Lattice Energy LLC

LENRs are disruptive new source of safe, radiation-free nuclear energy

Vladimir Putin claims that Russia successfully developed nuclear-powered cruise missile with unprecedented performance capabilities

Missile probably powered by *unshielded* Uranium fission reactor --- likely high radiation and waste emissions would be dangerous for environment.

LENRs now under development by Lattice and Mitsubishi Heavy Industries are truly safe nuclear technology that might someday propel such missiles

"One of them is creation of a small-size highly powerful nuclear power plant that can be planted inside the hull of a cruise missile identical to our air-launched X-101 or the United States' Tomahawk, but at the same time is capable of guaranteeing a flight range that is dozens of times greater, which is practically unlimited."

Quote from Vladimir Putin's address
Annual State-of-the-nation speech on March 1, 2018

Putin affirms nuclear-powered cruise missile has been tested

"All of those tests were successful, it's just each of these weapons systems is at a different stage of readiness…. Some of them still have to be fine-tuned and worked on, others are already available to the troops and already are battle-ready," Putin said in an interview with the NBC broadcaster, answering the host Megyn Kelly's question whether nuclear-powered intercontinental ballistic missiles (ICBMs) were really tested or were just a computer graphics, as some experts claimed.

https://sputniknews.com/russia/201803021062141342-russia-nuclear-powered-icbm-test/

Lattice, Mitsubishi Heavy Industries, Toyota, and Nissan are all developing new type of nuclear power generation technology that could be much better than fission or fusion because it would be hard-radiation-free and produce negligible long-lived radioactive wastes. While still in very early stage of commercial development, ultralow energy neutron reactions (LENRs) offer great promise as a new future source of affordable CO_2-free green energy.

Comparison of LENRs to fission and fusion

Fission, fusion, and LENRs all involve controlled release of nuclear binding energy (heat) for power generation: no CO_2 emissions; scale of energy release is MeVs (nuclear regime) > 1,000,000x energy density of chemical energy power sources

Heavy element fission: involves shattering heavy nuclei to release stored nuclear binding energy; requires massive shielding and containment structures to handle radiation; major radioactive waste clean-up issues and costs; limited sources of fuel: today, almost entirely Uranium; Thorium-based fuel cycles now under development; heavy element U-235 (fissile isotope fuel) + neutrons → complex array of lower-mass fission products (some are very long-lived radioisotopes) + energetic gamma radiation + energetic neutron radiation + heat

Fusion of light nuclei: involves smashing light nuclei together to release stored nuclear binding energy; present multi-billion $ development efforts (e.g., ITER, NIF, other Tokamaks) focusing mainly on D+T fusion reaction; requires massive shielding/containment structures to handle 14 MeV neutron radiation; minor radioactive waste clean-up $ costs vs. fission

Two key sources of fuel: Deuterium and Tritium (both are heavy isotopes of Hydrogen)

Most likely to be developed commercial fusion reaction involves the following:

D + T → He-4 (helium) + neutron + heat (total energy yield 17.6 MeV; ~14.1 MeV in neutron)

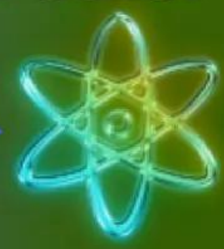
Ultralow energy neutron reactions (LENRs): distinguishing feature is neutron production via electroweak reaction; neutron capture on fuel + gamma conversion to IR + decays [β^-, α] releases nuclear binding energy; early-stage technology; no emission of energetic neutron or gamma radiation and no long-lived radioactive waste products; LENR systems would not require massive, expensive radiation shielding or containment structures → much lower $$$ cost; many possible fuels --- any element/isotope that can capture LENR neutrons; involves neutron-catalyzed transmutation of fuels into heavier stable elements; process creates heat

Revolutionary ultralow energy neutron reactions (LENRs)

Radiation-free LENRs transmute stable elements to other stable elements

Fission and fusion

Evolution of nuclear technology



Safe green LENRs

Laura 13

No deadly MeV-energy gamma radiation

No dangerous energetic neutron radiation

Insignificant production of radioactive waste

Vastly higher energies vs. chemical processes

Revolutionary, no CO_2 , and environmentally green

Is fully explained by physics of Widom-Larsen theory

Image credit: co-author Domenico Pacifici
From: "Nanoscale plasmonic interferometers for multispectral, high-throughput biochemical sensing"
J. Feng et al., *Nano Letters* pp. 602 - 609 (2012)

LENRs are green: no energetic radiation or radwastes

Lack of hard radiation obviates need for shielding and containment

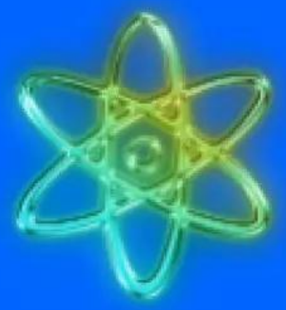
Major opportunity to develop broad range of competitive LENR power sources

Fission and fusion processes both emit deadly MeV-energy neutron and gamma radiation

Fission reactors need 1 foot of steel and 3 feet of concrete to protect human beings from dangerous hard radiation and wastes emitted by reactor; systems intrinsically large and heavy

Revolution in green nuclear technology

LENRs could enable future development of small, portable battery-like power sources that are very safe and disposable



Much larger LENR systems based on dusty plasma embodiments could potentially scale-up to megawatts

LENR technology has revolutionary competitive advantages

Unlike nuclear fission and fusion, yet again verified by recent Japanese results, LENRs do not emit deadly energetic gamma and neutron radiation or produce long-lived radioactive wastes. Consequently, future LENR power generation systems would not require heavy, expensive radiation shielding and containment subsystems for safe operation. That unique feature confers a revolutionary competitive advantage. It would enable LENR-based systems to be vastly smaller and less expensive than fission or fusion reactors and light-enough to be safely utilized in unshielded propulsion systems for motor vehicles, aircraft, and spacecraft. It would also allow eventual development of small, portable LENR power systems that would be disposable after use and compete directly with batteries and fuel cells.

LENR technology has revolutionary competitive advantages

Energy density of nuclear power surpasses any chemical technology

LENRs Versus Chemical Energy Sources: Batteries, Fuel Cells, and Microgenerators

Source of Energy	Approximate Energy Density (Watt*hours/kg)
Alkaline Battery	164
Lithium Battery	329
Zinc-Air Battery	460
Direct Methanol Fuel Cell (35% efficient)	1,680
Gas Burning Microgenerator (20% efficient)	2,300
100% Efficient Combustion of Pure Methanol	5,930
100% Efficient Combustion of Pure Gasoline	11,500
LENRs (based on an assumption of an average of 0.5 MeV per nuclear reaction in an LENR system)	**57,500,000** (maximum theoretical energy density – only a fraction would be achievable in practice)

~2,000 Wh/kg might someday be practical with Lithium-air batteries

~11,680 Wh/kg is theoretical maximum with Lithium-air

Chemical

LENRs

Future LENR systems could likely achieve 10x - 100x chemical

Nanocomposite LENR fuels could have 5,000x gasoline's energy density

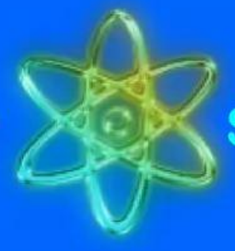
Estimated increases in range and endurance if LENR technology were commercialized

	Product Name	Present capabilities with today's power sources Range (endurance)	Vastly enhanced capabilities with future LENR-based power sources	
			10x chemical	100x chemical
Various aircraft	GreenWing e430	180 miles (~3 hours @ 60 mph)	1,800 (30)	18,000 (300)
	Airbus E-Fan 2.0	99 miles (1 hour @ 99 mph)	990 (10)	9,900 (100)
	Predator MQ-1	1,800 miles (24 hours @ 75 mph)	18,000 (240)	180,000 (2,400)
	Super Heron	est. ~ 4,000 miles (45 hours @ 89 mph?)	40,000 (450+)	400,000 (4,500)
	Springtail	184 miles (2.2+ hours @ 94 mph)	1,840 (200+)	18,400 (2,000+)
	Crazyflie	Speed not measured (3 - 10 minutes)	? (30 - 100 min.)	? (maybe 5 - 17 hrs.)
	InstantEye	est. ~ 8 miles (18 - 20 min @ 25 mph)	est. 80 (3.2 hrs.)	800 (32 hrs.)
	Tesla Model S car	~ 294 miles (4 - 5 hours @ 70 mph)	3,000 (40 - 50)	30,000 (400 - 500)
	Shkval torpedo	6.8 - 9.3 miles (1.8 - 2.4 min @230 mph)	68 - 93 (18 - 24 min)	680 - 930 (3 - 4 hrs)
	Exoskeletons and autonomous robots	Require tether cables connected to some type of external power source	Duration of autonomous activity might be extended up to weeks or even months	

Note: roughly 730 hours in a month - 8,760 hours in year
Average U.S. car's IC engine runs for ~5,000 hrs over lifetime

LENR technology could advance rapidly and surprise many

Fission and fusion  Evolution of nuclear technology

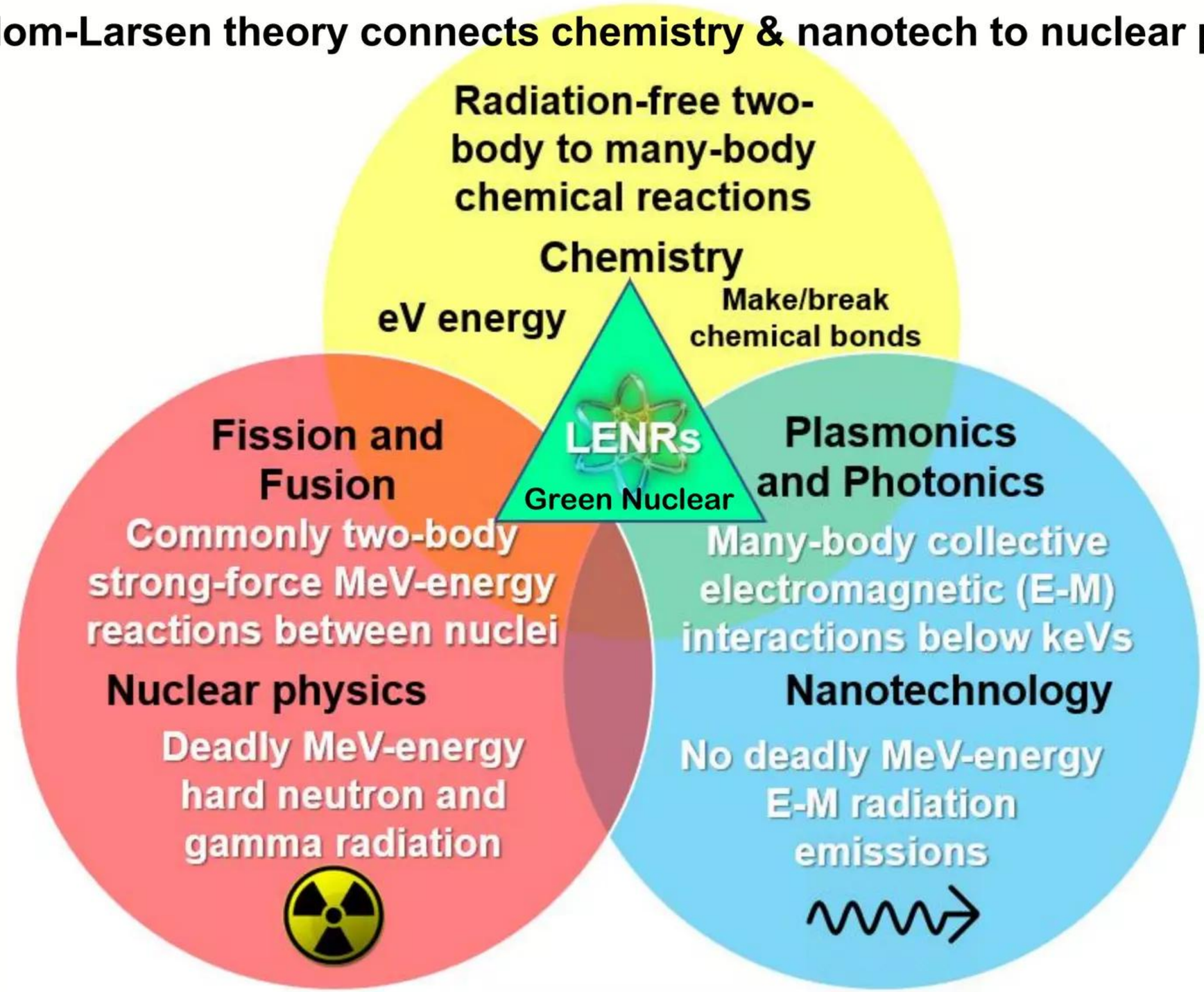
Enabled by Widom-Larsen theory  Safe green LENRs

LENR power generation technology could potentially advance very rapidly from this point and catch many by surprise. This is because Widom-Larsen theory, applied nanotech, and chemical knowledge can be leveraged to greatly accelerate progress through TRL stages (now at TRL-4). In that regard, Lattice recently discovered deep causal connections between 'green' many-body collective electroweak nuclear catalysis (safe neutron-producing $e + p$ reaction in condensed matter), enzymatic catalysis, and ordinary chemical catalysis; see public Lattice PowerPoint:

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-confirm-lattice-hypotheses-re-importance-of-adsorbed-protons-and-high-local-electric-fields-in-chemical-catalysis-june-27-2017

Chemistry & nuclear physics reunited after 100 years of separation

Widom-Larsen theory connects chemistry & nanotech to nuclear physics



Russia's newly announced nuclear-powered cruise missile

Missile most likely powered by unshielded Uranium-fueled fission reactor

- Using today's operational nuclear technology, Russia's cruise missile would probably utilize unshielded Uranium fission reactor in order to have high enough thrust/weight ratios and range/speed performance
- To maximize missile's range and reactor power output, likely to utilize highly-enriched Uranium (HEU) fuel rods akin to U.S. submarine reactors
- Consequence of no radiation shielding is that missile would be very dangerous during in-flight operation because reactor would produce enormous emissions of deadly MeV neutrons and gamma radiation
- Unless working fluids or intake air were isolated from interior reactor components, missile would emit radioactive particulates during flight
- Accidental crashes of missiles during testing or prior to hitting targets during hostilities would spew radioactive contaminants over wide area
- In 1960s, U.S. had $260M experimental program - Project Pluto - that aimed to create small unshielded fission reactor for powering aircraft or missiles. Initial tests were successful but program was cancelled in 1964 because, "Military worried that Pluto … before it even began to drop bombs, would deafen, flatten, and irradiate people along its flight path" and overflights would thus be equally "dangerous to U.S. allies"

Putin: nuclear-powered cruise missile is like U.S. Tomahawk

Photo shows size and shape of AGM-109 Tomahawk - jet engine is in rear

Image credit: General Dynamics

Technical specifications of U.S. Tomahawk cruise missile

Missile's maximum speed after acceleration by booster rocket is 550 mph

Military-Today.com

Country of origin	United States
Entered service	1983
Missile length (with booster)	6.25 m
Missile length (without booster)	5.56 m
Missile diameter	0.52 m
Wing span	2.67 m
Missile weight (with booster)	1,600 kg
Missile weight (without booster)	1,300 kg
Warhead weight	130 - 750 kg
Warhead type	Many including conventional and nuclear (see below)
Guidance system (land attack)	GPS, inertial navigation system, terrain-following radar
Guidance system (anti-ship)	active radar homing
Range of fire	up to 2,500 km
CEP (BGM-109A)	80 m
CEP (other models)	10 m

http://www.military-today.com/missiles/tomahawk.htm

U.S. Tomahawk cruise missile is powered by small jet engine

Small, very reliable Williams F107 high-bypass turbofan uses special fuel

Military-Today.com

"When the booster runs out of fuel, the Tomahawk is propelled though the rest of its flight by a Williams F107 turbofan engine. Designed expressly for powering cruise missiles, the F107 is also propelled by a special, high-density aviation turbine fuel that withstands harsh weather, rough handling, and long-term storage better than more conventional jet fuels. Most Tomahawks are powered by the F107-WR-400 engine with 2.7kN (600 lbs.) of thrust, while later models are powered by the improved F107-WR-402 with 3.1kN (700 lbs.) of thrust. These are both relatively reliable engines, as demonstrate by the fact that during Operation Desert Storm, only 19 of approximately 300 attempted launches ended in failure."

World's smallest high-bypass turbofan jet engine

F107-WR-400 FOR SLCM (WRI)

http://www.military-today.com/missiles/tomahawk.htm

Video of claimed flight test released during Putin's speech

http://www.thedrive.com/the-war-zone/18948/u-s-has-been-secretly-watching-russias-nuclear-powered-cruise-missiles-crash-and-burn

March 1, 2018: Putin revealed nuclear-powered cruise missile

Claimed missile has been successfully flight-tested and has huge range

Putin: Russia has nuclear weapons impossible to intercept

abc NEWS

By Vladimir Isachenkov
Associated Press Moscow - March 1, 2018

abc NEWS

THE NUCLEAR-POWERED GLOBAL-RANGE CRUISE MISSILE

"Putin's announcement that Russia has developed a nuclear-powered cruise missile marks the first time such weapon was officially mentioned."

"The Russian leader said a compact, nuclear-powered engine gives the new weapon a 'practically unlimited' range. He added that it has stealth capabilities making it hard to detect and high maneuverability to bypass an enemy's defenses. He emphasized that the cruise missile is 'invulnerable to any existing or perspective air and missile defense systems.' He said the missile was successfully tested last fall but doesn't have a name yet. He suggested the Defense Ministry hold a nationwide contest to find the best name for it."

https://abcnews.go.com/Technology/wireStory/putin-russia-nuclear-weapons-impossible-intercept-53442291

Tom Plant: "nuclear propulsion thing is potentially feasible"

Many observers of Russian military were surprised and initially skeptical

Putin boasts that Russia has a nuclear-powered cruise missile that can penetrate U.S. defense shields

Portland Press Herald

By Vladimir Isachenkov
Associated Press Moscow - March 1, 2018

"Tom Plant, director of proliferation and nuclear policy at the defense think-tank RUSI, also said he was not sure how much of the announcement to believe.

'The thing that sounds mad, the nuclear-propulsion thing, is potentially feasible,' he said, adding: 'I think it's insane'."

https://www.pressherald.com/2018/03/01/putin-boasts-that-russia-has-a-nuclear-powered-cruise-missile-that-can-penetrate-u-s-defense-shields/

David Axe: "There were no prior reports of its development"

Nuclear-powered missile "would pose a major danger to its own users"

Vladimir Putin's Nuclear-Powered Cruise Missile Is 'Batshit Crazy' By David Axe March 3, 2018 MOTHERBOARD

"But the fifth weapon --- nuclear-powered cruise missile --- was unknown to the public before Putin's speech. There were no prior reports of its development. The Trump administration's recently-released *Nuclear Posture Review*, which details major atomic-weapons developments, makes no mention of it."

" 'The nuclear-powered cruise missile is new --- and batshit crazy,' Jeffrey Lewis, a nuclear expert at the Middlebury Institute of International Studies at Monterey, told me. Not only could the missile upset the balance of power between the United States and Russia, it would also pose a major danger to its own users. 'It was an environmental nightmare,' Lewis explained. Every time the military launched a nuclear-powered cruise missile, even in testing, it would've sent a potentially unstable reactor out into the world without many safeguards to prevent accidents. But those risks might not deter Russia from developing an atomic-powered missile. 'Putin doesn't have to worry about pesky environmentalists,' Lewis said."

https://motherboard.vice.com/en_us/article/7x7jx9/vladimir-putins-nuclear-powered-cruise-missile-is-batshit-crazy

U.S. Pentagon officials cast doubt on success of test flights

Russia Reveals 'Unstoppable' Nuclear-Powered Cruise Missile

THE | DIPLOMAT
Read The Diplomat, *Know the Asia-Pacific*

By Franz-Stefans Gady The Diplomat – March 2, 2018

"He also noted that the new nuclear-powered cruise missile was already tested in 2017. 'During the flight the power plant achieved the design capacity and thrust. The launch of the missile and the tests on the ground allow for starting work to create a fundamentally new type of weapon — a strategic nuclear missile equipped with a nuclear power plant', he [Putin] noted."

"If a test indeed took place, it could have been a static ground test of the missile's engine. However, Pentagon officials speaking to U.S. media noted that the missile has recently crashed during testing in the Arctic, although there have been no corresponding reports of radioactive pollution by European monitors. 'The nuclear powered cruise missile Putin bragged about has actually crashed a few times,' one official told *Fox News*. 'Think about the environmental impact of that,' the official added. Despite the Pentagon's comments, it still remains unclear whether the nuclear cruise missile project is part of a full-fledged R&D program. Notably, the new nuclear-powered cruise missile was not mentioned in the recently released U.S. Nuclear Posture Review (NPR) … whereas the document discusses Russia's new long-range nuclear torpedo, codenamed Status-6."

https://thediplomat.com/2018/03/russia-reveals-unstoppable-nuclear-powered-cruise-missile/

No technical spec details on nuclear-powered cruise missile

Russia Reveals 'Unstoppable' Nuclear-Powered Cruise Missile

THE | DIPLOMAT
Read The Diplomat, Know the Asia-Pacific

By Franz-Stefans Gady The Diplomat – March 2, 2018

"For what it's worth, there are number of technical challenges that need to be addressed when designing a nuclear reactor for an intercontinental-range ramjet supersonic cruise missile. A paper published by Stanford University in 2015 discussing the U.S. Cold War-era Supersonic Low Altitude Missile (SLAM) program lists a number of challenges, including designing a lightweight reactor and the need to minimize radiation leakage from the reactor core."

"As of now, no technical specifications of the purported nuclear-powered cruise missile have been revealed. The new missile would also likely not be covered by the new Strategic Arms Reduction Treaty (START), although they may be discussed by the two powers during consultations."

https://thediplomat.com/2018/03/russia-reveals-unstoppable-nuclear-powered-cruise-missile/

An Atmospheric Nuclear Ramjet: the Supersonic Low Altitude Missile

By Federico Rossi Stanford University March 17, 2016

http://large.stanford.edu/courses/2015/ph241/rossi1/

U.S. government affirms nuclear-powered missile's existence

THE WARZONE

U.S. Has Been Secretly Watching Russia's Nuclear-Powered Cruise Missiles Crash and Burn

By Joseph Trevithick March 2, 2018

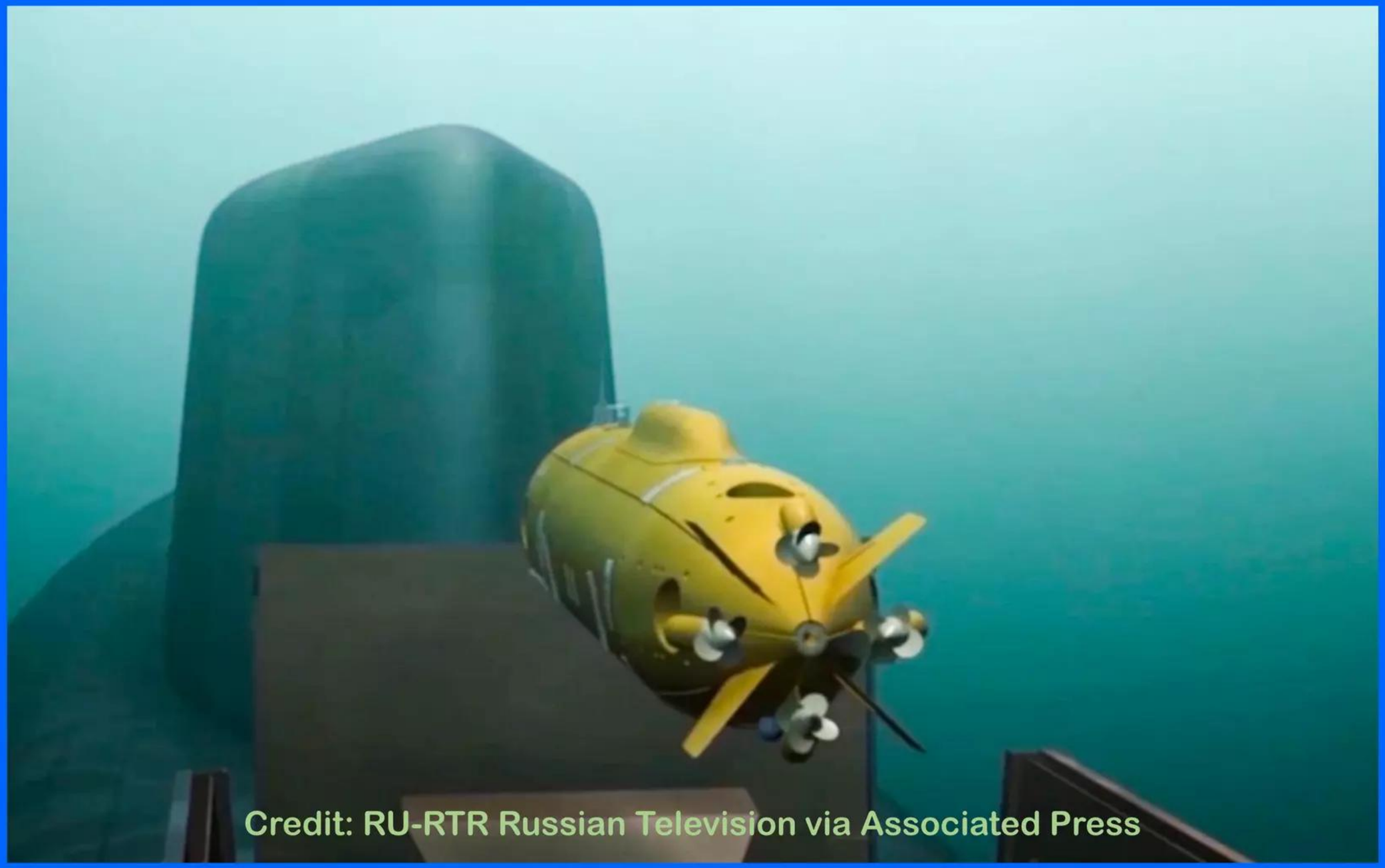
"Following Russian claims that it is developing a new nuclear-powered cruise missile, there are reports that the U.S. government has been actively spying on this work and that some or all of the test flights have failed. This, in turn, raises questions about the safety and viability of such a weapon, as well as why American officials would keep this knowledge a secret."

"But shortly after Putin's address, CNN, in a story citing an anonymous U.S. government official, cast doubt on the possibility that this weapon was anywhere near operational. That individual added that the 'United States had observed a small number of Russian tests of its nuclear-powered cruise missile and seen them all crash.' Fox News said its own sources indicated the same thing, that the weapon was in the research and development phase and that at least one had crashed during testing the arctic … The suggestion the U.S. government has been aware of this development program for any period of time, but kept that information secret, is notable in of itself."

http://www.thedrive.com/the-war-zone/18948/u-s-has-been-secretly-watching-russias-nuclear-powered-cruise-missiles-crash-and-burn

Putin speech: image of nuclear-powered underwater drone

Computer simulation of Russian submarine releasing nuclear-powered underwater drone



http://www.cbc.ca/news/technology/russia-nuclear-weapons-1.4557201

Putin also announced nuclear-powered underwater drone

Existence of underwater drone development was leaked several years ago

Putin: Russia has nuclear weapons impossible to intercept

abc NEWS

By Vladimir Isachenkov
Associated Press Moscow - March 1, 2018

abc NEWS

THE NUCLEAR-POWERED INTERCONTINENTAL UNDERWATER DRONE

"Russian news outlets first leaked reports about a nuclear-powered underwater drone called Status-6 several years ago, when its image taken during a Kremlin meeting was shown on national television in what many observers saw as a deliberate leak. On Thursday, Putin announced for the first time that Russia has built such a weapon. He said tests of a compact nuclear reactor that took years were completed successfully in December. Its nuclear reactor is 100 times smaller than those that power modern nuclear submarines and features a super-quick launch time, Putin added. The Russian president claims the new drone has 'fantastic' capabilities and can operate at 'very big' depth at a speed at least ten times faster than the fastest vessels or torpedoes in use today. He said the drone can carry a nuclear weapon to target both aircraft carrier groups and coastal facilities, adding that 'there are no means in the world to counter it now'."

https://abcnews.go.com/Technology/wireStory/putin-russia-nuclear-weapons-impossible-intercept-53442291

U.S. government affirms that nuclear underwater drone exists

Russia's nuclear underwater drone is real and in the Nuclear Posture Review

January 12, 2018 DefenseNews

https://www.defensenews.com/space/2018/01/12/russias-nuclear-underwater-drone-is-real-and-in-the-nuclear-posture-review/

U.S. government affirms that nuclear underwater drone exists

Autonomous drone capable of crossing entire ocean basins at 56 knots

Russia's nuclear underwater drone is real and in the Nuclear Posture Review

DefenseNews

By Valerie Insinna Defense News – January 12, 2018

WASHINGTON: "A draft of the Pentagon's Nuclear Posture Review confirms the existence of an underwater nuclear drone made and operated by Russia, a capability the U.S. Defense Department had not previously publicly acknowledged. A chart laying out Russian nuclear delivery vehicles developed over the past decade spells out the capability yet again, including a small illustration for an 'AUV,' or autonomous underwater vehicle, called Status-6. The black and white graphic posted by the Huffington Post makes it difficult to see whether the capability has been deployed."

"However, the Russian undersea drone — which is nicknamed 'Kanyon' by the Pentagon and goes by the full name Ocean Multipurpose System Status-6 — has been tested at least once … Status-6 was built by Rubin Design Bureau, the largest of Russia's three submarine manufacturers. According to a document shown on Russian television, the drone has a range of 6,200 miles, a top speed in excess of 56 knots and can descend to depths of 3,280 feet below sea level, the *Beacon* reported."

https://www.defensenews.com/space/2018/01/12/russias-nuclear-underwater-drone-is-real-and-in-the-nuclear-posture-review/

Russian nuclear-powered cruise missile: real weapon system

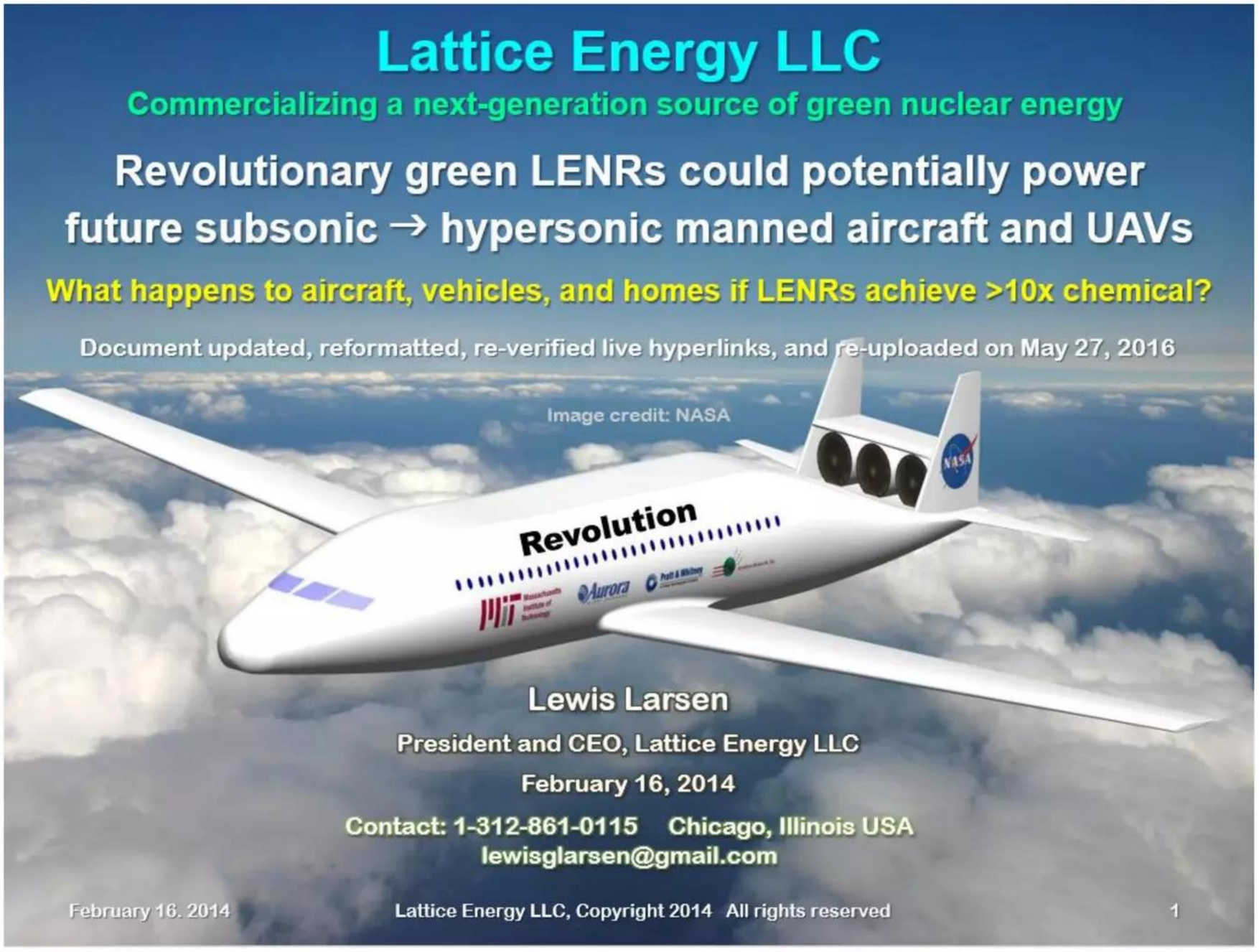
Putin's claim not empty boast but phase of development is open question

- U.S. government officials have effectively confirmed the existence of Russia's nuclear-powered cruise missile. However, detailed technical specifications were not released and development stage is still unclear
- Given that missile appears to be real, mission operational performance would be as Putin claimed; it would be game-changing weapon system. It is also possible Russians were able to design small airborne reactor with minuscule external release of radioactive nanoparticles during operation
- Claims by U.S. government sources that U.S. intelligence agencies had secretly monitored tests of new cruise missile and observed crashes during flight tests could either be deliberate disinformation or erroneous analysis and interpretation of intelligence collected about Russian tests. Although small, a crashed missile's reactor would probably rupture and release substantial amounts of readily detected enriched Uranium and radioactive fission products; no such large releases have been detected
- If Russia succeeded in developing new reactor with minimal particulate emissions, tiny telltale traces from flight tests might still be detected as anomalous U-235 isotope in Earth's atmosphere. In fact, such an anomaly has been detected during routine monitoring programs; see *Daily Mail* :

http://www.dailymail.co.uk/sciencetech/article-5395205/Mystery-radioactive-uranium-detected-Alaska.html

Feb. 2014: Lattice said LENRs might power future aircraft

Reveals NASA & Boeing studying LENRs as future propulsion technology



http://www.slideshare.net/lewisglarsen/lattice-energy-llc-revolutionary-lenrs-could-power-future-aircraft-and-other-systems-feb-16-2014

NASA/CR-2012-217556 project report was dated May 2012

Project studied LENRs as possible power source for future green aircraft

Subsonic Ultra Green Aircraft Research
Phase II: N+4 Advanced Concept Development

Marty K. Bradley and Christopher K. Droney
Boeing Research and Technology, Huntington Beach, California

Contract NASA/CR-2012-217556

- Power required to propel large future subsonic aircraft as shown in NASA/Boeing image to right is 10s of megawatts (MW)
- Modern General Electric GE90 fanjet system that powers large Boeing 777s (two such engines per plane) puts out ~160,000 horsepower or ~117 MW; by comparison: a smallish coal-fired power plant has a peak electrical output of ~500 - 600 MW
- NASA and Boeing appear to believe future LENR propulsion systems might eventually scale-up total system power outputs into 50 - 100 MW range; this is sufficient to be able to power large advanced subsonic aircraft

Image credit: NASA/The Boeing Company

Boeing patent application claimed LENRs for energy source

"Rotational annular airscrew with integrated acoustic arrester"

Europäisches Patentamt
European Patent Office
Office européen des brevets

"A propulsion system and methods are presented"

Europäisches Patentamt
European Patent Office
Office européen des brevets

Well-written application and innovative propulsion concept:

- "Rotational annular airscrew with integrated acoustic arrester"
- EP 2,730,501 A2 (English)
- Inventors: Matthew D. Moore and Kelly L. Boren (both from Everett, WA)
- Original USPTO filing date as US 201213674377 was November 12, 2012
- EPO application publication date: May 14, 2014

Contra-rotating fan blades

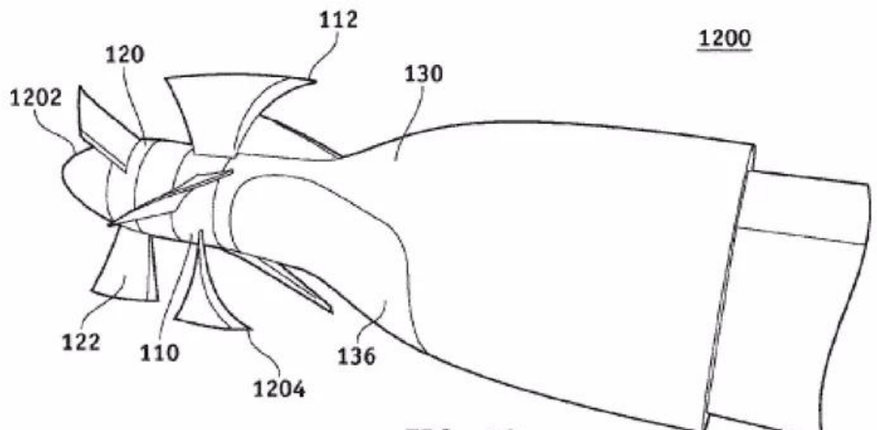


FIG. 12

Fan blades enshrouded with nacelle

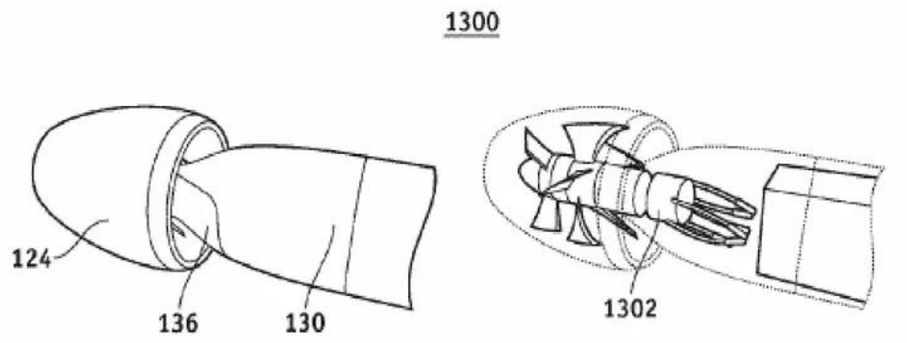


FIG. 13

https://data.epo.org/gpi/EP2730501A2-Rotational-annular-airscrew-with-integrated-acoustic-arrester

Boeing patent application claimed LENRs for energy source

Envisioned LENR propulsion systems for future passenger aircraft/ UAVs

In this EP application please see page #7, column 11, paragraph 0032 as follows (quoting):

"[0032] The contra-rotating forward coaxial electric motor 126 and the contra-rotating aft coaxial electric motor 128 are coupled to at least one energy source. The contra-rotating forward coaxial electric motor 126 and the contra-rotating aft coaxial electric motor 128 may be directly coupled to the at least one energy source, or through various control and/or power distribution circuits. The energy source may comprise, for example, a system to convert chemical, solar or nuclear energy into electricity within or coupled to a volume bearing structure. The energy source may comprise, for example but without limitation, a battery, a fuel cell, a solar cell, an energy harvesting device, low energy nuclear reactor (LENR), a hybrid propulsion system, or other energy source."

UAV embodiment

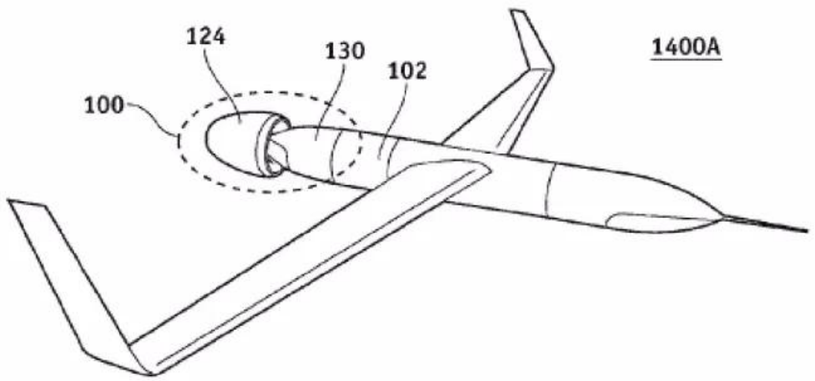


FIG. 14A

Passenger aircraft embodiment

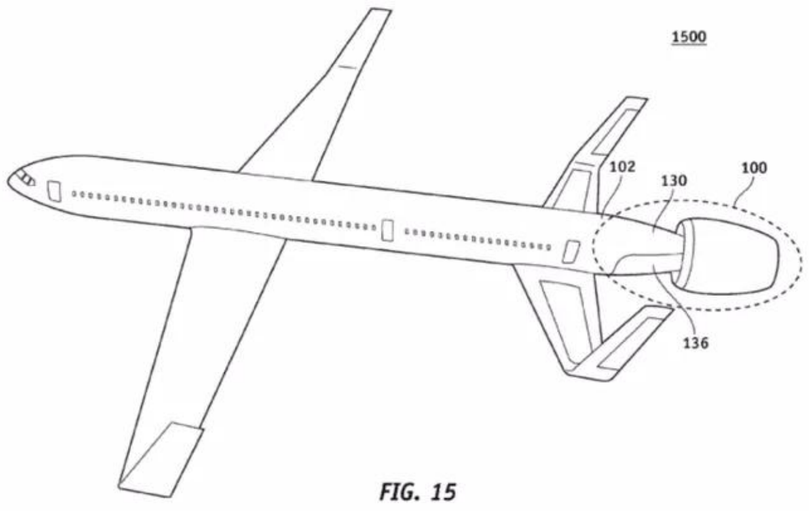
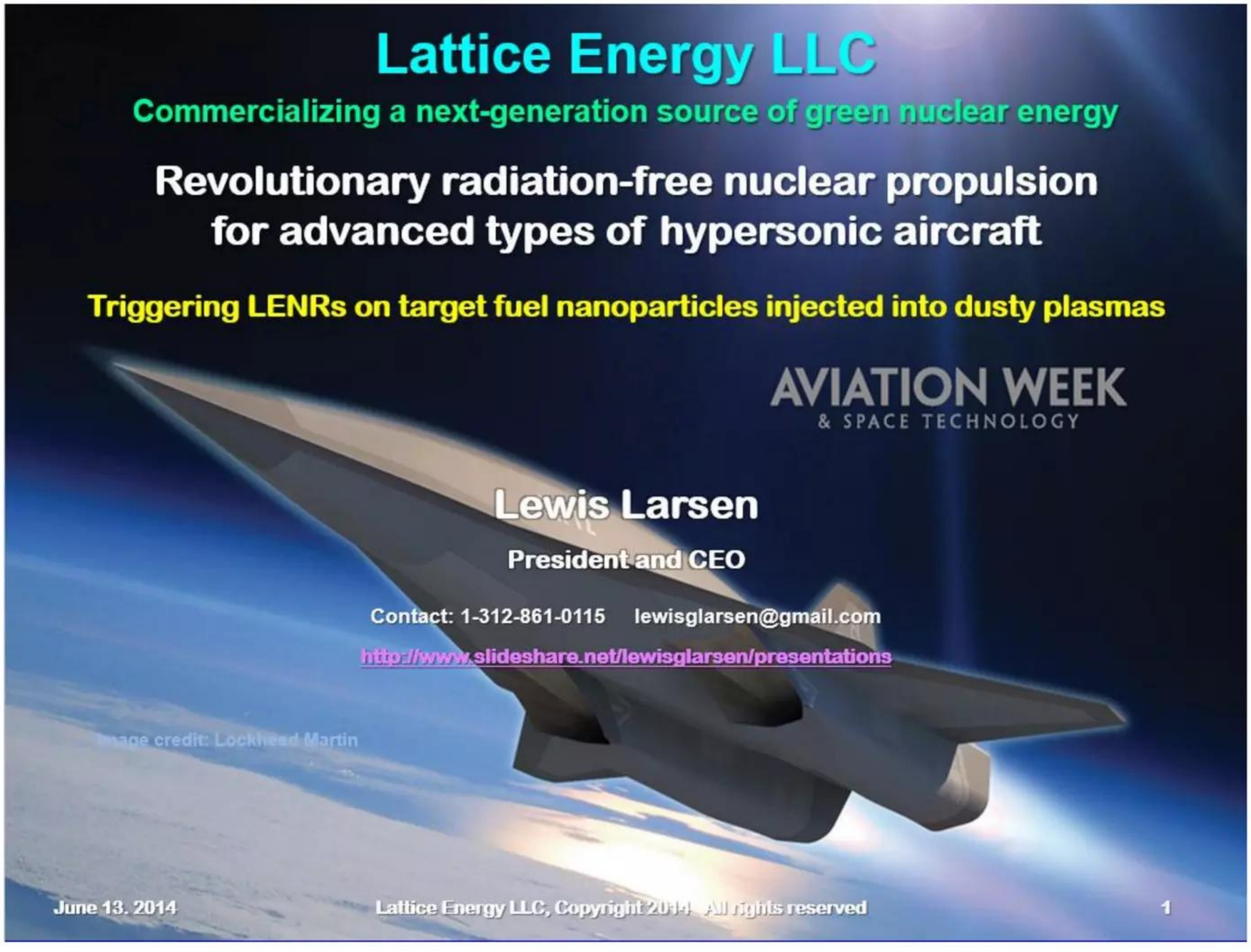


FIG. 15

https://data.epo.org/gpi/EP2730501A2-Rotational-annular-airscrew-with-integrated-acoustic-arrester

June 2014: Lattice said LENRs might power hypersonic craft

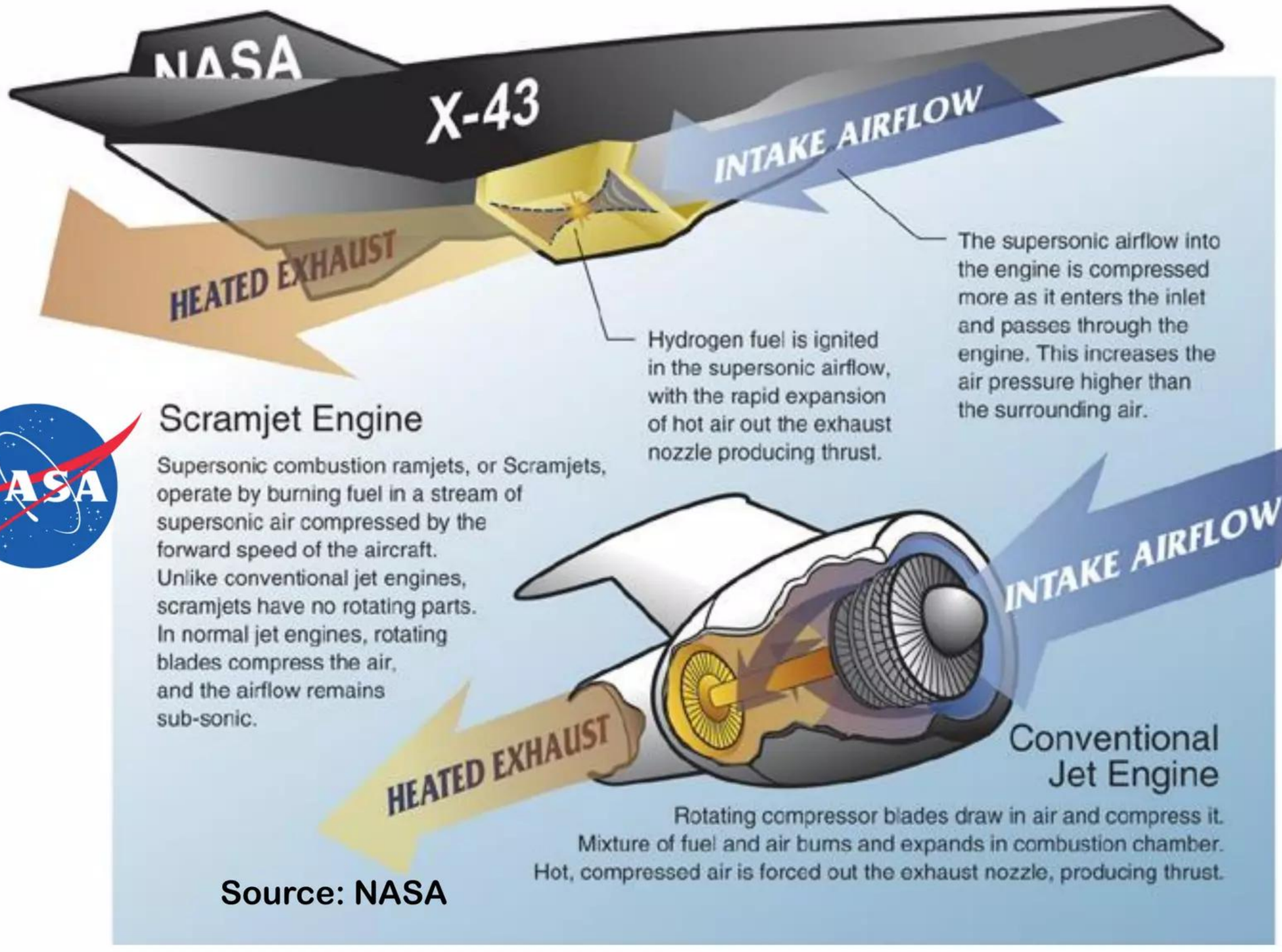
Nanocomposite LENR fuels have 5,000x energy density of chemical fuels



https://www.slideshare.net/lewisglarsen/lattice-energy-llc-radiationfree-nuclear-propulsion-for-advanced-hypersonic-aircraft-june-13-2014

Conceptual overview of scramjet vs. conventional jet engine

Hypersonic scramjet engines do not have any rotating internal parts

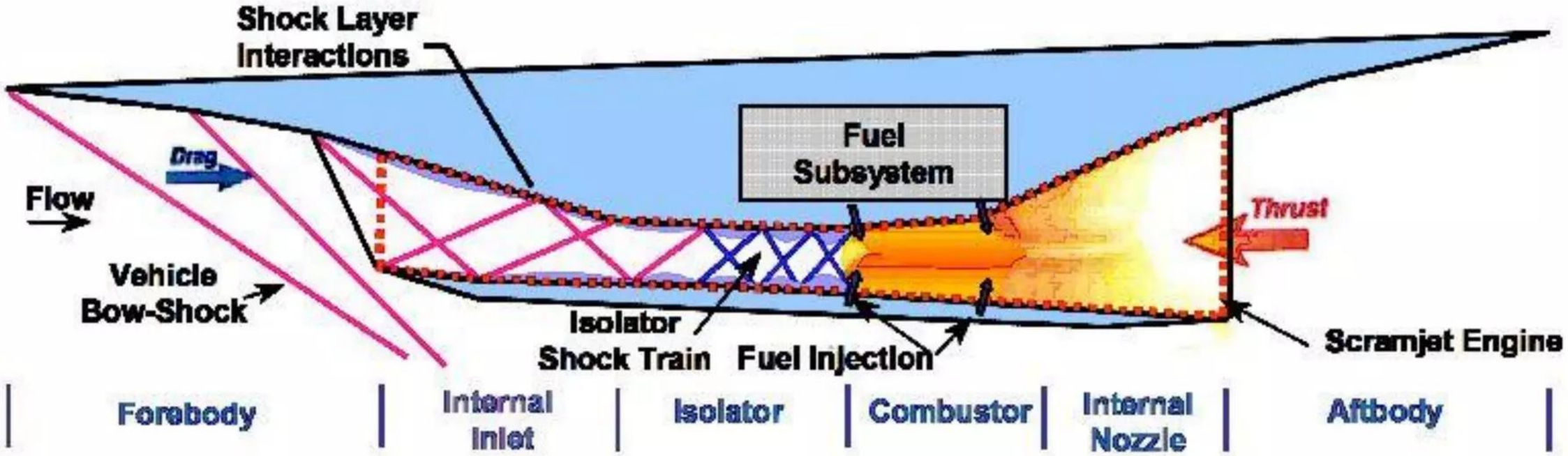


Source: NASA

Scramjet concept: plasma-assisted ignition and combustion

Impressive advantages for plasma-assisted ignition were demonstrated

FIG. 3 - Air-breathing supersonic combustion ramjet (scramjet)



"Plasma-Assisted Ignition and Combustion
A. Starikovskiy and N. Aleksandrov
Chapter 12 in "Aeronautics and Astronautics,"
M. Mulder, *ed.*, ISBN 978-953-307-473-3 (2011)
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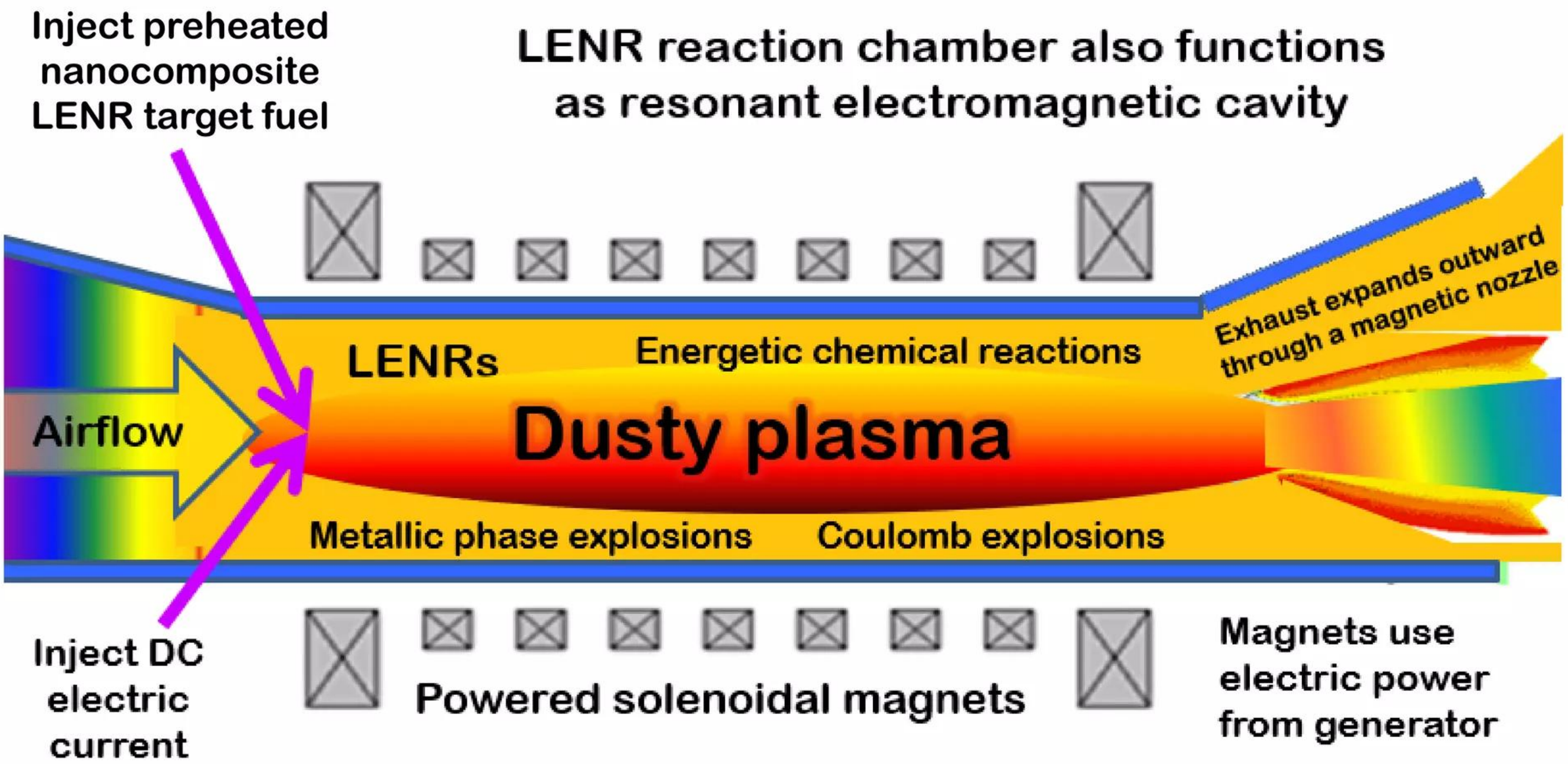
http://www.intechopen.com/books/aeronautics-and-astronautics/plasma-assisted-ignition-and-combustion

Lattice's concept for future LENR-powered scramjet engine

Nanocomposite LENR fuels injected into magnetically confined plasma

Thrust from LENRs, metallic phase/Coulomb explosions, and chemical reactions



https://www.slideshare.net/lewisglarsen/lattice-energy-llc-radiationfree-nuclear-propulsion-for-advanced-hypersonic-aircraft-june-13-2014

Energy density of future LENR fuels revolutionary for aircraft

LENR fuel for SR-71 mission could probably fit into two FedEx boxes

Huge advantage in using LENR propulsion technology: energy densities of onboard fuels could be ~5,000x gasoline → mass of fuel carried cut by > 90%

LOCKHEED MARTIN

SR-71 Blackbird carried ~12,000 gallons of JP-7 aviation fuel with full tanks; permitted unrefueled range of about 3,250 miles traveling at Mach 3.0

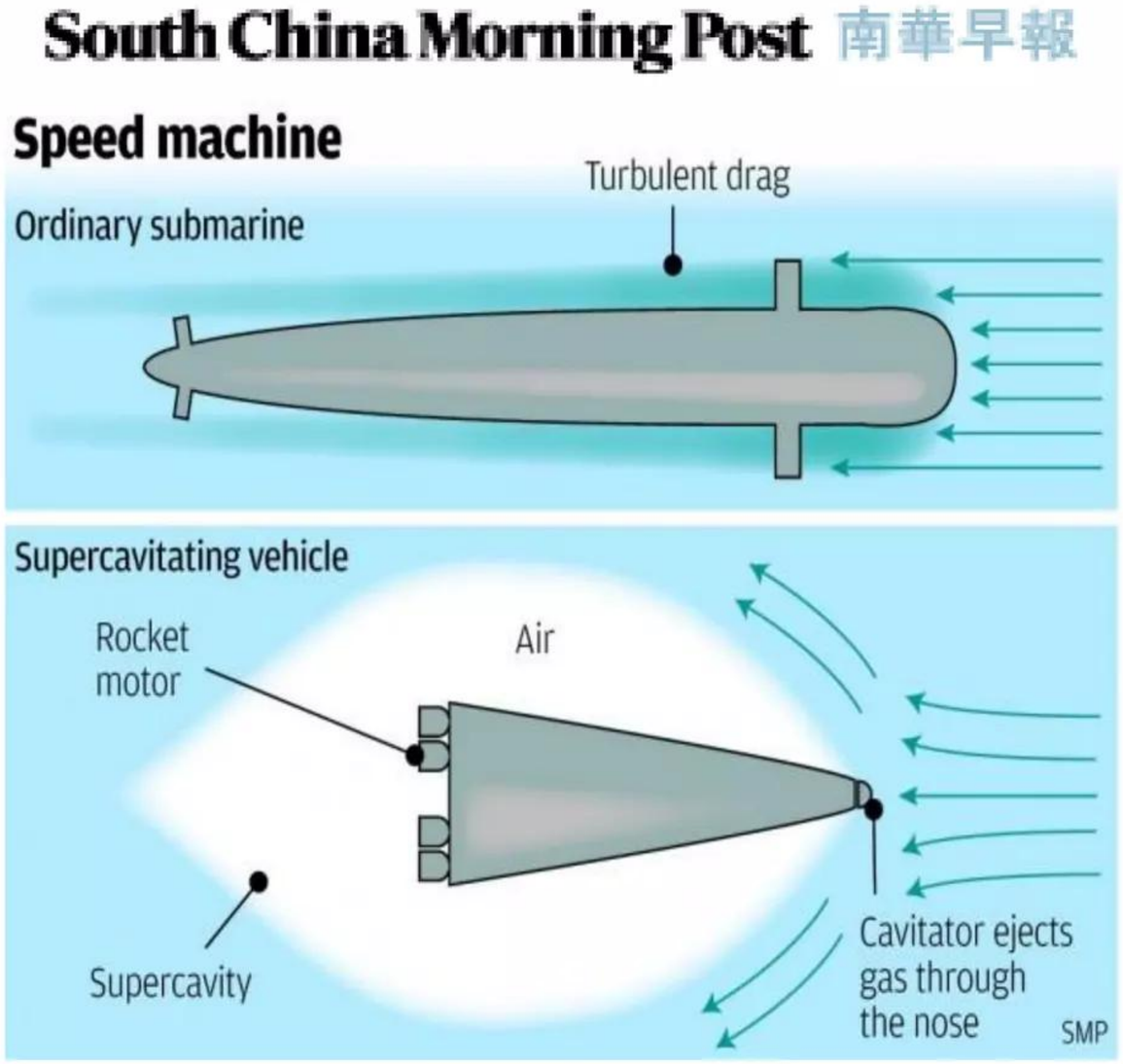
Tanker truck can carry ~12,000 gallons of JP-7 aviation fuel

Revolution

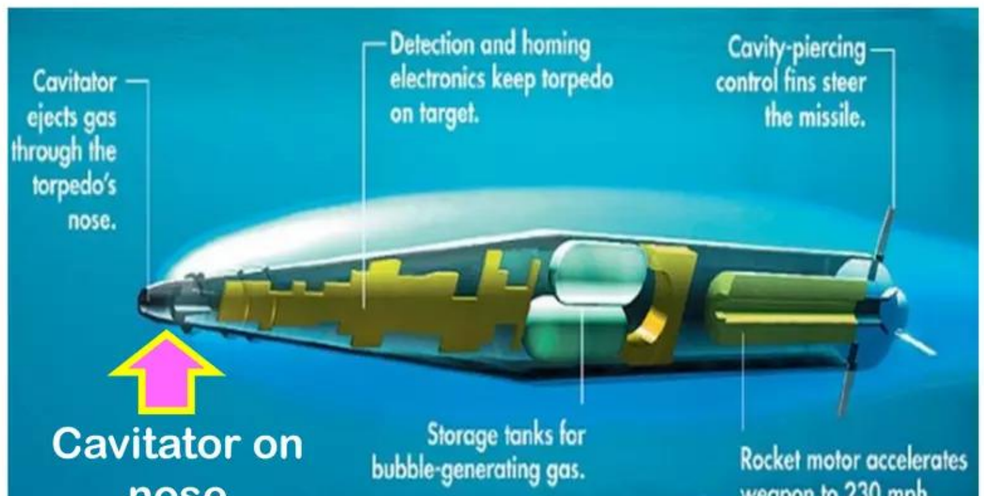
Feb. 2014: Lattice said LENRs might power undersea vehicles

LENR fuels' high energy density could enable enormous range and speed

Comparison of conventional submarine with future supercavitating UV



Concept for a 230 mph supercavitating underwater vehicle



Russian Shkval: first-deployed supercavitating military torpedo

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-revolutionary-lenrs-could-power-future-aircraft-and-other-systems-feb-16-2014

Japan's government targeting commercialization of LENRs

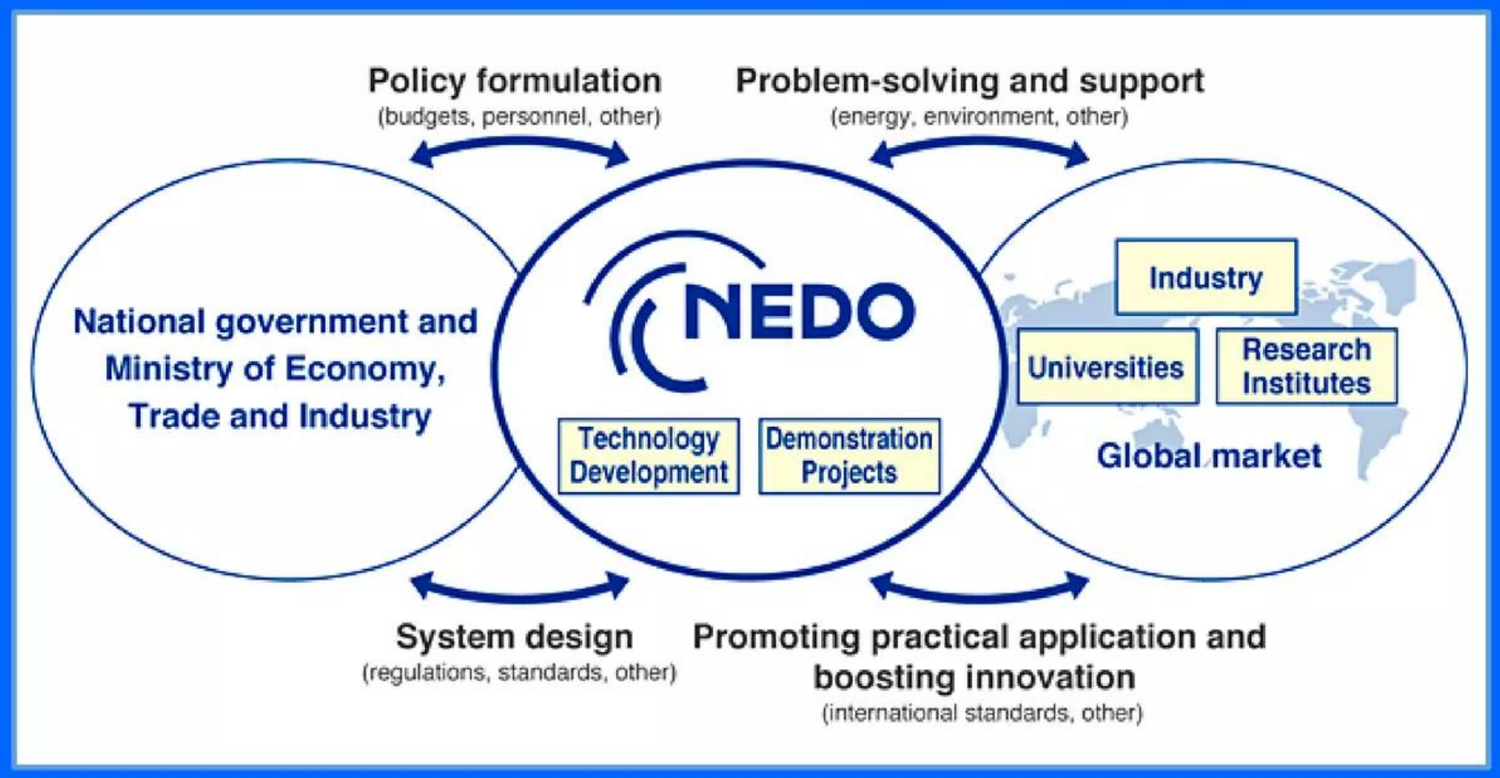
NEDO organized and funded LENR project with industry and academia

NEDO New Energy and Industrial Technology Development Organization

Combining the efforts of industry, government and academia and leveraging established international research networks, NEDO is committed to contributing to the resolution of energy and global environmental problems and further enhancing Japan's industrial competitiveness

http://www.nedo.go.jp/english/

NEDO's mode of operation – graphic copied from home page of NEDO website



経済産業省 Ministry of Economy, Trade and Industry

MITSUBISHI

TOYOTA

NISSAN

Japanese companies working on NEDO LENR R&D project

Technova Inc. (Toyota principal shareholder) manages NEDO project

NEDO

Technova | Inc.

MITSUBISHI

TOYOTA

NISSAN

TOHOKU UNIVERSITY

NAGOYA UNIVERSITY

KOBE UNIVERSITY

KYUSHU UNIVERSITY

Mitsubishi has deep experience in nuclear fission technology

Unlike Toyota and Nissan, MHI can leverage knowledge in nuclear power

MITSUBISHI HEAVY INDUSTRIES

MOVE THE WORLD FORWARD

MNES Mitsubishi Nuclear Energy Systems

MITSUBISHI HEAVY INDUSTRIES GROUP

Mitsubishi Nuclear Energy Systems

Mitsubishi Nuclear Energy Systems, or MNES, provides a range of state-of-the-art replacement components, services, and technologies to U.S. utilities operating pressurized water reactor (PWR) nuclear power plants. These include replacement reactor vessel closure heads, steam generators, and water jet peening technologies for Alloy 600 mitigation measures.

The company also offers U.S. utilities the next generation of clean nuclear energy, the US-APWR nuclear power plant. The US-APWR design, specifically engineered for the United States, achieves superior safety, reliability, economy, and compatibility with the environment. Our design grew out of the expertise gained by Mitsubishi's construction of 24 PWRs in Japan.

https://www.mnes-us.com/

Mitsubishi designs and manufactures jet engines for aircraft

MITSUBISHI HEAVY INDUSTRIES
AERO ENGINES, LTD.

New Technology Takes To The Skies.

"The MHI Group has nearly a century of experience with aircraft engines. In addition to manufacturing and servicing parts, it supports the global aircraft industry and comfortable air travel by undertaking international joint development of turbofan engines for commercial aircraft. The Group is participating in a program to develop all-new PW1200G engines for the next-generation regional jet, the MRJ (Mitsubishi Regional Jet). The program utilizes cutting-edge noise-suppressing and reduced gas emission technologies to produce an environmentally friendly engine that will help protect the global environment."

https://www.mhi-aeroeng.co.jp/en/products/index.html

Mitsubishi is already working on hypersonic anti-ship missile

Radiation-free LENR propulsion system could be integrated with XASM-3

Bullseye: The 5 Most Deadly Anti-Ship Missiles of All Time

THE NATIONAL INTEREST

By Kyle Mizokami March 13, 2015

"XASM-3: Japan's strictly defensive military doctrine has driven a requirement for smaller ASMs to arm ships, aircraft and ground batteries. Japan has designed and produced two generations of anti-ship missiles fitting this profile, but the third generation will likely be a radical departure from past designs. XASM-3 is an anti-ship missile currently under joint development by the Government of Japan's Technical Research and Development Institute and Mitsubishi Heavy Industries (MHI). Although relatively little is known about the missile at this point, if put into production it will represent a considerable leap over the Japan Self Defense Forces' existing capabilities. XASM-3 will be a hypersonic missile, a solid-fueled rocket with integrated ramjet operating at speeds of up to Mach 5. The missile is designed to be stealthy. Like Brahmos, XASM-3 will use speed to limit the enemy's reaction and engagement time. Using the same engagement parameters as Brahmos, XASM-3 will allow defenders only a 15 second reaction time."

http://nationalinterest.org/feature/bull%E2%80%99s-eye-the-5-most-deadly-anti-ship-missiles-all-time-12411?page=2

Mitsubishi's XASM-3 work could lead to future cruise missile

THE WARZONE

Japan Is Looking At Developing its Very Own Land Attack Capable Cruise Missile

By Joseph Trevithick November 21, 2017

"Japan is reportedly looking into developing its own stand-off cruise missile that aircraft, warships, and land-based launchers all might be fire at hostile targets both on land and at sea. The decision comes amid growing tensions on the Korean Peninsula, as North Korea continues to develop its nuclear weapon and missile capabilities, and a long-running dispute with China over ownership of a remote island chain in the East China Sea. On Nov. 20, 2017, *The Yomiuri Shimbun* reported that the Japanese Ministry of Defense would research adding a land-attack capability to an unspecified existing anti-ship missile development programs. Research and development would start some time during the 2018 fiscal year, which began on Oct. 1, 2017, but the newspaper did not give a timeline for when the missile might be ready for tests or enter service."

http://www.thedrive.com/the-war-zone/16320/japan-is-looking-at-developing-its-very-own-land-attack-capable-cruise-missile

Nanocomposite LENR devices in Japanese NEDO industry-academia-government R&D project produced enough cumulative excess heat to boil a cup of tea

LENR device excess heat production upped by 10^3 in 3 years

Achieved with new Pd-Ni-Zr nanocomposite LENR device materials

- Japan's NEDO industry-academia-government R&D program with Toyota, Mitsubishi Heavy Industries, Nissan Motors, and four universities, has just technically validated potential for LENRs to eventually become an important future CO_2-free energy source
- January 2018 summary project report and other recent project reports released by Technova Inc. on ResearchGate showed reproducible Watt or better excess heat production at an ~80% success rate with new types of Pd-Ni-Zr nanocomposite LENR device materials fabricated using typical cleanroom techniques
- Versus prior MHI thin-film Pd/CaO multilayer heterostructure LENR devices, developing new types of rigorously fabricated Pd-Ni-Zr ZrO_2/SiO_2 nanocomposite powder-like device materials enabled scientists to go from --- at best --- infrequent macroscopic heat production up to ~80% reproducibility. With respect to amounts of excess heat production, they essentiality improved from milliwatts up to Watts, or a factor of roughly 10^3 --- i.e., 1,000 times better
- This impressive improvement was accomplished in roughly 3 years

Still relying on spontaneous random formation of active sites

Next step in thermal output scale-up: purpose-built active site precursors

- Nanocomposite LENR devices in Japanese NEDO industry-academia-government R&D project finally produced enough cumulative excess heat to boil a cup of tea, > 0.0826 megajoules (MJ) of thermal energy
- NEDO results thus achieved long-sought experimental reproducibility for Watt-levels of excess heat. However, their methodology still relies on spontaneous *random* formation of LENR active sites in materials
- Widom-Larsen theory posits that LENRs occur in discrete microscopic nanometer to micron-sized active sites located on surfaces or at interfaces. There is no doubt that present levels of NEDO device performance can be further improved with better fabrication methods and yet-to-be-tested materials; that work presently underway in Japan
- However, Lattice believes vast improvements in device reproducibility and scale-up of excess heating power will require mastery of design, fabrication, and emplacement of purpose-built nanostructures that are precursors to W-L LENR active sites. Achieving manufacturability of active sites should enable scale-up to kilowatts of excess heat output

1st fission reactor created 0.5 Watts of heat, weighed 400 tons

LENR cruise missile propulsion system would require > 2 - 3 MW thermal

- Some might scoff at NEDO project's achieving only Watt-levels of excess heat, given that automotive applications would require on order of at least 60 kilowatts to successfully power full-sized motor vehicles. Skeptics would be wise to recall that world's first Uranium nuclear fission reactor, Fermi's CP-1 at University of Chicago in 1942, weighed 400 tons and only produced 0.5 Watts of excess heat; today's commercial reactors produce > 10^9 Watts. Including mass of reaction vessels, NEDO's primitive LENR reactor devices only weigh tens of kilograms and already produce more heat than did CP-1

- Unlike Uranium fission reactors, again verified by NEDO results, LENRs do not produce any deadly energetic gamma and neutron radiation or long-lived radioactive wastes. Consequently, if future commercial LENR reactors with sufficiently scaled-up power outputs can be developed they would not require heavy, expensive radiation shielding and containment systems for safe operation. That would enable LENR power systems to be vastly less expensive than fission or fusion reactors and light-enough to be utilized in unshielded propulsion systems for motor vehicles, aircraft, and spacecraft

- Lattice believes that LENRs and nanotechnology are intimately interrelated. NEDO project's excellent results with nanocomposites support idea that nanotech can be leveraged to greatly accelerate LENR commercialization

Total power output of nuclear plants was scaled-up by > 10^9 x

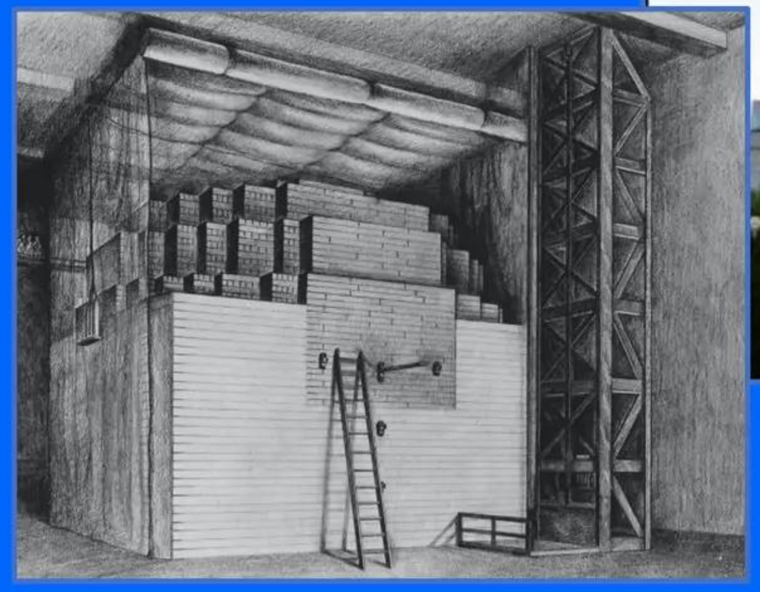
LENR-based power systems should also scale-up enormously over time

10^7 x output increase

12 years

5×10^{-1} Watts

World's 1st sustained fission chain reaction



Manhattan Project CP-1
USA 0.5 W 1942

5×10^6 Watts

World's 1st grid-connected fission power plant

Obinsk
Russia 5 MW 1954

8.2×10^9 Watts

World's largest multi-reactor fission power plant

Kashiwazaki-Kariwa
Japan 8.2 GW 2018

NEDO project has demonstrated that LENRs can produce non-trivial amounts of excess heat from nanocomposite multi-metal devices without emission of deadly fluxes of energetic neutron or gamma radiation --- safe nuclear technology

Next steps: further nanotech engineering, optimization of device materials, and scale-up of excess heat output and useful operating lifetimes

Credit: Getty Images

Further info re Japanese NEDO project and LENR technology

Purplish hyperlinks below are 'live' as well as in SlideShare PowerPoints

"Small, primitive nanocomposite LENR devices fabricated in NEDO project produced enough cumulative excess heat to boil cup of tea for up to 45 days"

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-nedo-industryacademiagovernment-project-nanocomposite-lenr-devices-produce-enough-heat-to-boil-cup-of-tea-feb-7-2018

"Japan's NEDO industry-academia-government R&D program's recent experimental results technically validated potential for LENRs to become major future energy source"

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-nedo-lenr-project-reported-reasonably-reproducible-wattlevel-excess-heat-production-feb-4-2018

"January 2018: project report released - summarized progress in Japanese government-funded NEDO R&D in LENRs for Oct. 2015 thru Oct. 2017. Project scientists reported good progress in developing nanocomposite LENR devices for use as powerful heat sources"

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-nedo-lenr-project-reported-good-progress-in-excess-heat-production-and-device-fabrication-jan-27-2018

"Scalability of LENR power generation systems"

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-scalability-of-lenr-power-generation-systems-nov-29-2015

Key publications about Widom-Larsen theory of LENRs

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen (author's copy)
European Physical Journal C - Particles and Fields 46 pp. 107 - 112 (2006)
http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen (author's copy)
Pramana - Journal of Physics 75 pp. 617 - 637 (March 2010)
http://www.slideshare.net/lewisglarsen/srivastava-widom-and-larsenprimer-for-electroweak-induced-low-energy-nuclear-reactionspramana-oct-2010

"Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces"
A. Widom and L. Larsen
Cornell physics preprint arXiv:nucl-th/0608059v2 12 pages (2007)
http://arxiv.org/pdf/nucl-th/0608059v2.pdf

"Hacking the Atom" (Volume 1 - 484 pages) popular science book
Steven B. Krivit, Pacific Oaks Press, San Rafael, CA, September 11, 2016
Paperback US$16.00; hardcover US$48.00; Kindle US$3.99
https://www.amazon.com/dp/0996886451

Working with Lattice Energy LLC, Chicago, Illinois USA

Partnering on LENR commercialization and consulting on other subjects

1-312-861-0115 lewisglarsen@gmail.com

L. Larsen c.v.: http://www.slideshare.net/lewisglarsen/lewis-g-larsen-cv-june-2013

- We believe Lattice is the world-leader in proprietary knowledge about LENR device engineering required to develop high-performance, long lived, scalable power sources. Our published peer-reviewed theoretical papers rigorously explain the breakthrough device physics of LENR processes, including the absence of dangerous energetic neutron or gamma radiation and lack of long-lived radioactive waste production
- Lattice welcomes inquiries from large, established organizations that have an interest in discussing the possibility of becoming Lattice's strategic capital and/or technology development partner
- Lewis Larsen also independently engages in consulting on variety of subject areas that include: Lithium-ion battery safety issues; long-term electricity grid reliability and resilience; and evaluating potential future impact of LENRs from a long-term investment risk management perspective for large CAPEX projects in the oil & gas, petrochemicals, transportation, utility, and aerospace industries