Tech Brief:
EMP – The Nuclear Threat to Satellites

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Introduction

Thursday, February 15, 2024:

"Washington, DC was engulfed in a firestorm of controversy on Thursday, February 15th, when House Intelligence Committee Chair Mike Turner released a cryptic statement about the national security threat posed by the possibility of a Russian nuclear-powered space asset designed to target American satellites." -Washington Post

- The issues surrounding High Altitude EMP (HEMP) were discovered ~70 years ago in series of atmospheric tests conducted by the US and USSR
- The impacts and effects were sever enough to drive the US and USSR into two critical treaties:
  - 1963 Nuclear Test Ban Treaty
  - 1967 Outer Space Treaty – banning nuclear weapons in space

HARDTACK ORANGE
High Altitude Nuclear test
12 August 1958

Those Treaties have Been Sacrosanct Until This Year

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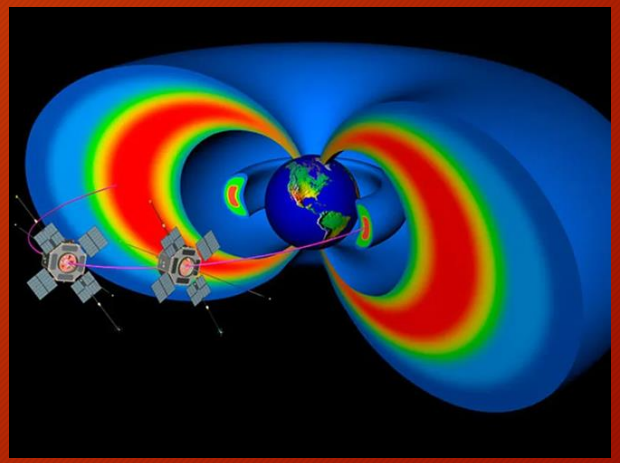
STARFISH PRIME – US High Altitude Nuclear Test

- STARFISH PRIME launched nuclear armed Thor missile from the Johnston Atoll pacific test center on July 9th, 1962.
- The Thor test missile followed a parabolic flight path detonated a 1.4 Mt weapon at 400 kilometers altitude – roughly the orbital height of the International Space Station (ISS)
- The results were unprecedented:
  - The rainbow-like explosion itself could be seen in Honolulu, HI, 1,400 km away.
  - Honolulu, Hawaii, power grid experienced unexpectedly overloaded and overheating lightning protection devices on powerlines.
  - The EMP damage to the microwave link between Kauai and the other Hawaiian islands shut down telephone service.
  - Three known U.S. satellites were immediately disabled by the blast's EMP and radiation

STARFISH PRIME
High Altitude Nuclear Test as seen from Honolulu, HI
9 July 1962

Impacts of STARFISH PRIME in LEO/MEO

- The explosion released an enormous number of high-energy electrons that became trapped in the magnetic fields of the inner Van Allen radiation belt
  - Satellites a Low and Middle Earth Orbit transit through these belts
- In 1968, 5 years later, residual high energy electrons remained in the radiation belts
- The effects on satellites parallel those of high energy solar flairs
  - Immediate destruction from direct radiation:
    - Telsat1 the worlds first television broadcast satellites was destroyed by STARFISH PRIME
  - Latent destruction from traversing man-made radiation belts
    - 6 additional satellites failed over time including the United Kingdom's first satellite, Ariel 1
- The Human Factor
  - Mercury astronaut Walter Schirra, flew a LEO space mission a few weeks later at ~400Km Altitude
  - Studies later showed that if his orbit had reached 640Km or higher he would have died of radiation exposure



Satellites Traverse the Van Allen Radiation belts of trapped electrons in the Earth's Magnetic Fields

USSR “K-Series” High Altitude Tests

- From 1960 to 1962 the USSR conducted “K-Series of atmospheric tests with detonations over what is now Kazakhstan
- USSR Test #184, "K-4" launched on 22 October 1962, detonated a 300Kt nuclear device at an altitude of 290 km
- “K-4” damage was extensive:
  - Widespread diesel generator due to dielectric breakdown in the generator windings
  - major damage 1000-kilometer underground power line running to the capital city of Kazakhstan
  - Fires and damage at several power plants
- Satellite damage to USSR and US damage remains classified

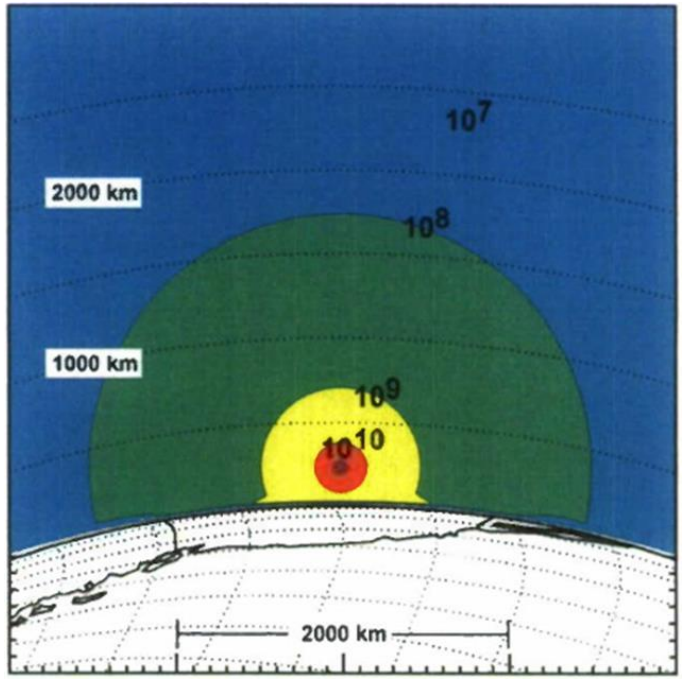
Soviet Nuclear Test #184 "K-4“ launched from Kapustin Yar detonated near Zhezqazghan, Kazakhstan

By 1962 Both USSR and US understood the dangers of HEMP
They quickly banned atmospheric testing and nuclear weapon in space

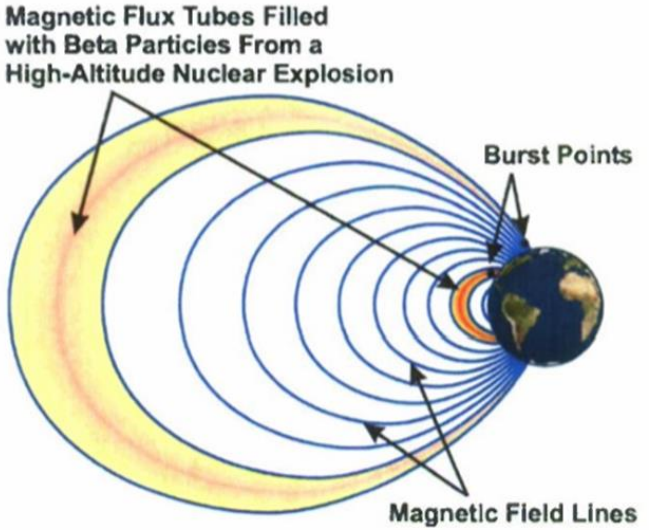
Nuclear Effects on Satellites –The Details

EMP Effects on Satellites

- Immediate Nuclear Blast effects from X-ray, Gamma (photon), and Beta(high energy electron radiation)
  - A 1MT device has an effect radius of nearly 2000 Km
  - Initial gamma ray induced EM Field – short circuits electronics and battery sub-system
  - Combined radiation degrades solar cells
- Long term exposure to “Pumped Radiation Belts”
  - Beta particles are captured in the earth magnetic fields
  - Satellites are destroyed by the cumulative damage of passing through these "pumped" belts as they orbit. (accelerated life failure)
  - Pumped belts can take years to decay



Delayed Gamma Radiation from a 1 Mt 200 Km altitude HEMP blast



"Pumped Belts" of captured beta particles from HEMP burst

Conclusion about Space Based EMP

- Here are some conclusions that can be drawn from the Nuclear Threat:
  - All satellites, regardless of orbit, are vulnerable to direct attack (nuclear or non-nuclear)
  - Ground control stations for satellites are subject to direct attack by EMP or any other means
  - An attack on MEO or GEO satellites by high-altitude nuclear detonations for the purpose of populating electron belts at those altitudes would require large-yield Nuclear weapons over 10 Mt (megaton) – that is an incredibly powerful weapon
  - Satellites in MEO or GEO are **not** at risk to immediate loss from radiation damage resulting from a credible EMP attack anywhere on Earth.
  - ALL satellites in LEO are at risk to serious damage from line-of-sight or enhanced radiation belt exposure resulting from EMP attacks over many geographical locations of the Earth.
    - **The effects would be indiscriminate - harming satellites of all nations in the affected area**
  - Stringent nuclear hardening criteria should be placed on LEO satellites and control systems that serve military and intelligence missions.

Ultimately, using a HEMP against LEO satellites is counterproductive because all satellites, allied or enemy, will pass through these belts, receiving increased doses of radiation accelerating satellite damage till failure.

The Alternate Threat: Direct Energy or EMP Satellite

Emerging Orbital Threats

- Evolving capabilities for satellite-on-satellite destructive or reversible threats
  - Reversable RF Jamming / Optical Dazzler
  - Destructive high power Laser / High-power microwaves (EMP)
  - Destructive chemical/paint spray – highly degrade solar cells – energy starvation
  - Mechanical Capture – tow out of orbit or capture and return ("Skyhook")
- Orbital anti-satellite can be effective against large expensive military satellite networks with small constellation
- Limitations of Orbital threats:
  - Economics: Launch and vehicle cost on pr with target Space Awareness allows defensive
  - Space Awareness allows for Defensive maneuvering as a countermeasure

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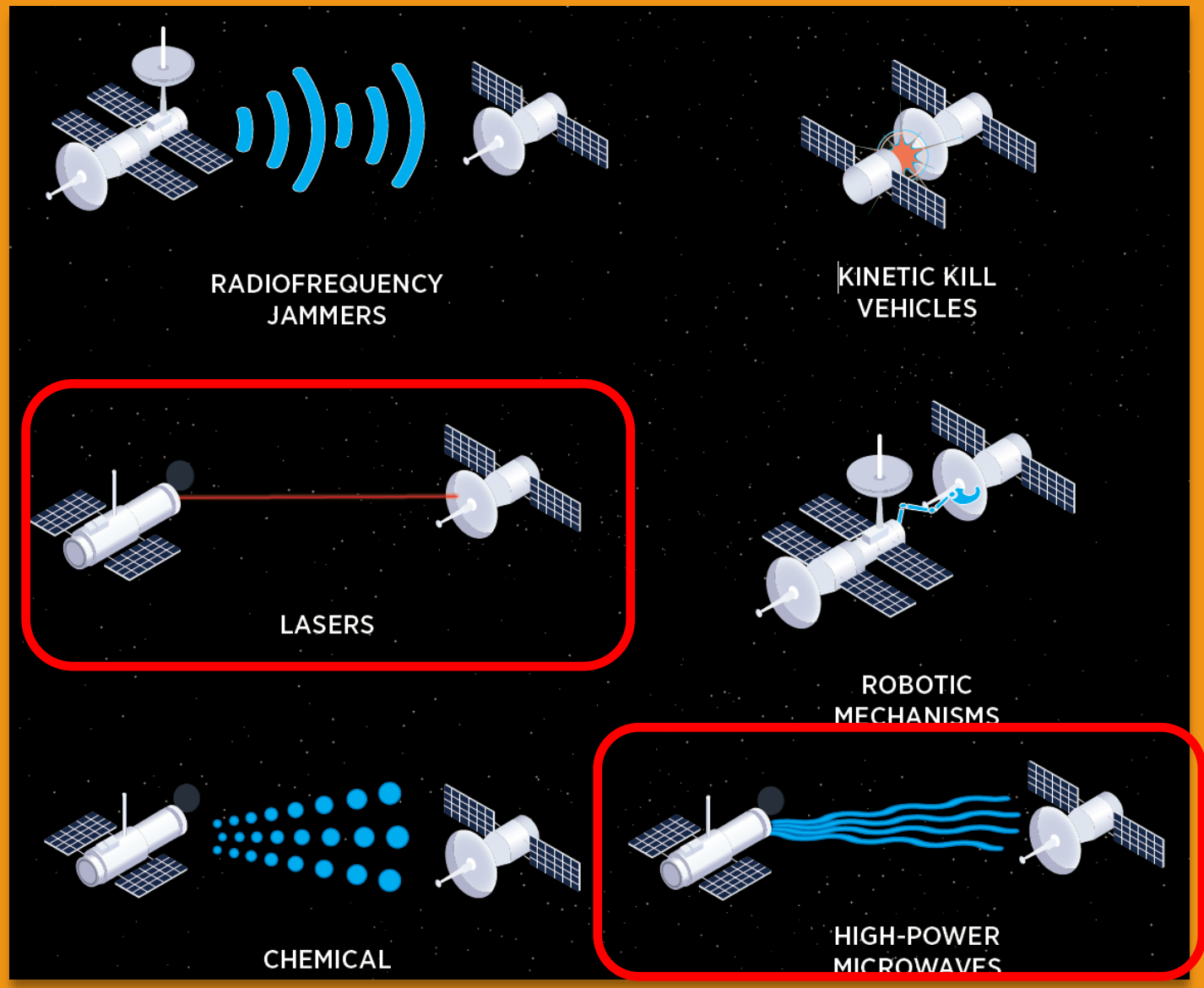
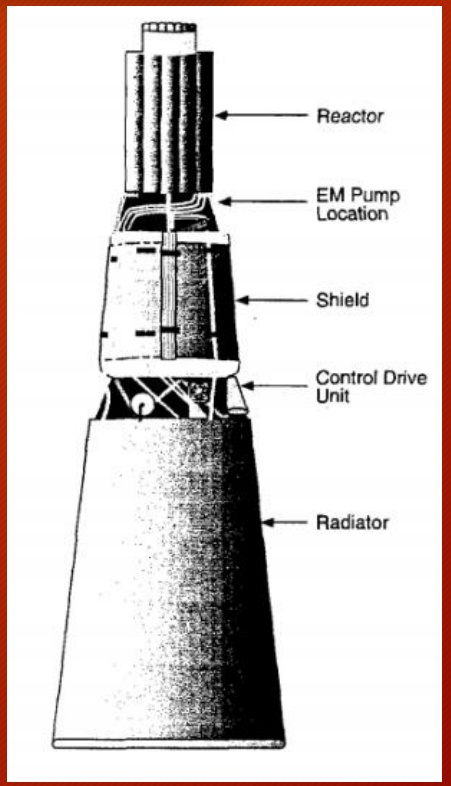


Defense Intelligence Agency – Orbital Threats

Is a High Energy Satellite Weapon possible?

- Russia has a long history of building Nuclear Thermionic Converter Reactors
  - TOPAZ II – 3-5 year in orbit operation at minimum 6kW output
  - Couple with a capacitor bank to accumulate power pulse
- Current generation EMP and Laser weapons capable of 100Kw direct energy with 200+ kW in test
- **YES** - a nuclear powered space based high energy weapon is possible
- Advantage
  - 5 year orbital life
  - nearly unlimited magazine (i.e. number of shots)



TOPAZ II –Spaced based Nuclear Thermionic Converter Reactor

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Deployment Scenarios: EMP and Energy Weapons (

- **"Brilliant Pebbles," a constellation of non-nuclear EMP (NNEMP) bomb devices**
  - Allows for precise targeting
  - Significant launch and satellite device costs due to the 100s, if not 1000s, of devices needed to mount a credible threat
  - No stealth or secrecy due to the number of weapons involved
- **FOB - Fractional Orbital Bomb**
  - Revive the 1960s-era FOB to disguise a nuclear EMP strike as a LEO polar orbit satellite launch.
  - Essentially HEMP and Will have both ground and space based EMP effects
- **One or a small constellation of nuclear weapons in Earth orbit (HEMP from orbit)**
  - Weapons positioning could be by stealth (undeclared disguised platform) or out in the open (declared-intentional)
  - A major violation of 1967 Outer Space Treaty
- One or a small constellation of High Power Laser/Microwave Energy Weapon Satellites
  - Nearly as effective as nuclear HEMP without indiscrete collateral damage or long-term radiation "belt pumping." That causes long-term satellite failure.
  - Is this a breach of the 1967 Outer Space Treaty? Possibly. It is a gray area.

Thank You

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Pending Book release:
How the Hell Did We Get Here?
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