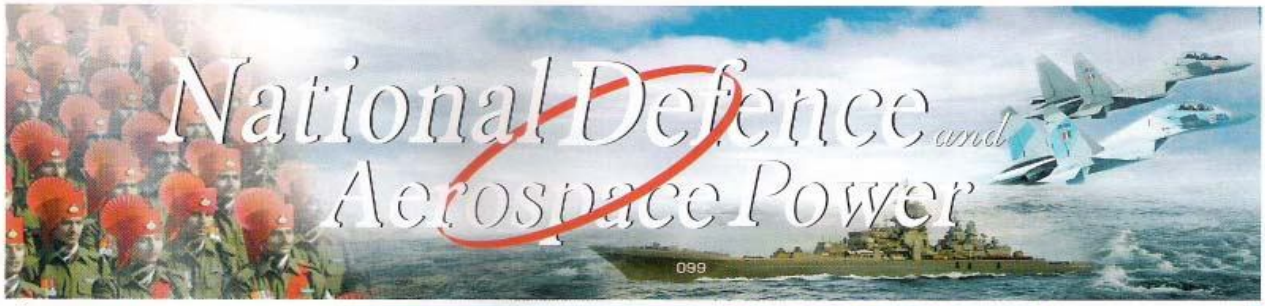

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DIRECTED ENERGY WEAPONS: SAFETY OF AIRBORNE PLATFORM

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On May 28, 2017 *The Sunday Guardian*[1] grabbed the spotlight when it came out with an article that the ill-fated Sukhoi-30 fighter of IAF that crashed close to China's border on May 23, 2017, was downed by cyber weapons. The article quoted expert opinions from New York and St Petersburg who had been warning about the possibilities of such attacks for some time. The commentary speculated, with certain degree of reasonability, that the crash of such an advanced aircraft - which is certified as safe - may be the result of "cyber-interference with the on-board computers" in the cockpit. They also added that possibilities exist that the damage may have been caused by a larger array of guided electromagnetic pulse originating from a few hundred metres to few thousand kilometres of the India-China border.

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Capabilities of Directed Energy Weapons in shooting down airborne objects have been a topic of debate ever since the Malaysian Airlines Jet MH370[2] went missing on March 08, 2014 while flying from Kuala Lumpur to Beijing.

Directed Energy Weapons use High Power Electromagnetic Pulse (EMP)[3] generation techniques and High Power Microwave technology. The EMP effect was first observed in 1962[4] after an above ground nuclear test in a Pacific island disabled electronic appliances in Hawaii. The effect was characterised by short (few nanoseconds), but intense electromagnetic pulse, propagating in all directions. EMP is similar to an Electro Magnetic Shockwave but strong enough to produce short duration transient voltages of few kilovolts on exposed long electrical conductors, printed circuit boards (PCB), programmable logic circuit (PLC), etc. damaging them permanently. This characteristic of the EMP is of military significance, as it can cause irreversible damage to electrical and electronic equipment, particularly computers, radio or radar receivers.

Commercial computer equipment is built with high density Metal Oxide Semiconductor (MOS) devices which are particularly vulnerable to EMP effect or exposure to high transient voltage. Further, MOS devices require very little energy to permanently disable or destroy them. Theoretically, high voltage EMP with frequency 300-3,00,000 MHz could shut down all electronic systems by overloading circuits. The higher the energy of pulse, greater the disruption (or physical damage) caused. As modern military platforms are densely packed with electronic equipment, a high energy

EMP device can substantially incapacitate their function or render them useless.

Demonstrated Capabilities of EMP: Russian Claims

In April 2014, Russians claimed that USS Donald Cook[5], an Arleigh Burke-class guided missile destroyer of the US Navy, while in the Black Sea, was substantially crippled by electronic interference, possibly sourced from a low-flying Sukhoi-24. Exactly a year later, (possibly) another Sukhoi disabled the USS Theodore Roosevelt (an aircraft carrier armed with multiple defensive and safety mechanisms) in the Baltic Sea. It is believed that Russia orchestrated the electronic warfare attacks using Magrav Technology.

Russia's electronic warfare measures are based on what is called "Magrav Technology" (Western codename "Khibiny"[6]) and developed by Iranian-born nuclear engineer Mehran Keshe. He boasted, "The aircraft carriers of the US will become nothing but floating bathtubs if Magrav technology is used effectively; these battleships would have to be rewired from A to Z before they can ever operate again."

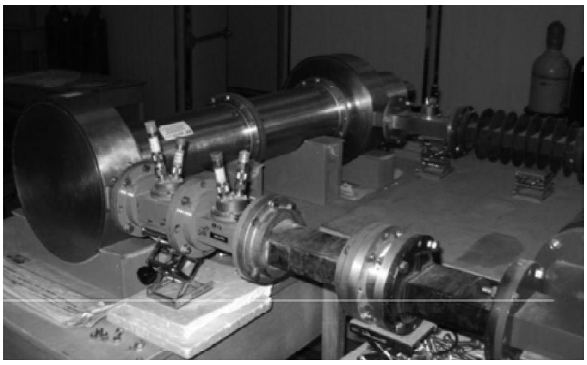
American Capability

To counter this, in October 2016, Boeing (USA) announced successful testing of an electromagnetic pulse missile with capabilities of disabling electronic systems without affecting structures. The Counter-electronics High-powered Advanced Missile Project (CHAMP)[7] was tested by Boeing Phantom Works at U.S. Air Force Research Laboratory. It fired high-power microwave bursts at a multi-storey building containing computer systems and devices. The drone-like weapon disabled workstations, terminals and electronics in the targeted building. The cameras recording the operation also got blanked.

CHAMP is basically an EMP cannon that destroys electronic equipment as it flies over the battlefield. The pulse overloads electronic equipment with massive surge of power, faster than circuit breakers or surge protectors can respond. The US Air Force describes it as an air-launched Directed Energy Weapon capable of emitting multi-shot, multi-target, high-power microwave (HPM) packages against Command and Control Centres. It destroys instead of jamming electronically sensitive electronic warfare equipment/ systems.

China's Position

Figure 1. Chinese EMP Weapon: Northwest Institute of Nuclear Technology, Xi'an



In China[8], for the last six years, Huang Wenhua and his team at the Northwest Institute of Nuclear Technology, Xi'an, have been working on a potent microwave weapon. It is reported that this weapon also won China's National Science and Technology Progress Award. It is believed to be small enough to fit on a lab work bench, (Figure 1) making it theoretically portable for mounting on trucks or aircraft. PLAAF plans to develop these electromagnetic pulse weapons for use against U.S. aircraft carriers in conflicts over Taiwan or the South China Sea.

India's Answer

The KALI[9] (Kilo Ampere Linear Injector) is a linear electron accelerator developed by Defence Research and Development Organization (DRDO) and Bhabha Atomic Research Centre (BARC). It is designed to work against airborne enemy missiles by emitting powerful pulses of Relativistic Electron Beams (REB) that, unlike laser beams, do not burn a hole in the target but damage the on-board electronic systems/ computer chips by firing bursts of microwaves packed with gigawatts[10] of power.

Directed Energy Weapon: Use of Microwaves

During the "International Military-Technical Forum" Army-2015 Expo held at Moscow in June 2015, Russia showcased (Figure 2) the world's first weapon to use microwave energy 'death-rays' against UAVs. The international event was organized by the Russian Defence Ministry, the

Federal Space Agency 'Roscosmos' and state technology corporation 'Rostec'. According to news agency sputniknews.com[11], the weapon is a super-high-frequency gun capable of neutralising airborne electronics in a ten kilometre range. The developer of the system, United Instrument Manufacturing Corporation (UIMC), Russia, claims that the equipment

Figure 2. Death Ray: Microwave Gun

deactivates the radio electronics of warheads of precision weapons, UAVs and aircraft. According to Igor Korotchenko, editor-in-chief of the National Defence journal, the system is capable of out-of-band suppression of radio electronic equipment of low-flying aircraft, UAVs and the forward looking guidance systems of precision weapons.

Can Aircraft be Shot down by EMP/ Directed Energy Weapons?

Theoretically, the answer to this question could be a 'yes'[12]. That is, if high energy electronic waves E1[13] are directed towards a modern commercial or fighter aircraft the on-board computers on it could misbehave. They could either reboot or over excite and shut down permanently, the consequences of which could be serious.

Technically, all airborne systems and instrumentation on aircraft that are not EMP hardened would be affected by electronic interference.

However, most electronic and communication equipment fitted on advanced commercial and fighter aircraft are designed to arrest Electromagnetic Interference (EMI) and regularly checked/ tested for Electromagnetic Compatibility (EMC). These checks ensure on-board equipment is protected against non-hostile EM environment. Measures like enclosing electronic controllers, LRU, PCB, computers in a Faraday's Cage and increasingly using fibre optics in place of metal cables prevent damages from EMP. American Federal Aviation Administration (FAA)[14], International Civil Aviation Organisation (ICAO) and European Air Safety Agency (EASA) mandate designing and regular testing of all airborne electronic components and systems to ensure that they do not fail when exposed to high radiations. The US government's 'Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP)'[15] had practically put an aircraft under test for EMP interference simulating DEW environment (Figure 3). Eminent writer Jerry Emanuelson in an article in Future Science magazine explains in great details the "EMP Myths"[16].

Figure 3. EMP Simulator HAGII-C testing a Boeing E-4 aircraft.

Reverting to the article published on 28 May 17, assuming that China has somehow mastered the EMP technology and was able to fire DEW across the border, directed precisely on the ill-fated Su-30, it is difficult to appreciate that the electronic interference went un-noticed by the second aircraft flying in its close proximity. Concurrently, locals of Army units stationed in the area, using electronic devices like radio, TV, mobile phones, etc. did not report disruption of service or interference in communication sets which are equally susceptible to EMP.

Therefore, in the present scenario and analysis of demonstrated technology or published literature on capabilities of Directed Energy Weapons it is most unlikely that a modern fighter can be shot down so silently from a weapon station in the Chinese territory as the electrical

power required to generate an Electromagnetic Pulse, strong enough to kill on-board computer of aircraft flying about 100Km away, would be a few thousand KW. Yield of Non-Nuclear Electromagnetic Pulse (NNEMP) sourced[17] weapon is much less than a conventional nuclear blast and can cover a few km at most. Therefore, the hypothesis of IAF Su-30 being downed by cyber (read DEW) weapon may be disregarded.

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Preventive Measure: EMP Shielding

Attenuation coefficient of a material is its property to arrest penetration of radiant energy (or matter) by absorbing or scattering it. Attenuation coefficient is an important consideration while designing components and electrical wirings for spacecraft and satellites. Objects in outer space are continuously bombarded with EMP waves of varying intensity and frequencies. Therefore, all the on-board electronics fitted on satellites are effectively shielded from radiation. India being one of the few countries to indigenously build and operate satellites, has mastered the EMP shielding technology.

In view of the clear and present threat from EMP weapons, aircraft need to be protected against damage due to hostile radiations. Technologies for EMP shielding developed for use on space craft and satellites also need to be adapted for use on military aircraft.

In view of the clear and present threat from EMP weapons, aircraft need to be protected against damage due to hostile radiations. Technologies for EMP shielding developed for use on space craft and satellites also need to be adapted for use on military aircraft. Procedures for testing airborne electronics for immunity also need to be developed. In light of the recent developments in the arena of DEWs, designing protective interference shields for critical equipment of military aircraft is a necessity. This requirement is not only formilitary aircraft but also for commercial airliners as they are equally vulnerable to DEW in a future EW battlefield.

Notes

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[10]1.0 GW= 10^9 Watts, Watt is the measure of "Rate of Transfer of Energy", One Watt is the rate at which work is done when One Ampere(A) of current flows through an electrical potential difference of One Volt(V). 1 W= 1 V.A

[11]Mihail Mokrushin, "Russia Develops 'Microwave Gun' Able to Deactivate Drones, Warheads", *Sputnik International*, Jun 15, 2015, https://sputniknews.com/

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[12]Jerry Emanuelson, "Notes about nuclear EMP", http://www.futurescience.com/emp/emp-notes.html, accessed May 31, 2017

[13]E1 pulse is gamma radiation and the fastest component of nuclear EMP. It is a brief but intense electromagnetic field that can quickly induce very high voltages in electrical conductors causing breakdown in computers and communications equipment.

[14]U.S. Department of Transportation Federal Aviation Administration, Advisory Circular, "Environmental Conditions and Test Procedures for Airborne Equipment" RTCA/DO-160F, June 2011, accessed on May 31, 2017

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Centre for Air Power Studies

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