Militaries racing to deploy Railgun on Navy Warships to shoot down stealth aircraft and missiles including against hypersonic threats

Electromagnetic Rail Gun, EMRG , is a cannon that uses electricity rather than chemical propellants (i.e., gunpowder charges) to launch projectiles at distances over 100 nautical miles – and at speeds exceeding Mach 5. In EMRG, "magnetic fields created by high electrical currents accelerate a sliding metal conductor, or armature, between two rails to launch projectiles at [speeds of] 4,500 mph to 5,600 mph," or roughly Mach 5.9 to Mach 7.4 at sea level.

The Railguns provide revolutionary military capabilities. They provide Long range artillery (in excess of 200 Km) with increased penetration because of high impact speed and simultaneous impacts via rate of fire and velocity control. Railgun-equipped warships can fire hypersonic projectiles to shoot down stealth aircraft and ballistic missiles, or bombard enemy ships and land targets from hundreds of miles away. They can be employed for Anti-surface (naval), Anti air and anti missile defense (including against hypersonic threats).

The U.S. China , Russia, Japan and France are reportedly developing their own version of the railgun. According to the navyrecognition.com, The pictures released on January 31st show the People's Liberation Army Navy (PLAN or Chinese

Navy) Type 072 III landing ship Haiyangshan (hull number 936) fitted with the suspected railgun at its bow and several ISO containers amidship. If this turns out to be an actual EM railgun, China would become the very first country to test such a system at sea. The China Navy's experimental railgun is mounted on landing ship as the test platform and speculated to enter service with the next Type055 DDG variant. Early, rear Admiral Ma Weiming told Chinese experts in electromagnetic research that the country has made breakthroughs in key areas of electromagnetic applications, such as railguns and electromagnetic-assisted launch system (EMALS) catapults.

The U.S. Navy, along with the Office of Naval Research (ONR) and BAE Systems has been working on the technology for several years. US Navy is ready to deploy their futuristic Electromagnetic Railgun (EMRG) for field tests.ONR has demonstrated the ability to conduct "multi shot salvo" (with two projectiles are fired in a 12 seconds span or about 5 rounds per minute) at the Naval Surface Warfare Center Dahlgren Division, a land based facility. Rear Admiral Matthew Klunder, head of US Naval Research, said the futuristic electromagnetic railgun – so called because it fires from two parallel rails – had already undergone extensive testing on land. "Energetic weapons, such as EM railguns, are the future of naval combat," said Rear Adm. Matt Klunder, the chief of naval research.

While initially conceived of and developed for the Navy's emerging Rail Gun Weapon, the Pentagon and Army are now firing the Hyper Velocity Projectile from an Army Howitzer an effort to fast-track increasing lethal and effective weapons to warzones and key strategic locations, Pentagon officials said. Army is looking to target buildings, force concentrations, weapons systems, drones, aircraft,vehicle

bunkers and even incoming enemy missiles and artillery rounds. “We can defend against an incoming salvo with a bullet. That is very much a focus getting ready for the future,” Dr. William Roper, Director of the Pentagon’s once-secret Strategic Capabilities Office, told Scout Warrior among a small group of reporters.

A team of Russian scientists has successfully tested the country’s first railgun, which relies on electromagnetic forces rather than explosives or propellant. According to experts at the Institute of High Temperatures’ branch in Shatura, just outside Moscow, the railgun can fire shells at an incredibly fast speed of 3 kilometers per second, which is well enough to cut through any type of armor existing today. During the latest test, a 15 gram plastic cylinder fired by the railgun went through an aluminum plate several centimeters thick. “The newspaper’s report was no surprise. Similar developments are also actively under way in Russia,” Franz Klintsevich had told RIA Novosti.

While many countries are already staking on the railgun as a future weapon, Russia is also considering other, more peaceful applications, such as ferrying cargoes to the International Space Station. “The railgun is a big boost to our study of high energy physics as we are now ready to build apparatuses working at speeds exceeding 4.5 kilometers a second,” the Shatura Institute’s director Alexei Shurpov told Zvezda TV.

US Navy’s railgun programme

The US Navy super-powerful electromagnetic railgun is targeted to to fire rounds at speeds up to Mach 7.5, which at 9,100 kilometers per hour, is more than seven times the speed

of sound, and covers a distance of about 400 kilometers.The weapons are not only devastating in their speed, but at $25,000 per round are much cheaper than their explosive counterparts such as the Tomahawk or Harpoon, which can cost up to $1 million each. ‘The railgun is a true warfighter game changer,’ the Navy says. ‘Wide-area coverage, exceptionally quick response and very deep magazines will extend the reach and lethality of ships armed with this technology.’

The electromagnetic rail gun uses electrical energy generated by its host ship and stored over several seconds in a pulsed power system to create a magnetic field that propels the kinetic energy projectile well over 100 miles toward a wide range of targets, such as enemy vehicles, or cruise and ballistic missiles. The weapon can release up to 5 million amps, or 1,200 volts within 10 milliseconds, according to Military.com. That’s enough to speed up a 45-pound projectile from zero to 5,000 mph in one one-hundredth of a second, the site said.

However, they were ‘not suitable for integration aboard a ship’ and were too big to fit the latest Zumwalt-class destroyers, Thomas Beutner, head of ONR’s Naval Air Warfare and Weapons Department, said during a July event in Washington, according to Defence One. To get around the issue, ONR researchers developed their own capacitors, which are far smaller, but can supply 20 megajoules per shot, with a goal of 32 megajoules by next year. According to ONR, ‘you can think of a megajoule as about the same, energy-wise, as a one-ton vehicle moving at 160 mph.’ These new capacitors ‘represent a new generation of pulse power, with an energy density of over a megajoule per cubic meter,’ said Beutner. The current

version is now capable of firing multiple shots in succession, the group is also aiming to ramp the firing rate up to 10 shots per minute by 2018, the report said.

The US Navy has been working on the gun with BAE Systems since 2005. During phase I developers focused on developing pulsed power technology. During phase II, which started in 2012, will further develop the pulsed power system and the launcher system.

The Navy funded the development of two industry-built EMRG prototype demonstrators, one by BAE Systems and the other by General Atomics. The two industry-built prototypes are designed to fire projectiles at energy levels of 20 to 32 megajoules, which is enough to propel a projectile 50 to 100 nautical miles. (Such ranges might refer to using the EMRG for NSFS missions. Intercepts of ASCMs and ASBMs might take place at much shorter ranges.) The Navy began evaluating the two industry-built prototypes in 2012.

The Navy originally began developing EMRG as a naval surface fire support (NSFS) weapon for supporting U.S. Marines operating ashore, but subsequently determined that the weapon also has potential for defending against ASCMs and ASBMs.The weapon would also eliminate the hazards of high explosives in the ship and unexploded ordnance on the battlefield, Navy officials say.

Deputy defense secretary Bob Work described his vision for a future Navy fleet that would rely on railguns and lasers for fleet defense. “If the Navy can develop working railguns and

lasers that are practical enough for a warship, it would not only solve the magazine depth issue, but would also free up missile tubes for the FSC's offensive sea-control and land attack missions."

While the weapon is currently configured to guide the projectile against fixed or static targets using GPS technology, it is possible that in the future the rail gun could be configured to destroy moving targets as well, Capt. Mike Ziv, Program Manager for Directed Energy and Electric Weapon Systems said.

The Navy is evaluating whether to mount its new Electromagnetic Rail Gun weapon aboard the high-tech DDG 1002 destroyer by the mid-2020s, service officials said. The DDG 1002's Integrated Power System provides a large amount of on board electricity sufficient to accommodate the weapon, said Capt. Mike Ziv, Program Manager for Directed Energy and Electric Weapon Systems. The US Navy has also revealed plans to test a prototype electromagnetic on-board a joint high-speed vessel (JHSV) this year.

In January 2015, it was reported that the US Navy is projecting that EMRG could become operational on a Navy ship between 2020 and 2025. In April 2015, it was reported that the Navy is considering installing an EMRG on a Zumwalt (DDG-1000) class destroyer by the mid-2020s.

Challenges of Railguns

Crucially, the weapon currently requires a 25-megawatt power plant of its own to fire at all. The vast power consumption

can so far be supported by only three US destroyers being built. Another problem here is that the longer the distance to the target the weaker the impact of this shot as air resistance keeps slowing the projectile down as it travels to its target. Another major challenge is the guidance system, which is to be based on GPS, and the sensitive electronics that should be modernized to withstand the gravity in order not to crumble.

One of the challenge is that the high muzzle velocity quickly wears out their “barrels” (which are actually two conductive metal rods along which the projectile is driven), requiring frequent replacement.

The Office of Naval Research recently identified several key “research opportunities” to make the railgun a success, including better thermal management for the gun’s launch rails; extending the service life of the equipment; developing high-strength dielectric structural materials; and reducing the size of associated power systems and control electronics. Experts say that the limited durability of a railgun’s rails under the stress of repeated firing is an especially serious challenge for the technology – one that rapid-fire testing may help address.

Russia downplays railgun as being too inexpensive and still technologically immature

Klintsevich, first deputy chairman of Russia’s Senate committee for defense and security, has accused Washington of trying to impose a new Cold War-style arms race while saying the “supergun,” dubbed a potential game-changer by the

Pentagon, is not yet an effective technological breakthrough.

“There is a huge distance between a first test and mass production, moreover, at present, the main problem of creating a supergun – its expensiveness – isn’t solved.” the senator told RIA Novosti on Sunday.

Even if the US Navy manages to make a breakthrough its ambitious and costly project, it will not succeed in dragging Russia into another weapons race, Klintsevich stressed, suggesting that Russia may respond asymmetrically with existing capabilities. “To not allow the change of balance of power in the world, we have lots of other possibilities. Which will be used, if necessary. In short, situation is under control.”

Raytheon delivers pulse power containers for US Navy’s railgun programme

Raytheon has started delivering pulse power containers (PPCs) to support the US Navy’s railgun programme. In January 2012, the US Naval Sea Systems Command awarded an initial $10m contract to Raytheon for the preliminary design of a large power system, Pulse Forming Network (PFN).

‘Pulse Power Containers’ (PPC) consist of huge banks of capacitors or rechargeable batteries packed inside standard ISO containers. Developed by Raytheon, each container packs

enough energy to discharge 18 kilowatts for each shot. To enable the railgun to fire ten such shots per minute the PPC must recharge from the host ship in seconds and be able to store and discharge the energy in very short time while managing the thermal load generated by the process.

The PFN will provide the electromagnetic energy for the railgun projectile to travel without the use of an explosive charge or rocket motor. The containers will be included in the navy's railgun test range for additional development and testing. According to Raytheon, these PPCs, when combined, produce enough power to trigger an electromagnetic launch of a railgun's high-velocity projectile, at speeds of more than mach 6.

Raytheon Integrated Defense Systems Business Advanced Technology vice-president Colin Whelan said: "Directed energy has the potential to redefine military technology beyond missiles and our pulse power modules and containers will provide the tremendous amount of energy required to power applications like the navy railgun. The US Navy's railgun uses an electromagnetic force, known as the 'Lorenz Force', to fire a projectile at six or seven times the speed of sound.

The Navy, in addition to developing the railgun itself, is working on a hypervelocity projectile (HVP) that will support both the railgun and conventional 5-inch guns. The GPS-guided round will fly at hypersonic speeds, but the Navy is still working with the Pentagon's Strategic Capabilities Office to close the fire control loop between the gun and the projectile.

Typical Railgun

The speed of projectiles in conventional or light gas guns, both are limited by the acceleration of the expanding gas it uses. As EMRGs convert electrical energy into kinetic energy, effectively instantaneously, they are not limited by a maximum acceleration. Though EMRGs themselves tend to only be about 2% efficient, theoretically they have no limit to how much energy can be input to the system and thusly no maximum velocity the system can attain.EMRGs are made up of a few subsystems: an electrical subsystem, an injector, a pair of supported conductive rails, and a projectile.

1. Electrical Subsystem

The EMRG electrical subsystem is composed of three subsystems that output a pulse of current: a power source, a storage system; and a delivery system. The power source provides the storage system with electricity that is then stored. When the EMRG is fully charged and ready to fire the storage system sends the electricity as quickly as possible through a delivery system, a system of electrical cabling, and to the conductive rails.

2. Injector

The injector subsystem is required to accelerate the projectile before it reaches the electric rails. If the projectile enters the electric rails with no or a low initial velocity, the projectile will weld to the rails. To combat this, an injector system must be used to give the projectile an initial velocity. The more initial velocity obtained using the injector is also energy that the electric rails do not have to impart onto the projectile; ideally an injector that provides as much velocity as possible should be used.

3. Supported Conductive Rails
The conductive rails are the most important subsystem in the EMRG. They are the system responsible for converting electrical energy into kinetic energy using Lorentz force. Based on the size and distance between the rails the rate of conversion between electrical and kinetic energy is controlled. This conversion creates a large amount of force on the projectile but also on the rails themselves. To ensure that the rails do not fail due to the induced force, they are supported by a rigid structure.

4. Projectile
The projectile itself must be conductive. This allows the current to pass through the projectile and convert the electric energy into a force on the projectile. High melting points will maintain their shape better under firing conditions, but will also tend to do more damage to the barrel when they fragment.

References and Resources also include:

http://www.naval-technology.com/news/newsraytheon-delivers-pulse-power-containers-for-us-navys-railgun-programme-4904013

http://www.militaryaerospace.com/articles/print/volume-27/issue-5/product-appilcations/saft-to-provide-energy-storage-and-power-electronics-support-for-navy-electromagnetic-railgun.html

http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1059&context=aerosp

https://www.rt.com/news/344894-pentagon-railgun-russia-senator

/

https://fas.org/sgp/crs/weapons/R44175.pdf

https://sputniknews.com/russia/201701091049399104-russia-railgun-tests/

http://www.maritime-executive.com/article/us-navy-tech-moves-forward-emals-lrasm-and-railgun

https://www.navyrecognition.com/index.php/news/defence-news/2018/february-2018-navy-naval-defense-news/5910-is-china-s-plan-about-to-test-a-railgun-at-sea.html