion4freedom.us/pdfs/McGuireAPS.pdf
- Ariel Cohen, "Will LM Change The World With Its New Fusion Reactor?" Forbes, 1 August 2018: https://www.forbes.com/sites/arielcohen/2018/08/01/will-lockheed-martin-change-the-world-with-its-new-fusion-reactor/?sh=23f4b9db4c49
- Joseph Trevithick, "Lockheed Martin Now Has a Patent For Its Potentially World Changing Fusion Reactor," TheDrive, 26 March 2018: https://www.thedrive.com/the-war-zone/19652/lockheed-martin-now-has-a-patent-for-its-potentially-world-changing-fusion-reactor
- Lt. Col. (res) Dr. Raphael Ofek, "Lockheed Martin's Compact Fusion Reactor," The Begin-Sadat Center for Strategic Studies,

29 July 2018: https://besacenter.org/wp-content/uploads/2018/07/909-Lockheed-Martins-Compact-Fusion-Reactor-Ofek-English-final.pdf
- Joseph Trevithick, “Skunk Works' Exotic Fusion Reactor Program Moves Forward With Larger, More Powerful Design,” TheDrive, 19 July 2019: https://www.thedrive.com/the-war-zone/29074/skunk-works-exotic-fusion-reactor-program-moves-forward-with-larger-more-powerful-design

Video

- “Lockheed Martin: Compact Fusion Research & Development,” (3:57 minutes), 2014: https://www.youtube.com/channel/UCJWcF0ex7_doPdIQGbVpDsQ?feature=emb_ch_name_ex

Patents

- Patent US2018/0047462A1, “Encapsulating Magnetic Fields for Plasma Confinement,” filed 2 April 2014, granted 1 May 2018, assigned to Lockheed Martin Corp.: https://patents.google.com/patent/US20180047462A1/en
- Patent US9947420B2, “Magnetic field plasma confinement for compact fusion power,” filed 2 April 2014, granted 17 April 2018, assigned to: Lockheed Martin Corp.: https://patents.google.com/patent/US9947420B2/en?oq=9947420
- Patent US9941024B2, “Heating plasma for fusion power using electromagnetic waves,” filed 2 April 2014, granted 10 April 2018, assigned to Lockheed Martin Corp.: https://patents.google.com/patent/US9941024B2/en?oq=9941024
- Patent US9934876B2, “Magnetic field plasma confinement for compact fusion power,” filed 2 April 2014, granted 3 April 2018, assigned to Lockheed Martin Corp.: https://patents.google.com/patent/US9934876B2/en?oq=9934876