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Presentation on Electromagnetic Pulse

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High Altitude Electromagnetic Pulse, often referred to as Electromagnetic Pulse (EMP) has always had a slightly spooky feel to it. It has never had a good name amongst certain sections of the nuclear disarmament NGO community, having been poo-pooed by some prominent individuals. I shall try to argue that this ought to change. It is bedevilled by spooky and counterintuitive physics, incomprehensible math, and equally counterintuitive and incomprehensible politics. One might argue that the politics is even less understandable than the physics.

EMP is one way that high-tech societies might be completely paralysed by a very few nuclear weapons. It has to be taken very seriously. That does not necessarily mean however, that the best response to it is either to bomb or threaten to bomb, someone else, or indeed that so-called 'deterrence' has any role whatsoever to play.

I personally am convinced, while endeavoring to maintain an open mind, that EMP is very real, and has the potential to destroy hyperconnected wired societies. To crib from John Lewallen's fact sheet,

"...The fact that today a few nuclear bombs detonated in space could wipe out the global nervous system of electronic civilisation is a fundamental reality of modern life that everyone deserves to understand. Like a virus that threatens the whole human race, dealing with nuclear EMP requires all of us to work for international peace to avoid nuclear war"

While the radiation and the city- busting aspects of more conventional uses of nuclear weapons, together with nuclear winter after-effects as well as the real possibility of nuclear war by accident have, - (partly as a result of this authors and Steve here's efforts over a number of years), rightly received, and now continue to receive, ample attention in UN forums here as well as in Vienna and Geneva, EMP has thus far not even been mentioned in UN nuclear disarmament contexts.

The potentially strategically destabilising nuclear strategic aspects of EMP, and especially of 'super- EMP' weapons (if such turn out to be physically possible), destroy the very basis of deterrence, namely the assurance or reasonable possibility of, of retaliation, but have not been explored. The implications of something that fries electronics for hyper-wired, hyper-hi-tech societies (not just the US) – the possibility of completely paralysing them – which Maj. David Stuckenberg calls the 'Nation-Killing' aspects of EMP remain unspoken of. Our gathering here in this 'obscure' UN sub-basement (where so many important things have begun) is the first time EMP has been spoken of in this environment.

The kind of contempt that EMP as an issue has been held in is illustrated by a recent Washington Post article that ran in response to a Trump Presidential Executive Order on EMP. The Presidential Order (presumably drafted by someone other than the President himself, as it is literate and more than a page or so long, and reasonably detailed), seems to anyone who thinks that making societies more resilient to electronic catastrophe (from EMP or from Geomagnetic Storms) -to be an eminently sensible idea, where-ever, and who-ever, it came from.

The Trump EMP Executive Order (which reads very much as if it is written by someone who actually does know something about EMP), starts by saying:

“...An electromagnetic pulse (EMP) has the potential to disrupt, degrade, and damage technology and critical infrastructure systems. Human-made or naturally occurring EMPs can affect large geographic areas, disrupting elements critical to the Nation’s security and economic prosperity, and could adversely affect global commerce and stability.

The Federal Government must foster sustainable, efficient, and cost-effective approaches to improving the Nation’s resilience to the effects of EMPs.”

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Quite so.

The Trump Executive Order has a broad, all-encompassing definition of EMP (as opposed to some much narrower ones by some EMP experts, who recognize only HEMP as EMP, excluding GMD's/CME's as well as smaller EMP devices):

“...Electromagnetic pulse” is a burst of electromagnetic energy. EMPs have the potential to negatively affect technology systems on Earth and in space.

A high-altitude EMP (HEMP) is a type of human-made EMP that occurs when a nuclear device is detonated at approximately 40 kilometers or more above the surface of Earth.

A geomagnetic disturbance (GMD) is a type of natural EMP driven by a temporary disturbance of Earth's magnetic field resulting from interactions with solar eruptions.

Both HEMPs and GMDs can affect large geographic areas.”

And it suggests policy options that are on the whole sensible, if a little underwhelming and a little 'motherhood':

“...Policy. (a) It is the policy of the United States to prepare for the effects of EMPs through targeted approaches that coordinate whole-of-government activities and encourage private-sector engagement. The Federal Government must provide warning of an impending EMP; protect against, respond to, and recover from the effects of an EMP through public and private engagement, planning, and investment; and prevent adversarial events through deterrence, defence, and nuclear nonproliferation efforts.

To achieve these goals, the Federal Government shall engage in risk-informed planning, prioritise research and development (R&D) to address the needs of critical infrastructure stakeholders, and, for adversarial threats, consult Intelligence Community assessments.”

The Washington Post on the other hand is quite dismissive:

“Fortunately, there’s little cause for concern about an EMP attack in isolation, because a nuclear EMP attack would be just that: a nuclear attack. Such brazen aggression would prompt an overwhelming — and [most likely nuclear](#) — American response. Such [deterrence](#) makes it unlikely a nuclear EMP attack would happen in the first place.”

This assumes both that the attack is attributable at all, and assumes that it cannot paralyse US retaliatory capacity.(and thus make nonsense of ‘deterrence’.) Yet the very most destabilising aspect of EMP is precisely the possibility that putative ‘Super-EMP’ might do just exactly that.(ie, paralyze the ability to retaliate) In any case, who knows what calculations might be made by, say, a Kim Jong Un who believes he is likely to die in the next 24-48 hours anyway? We will return to this theme later.

That the disparagement of EMP, and even dismissal of its reality is not new, is attested to by an EMP - theory pioneer, Conrad Longmire, who in an introduction to an otherwise highly mathematical justification of EMP physics theory, notes that:

“Over the 22 years since the first publication of the theory of High Altitude Electromagnetic Pulse, (HEMP), there have been several doubters of the correctness of that theory. One one occasion it was briefly claimed that the HEMP is a much larger pulse than our theory indicates, and is a longitudinal wave rather than transverse....more commonly it has been claimed that the HEMP is a much smaller pulse than our theory indicates...and it has been implied though not directly stated in writing that the HEMP has been exaggerated by those who work on it in order to perpetuate their own employment. It could be noted that in some quarters, the disparagement of HEMP has itself become an occupation. While we have found that no amount of technical reasoning suffices to quiet such criticism, we have learned to live with it, and even to regard it as having possibly some beneficial effects, for example in bringing the question of the HEMP threat to electrical and electronic systems to the attention of a wider circle of individuals who have responsibility for those systems.” (Longmire, June 1986)

An (EPRI funded) study by Mario Rabinowitz (EPRI has made a habit of dismissing or minimising

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EMP effects) concludes that:

“...This paper concludes that EMP is no more harmful to the power grid than its counterparts in nature. An upper limit of the electric field of the very fast, high-amplitude EMP is derived from first principles. The resulting values are significantly lower than the commonly presented values. Additional calculations show that the ionisation produced by a nuclear burst severely attenuates the EMP.”

Rabinowitz’s work in 1987 has been critiqued in detail by Longmire, Vance, Baum, Tesche and Radasky amongst others. The mathematics of the critique are beyond me.

Rabinowitz also tries to argue that the effects on Hawaii streetlights observed during the 1962 Starfish Prime test either were nonexistent or didn't amount to much. This too has been critiqued in detail. The technical discussion is wearying and often incomprehensible to laypersons such as myself, but there doesn't seem to be too much doubt that Starfish Prime DID affect (some) Hawaii streetlights, and that its effects either on the mainland USA or on present-day systems would have been much more damaging than on the primitive but robust and simple electrical and electronic systems of 1962.

I confess I am puzzled and troubled by the dismissal of EMP by those who in other respects are relatively enlightened, and who (rightly) take the threat of nuclear winter (or for that matter global warming) seriously.

While EMP's physics is often mysterious and counterintuitive, the real mystery is 'why is this discussion even taking place'?

Yet for some reason EMP has always been puzzlingly 'politically incorrect' on the disarmament side of politics. Some prominent disarmament activists have from time to time portrayed EMP activists as paranoid rightwing conspiracy theorists wearing 'tin hats' (God knows why). Its worth noting that nuclear winter took time to be taken as seriously as it now is. EMP has been known about at least in theory since 1945, and more concretely since the 1962 Starfish Prime and Soviet high altitude tests. There is no serious doubt that it is real. There is some room for dispute over just how powerful it may be, depending on a large number of variables.

Behind this doubt from some nuclear expert circles, are some deeper, more troubling, reasons that EMP advocates haven't done themselves any favors, outside conservative US circles. Other than within the US, EMP gets (almost) zero attention. (Not quite zero – a UK Parliamentary committee held hearings on it and produced a report that is worth reading, Lloyds of London has done a worthy report on the impact of CME's/GMDs on power systems globally, and there is an EU study on it, based on a simulation of the response of the

Finnish grid to a coronal mass ejection that minimises its seriousness.)

The 2017 EMP Commission was in no doubt about the seriousness of EMP. In its Executive Summary it notes that:

“...The critical national infrastructure in the United States faces a present and continuing existential threat from combined-arms warfare, including cyber and manmade electromagnetic pulse (EMP) attack, as well as from natural EMP from a solar superstorm. **During the Cold War, the U.S. was primarily concerned about an EMP attack generated by a high-altitude nuclear weapon as a tactic by which the Soviet Union could suppress the U.S. national command authority and the ability to respond to a nuclear attack—and thus negate the deterrence value of assured nuclear retaliation**

. Within the last decade, newly-armed adversaries, including North Korea, have been developing the ability and threatening to carry out an EMP attack against the United States. Such an attack would give countries that have only a small number of nuclear weapons the ability to cause widespread, long-lasting damage to critical national infrastructures, to the United States itself as a viable country, and to the survival of a majority of its population.”

The GAO notes that:

“Given the interdependency among infrastructure sectors, an EMP or major GMD event that disrupts the electric grid could also result in potential cascading impacts on fuel distribution, transportation systems, food and water supplies, and communications and equipment for emergency services as well as other communication systems that utilise the civilian electrical infrastructure.”

While according to Obama science advisor Dr John Holdren:

“Solar storms or a large EMP event impact could be big - on the order of \$2 trillion during the first year in the United States alone, with a recovery period of 4-10 years”

EMP has also suffered from the fact that many of its details are in fact classified. A Metatech report notes that:

“...Including all details, even simple ones, was done because, especially with the Internet, there is much erroneous EMP information available. Much of the best E1 HEMP material is not readily available, and much of what is easily available has inaccuracies. This is especially true for some of the E1 HEMP information on the Internet. For example, burst “yield” is often considered as the measure of a nuclear device, and correctly so for the blast and shock produced by a surface burst. For E1 HEMP the burst yield has much less significance. Maximum E1 HEMP levels on the ground do not correlate well with device yield.

E1 HEMP work has often been done within the classified environment. Two important reasons for this security are:

1. HEMP generation is intimately connected to significant design details of a nuclear weapon.

2. The work might directly, or indirectly, involve the vulnerability levels of U.S. military systems, and we do not want our enemies to know the HEMP levels to which our security forces are hardened.

E1 HEMP development is reflected in numerous government supported technical reports, and many are classified. However there is also much material in open literature, which is applied in this report.”

The same Metatech report notes problems in the way EMP is perceived, in a wider sense:

“...The U.S. military has taken E1 HEMP very seriously for a long time, including hardening and testing efforts. On the civilian side, the problems have not really been addressed. There has been a wide range in the perception of E1 HEMP as a threat. There are skeptics – those that think E1 HEMP does not exist, or that the models are wrong, or the field levels are not as bad as calculated. There are also those who believe we cannot do anything about it – if it happens we will just have to deal with it then. Then there are others that think every electronic device in the country will fail, and we will go back to the Stone Age. There are many such exaggerated scenarios; for example, it is doubtful that more than a very small fraction of vehicles will suddenly stop working – but how long will they be able to run with gasoline supply disruptions from possible electric power grid problems? And much of the open discussions of nuclear burst EM effects deal with E1 HEMP, as it has very large peak fields, and has often been what is meant by the term “HEMP”. However, there are also other parts to HEMP, and E3 HEMP effects could be just as disastrous to the power grid, or even more so in some cases, than E1 HEMP.”

Calls for attention to EMP as an issue have unfortunately often been linked to calls to 'confront' rather than to repair relations with, the DPRK, China, Russia, and Iran.

EMP does often look as if it has been lifted out of a box of horrors precisely in order to beat Iran, the DPRK, Russia, and China over the head with. This is exactly the opposite to what really

needs to be done with relations with those governments, and absolutely not the solution to EMP

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vulnerabilities.

Pry, while he gives excellent and welcome details on just how EMP is perceived in Russia, China, and the DPRK, comes close to the 'bomb someone yesterday' school unless I have misunderstood him. Yet his grasp of exactly how EMP is thought of by governments around the world is second to none. Nonetheless, the EMP vulnerability of Hyper-wired societies is NOT something that was created by China, Russia, or the DPRK – it is a function of market-only solutions adopted by those hyper-wired societies themselves. The fixes simply do not lie with the DPRK, Russia, or China. Furthermore hyper-wired societies (not just the USA) are acutely vulnerable to dysfunction in ways that have absolutely nothing to do with external 'actors'. However, that China, the DPRK, and Russia are all thinking in terms of exploiting EMP vulnerabilities 'asymmetrically' is hardly surprising.

Regarding Iran, EMP has been linked in ways that frankly make no sense at all. Hostility to Iran will, if there was not a problem to begin with, will certainly create one. (and not merely in terms of EMP vulnerability) The evidence has been, that Iran currently does **not** pursue nuclear weapons, let alone an EMP capability. However, there is a faction within Iran that might like to do so. Hostility and confrontation of the sort that is looming now, will empower that faction. That Iran's military may be interested in means to pursue 'asymmetric' warfare with the US is hardly surprising. However Iran is **not**

currently an EMP threat (or a nuclear threat at all) and should not be made into one, which is all hostility will achieve.

The same is broadly true for the much more real HEMP/EMP and nuclear threats from the DPRK, Russia and China. The preferred solution to a threat seems to be to issue a counter threat – and thereby make the initial threat, (whether real, unreal, or half – real), much worse. These attitudes, applied either to HEMP or to anything else, rightly send both non-US Governments and NGOs running for shelter in the opposite direction. That some NGOs ‘solve’ the HEMP/EMP problem for themselves by dismissing it as a rightwing plot is a natural, but misguided and deluded, response.

That said, the bulk of the measures in the recent Trump executive order on HEMP/EMP do seem to primarily cover measures to make the US grid less vulnerable both to HEMP/EMP and to the results of a solar coronal mass ejection, and to facilitate recovery from an HEMP/EMP event. They do **not** look like measures to achieve regime change in Iran or the DPRK. As such they deserve support.

The DPRK openly claims to have an HEMP capacity. North Korean state news, KCNA, displayed photos of an alleged thermonuclear weapon and claimed on September 3, 2017:

“The H-bomb, the explosive power of which is adjustable from tens of kilotons to hundreds of kilotons, is a multi-functional thermonuclear nuke [sic] with great destructive power which can be detonated even at high altitudes for super- powerful EMP (electromagnetic pulse) attack according to strategic goals.”

Does this then constitute a claim not merely to have EMP, but to have 'Super-EMP' or at least to have a warhead optimised for EMP production?

If we assume that at least the DPRK, China and Russia DO have EMP capabilities, and that if cornered they might think in terms of an EMP strike against the US – (and it would be surprising if they had NOT thought about EMP given the strategic realities of the situation and the 'asymmetric' aspects of EMP) – the policy prescriptions for dealing with this do NOT consist of sending relationships with any of them further down the tubes than they already are! Such policy prescriptions are like seeing a fire and trying to put it out with a mixture of gasoline and nitro. The correct policy prescriptions are the same indeed with, or without, EMP – what is required is a positive transformation in relationships between the US and its rivals. This is not 'pie in the sky' nor in any way 'idealistic'. It is simply the only thing that has a hope of working. In each and every case furthermore, transformation in the nature of the relationship, and trust – building, must come BEFORE anyone will let go of nuclear arsenals – including ones that have EMP- optimised warheads. The potentially catastrophic impacts of EMP on a vulnerable hi-tech society, and the potentially destabilising impacts of putative 'Super-EMP' weapons on strategic stability merely

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add urgency to that situation.

In addition, such policy prescriptions pay no attention to China's declared 'No First Use' policy. While there is clearly debate about that within China's military establishment, and it's impossible to guess what might take place in the pressure of an intense crisis, we do not do well to disregard, or to contemptuously dismiss, the declared nuclear use policy of a nuclear weapons state. (In fact we may be strengthening the position of factions who advocate policies we would see as much less desirable.) Indeed we would do well to note that the actual posture of Chinese nuclear weapons is exactly what we should expect of a state that does not intend to use its nuclear weapons first. A policy of NFU of course, makes the use of EMP all but impossible: The whole point of hitting the US with an EMP weapon would be to do it FIRST. So a policy of NFU taken seriously, may put question marks over the credibility of EMP employment by China. (Conversely, if China were optimized to perform an EMP strike that might place question-marks over their NFU policy.)

The Russian military in a number of publications, accuse the US itself of developing 'Super-EMP'. Pry suggests that Russia is 'projecting', accusing the US of doing what it is actually doing itself. This may or may not be the case. If 'super-MP' weapons are physically possible, it would be surprising if both Russia and the US did not have them. And Russia is not the only Government that indulges in 'projecting'.

Thus, quoted in Pry:

"From the early 1980s, U.S. military scientists...aimed at creating...a super- EMP [weapon] with intensified electromagnetic radiation output...They figure to use it to increase the intensity of the field at the Earth's surface to several hundred kilovolts per meter. In their calculations, the explosion of a 10 MT warhead at an altitude of 300-400 km above the geographic centre of the United States (state of Nebraska) can lead to the disruption of the operation of electronic equipment on almost the country's entire territory for the time necessary to disrupt retaliatory measures."⁴⁶ (General V. Belous, Military Thought, 1991)

Again, from General Vinogradov, quoted in Pry:

"There is information that the U.S. Department of Energy assigned research of a so-called radio-frequency weapon for Air Force ICBMs based on an order of the Air Force Space Command and the Strategic Command. With detonation at an altitude of 50-100 km, the main casualty and damage producing element of this munition is a **selectively enhanced electromagnetic pulse with high field intensity that knocks out any electronic equipment in a sector with a diameter of around 1,000 km**

. Insofar as is known, the beginning of experimental development work was postponed, but the intention to develop a weapon for a first blinding strike speaks for itself....[The international community should] determine measures for preventing modernisation not only of delivery vehicles, but also of munitions as a counterforce means of delivering a first disarming strike (a means...manifesting readiness for aggression);

for example, a ban on creating penetrators, super-EMP..."

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(General Mikhail Vinogradov, Yadernyy Kontrol, 4 April 2000)

Pry uses these quotes, please note, to 'prove' that Russia is in fact merely accusing the US of doing exactly what it (Russia) is itself doing.(note the backhanded logic). Of course, while projection may be going on, projection is not something confined to Russia. And the fact that Russia points to EMP research in the US, while it may or may not indicate EMP work in Russia, may also indicate exactly what it seems to indicate: namely EMP work and capabilities

in the US.

China also accuses the US of developing EMP weapons:

"...the U.S. continues to actively develop third generation nuclear weapons such as

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electromagnetic pulse bombs....On the one hand, the U.S. declares its abandonment of 'winning a nuclear war,' while on the other hand it desperately strives for a clearly-directed nuclear dominance."52 Zhao Xudong, Hsien-Tai Chun-Shih, 11 March 1998)

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A series of questions (and answers) can be made on EMP.

--Is EMP real at all?

(...and why are we even asking this question?)

I for one need no convincing that it is real. However, even some close colleagues and media (note the Wash Post article just now), often people who are otherwise reliable and well informed on nuclear matters, seem to think concern over the possibility of EMP is the result of hype, some awful movies, rightwing conspiracy theorists, and crazed and ammunition-obsessed survivalists.

EMP was theorised about even as the very first nuclear bombs were exploded (when it was called 'radio-flash'), and has been talked about more systematically since the 1950s. The first solid evidence for EMP was in the Starfish Prime tests 1400km from Hawaii in 1962, and from three Russian tests in Kazakhstan the same year. The Starfish Prime tests managed to knock out streetlights and set off burglar alarms 1000Km away in Hawaii, while the Russian tests which were shot over land in Kazakhstan were more spectacular, shorting out insulators in high tension lines and damaging analog long - haul telephone repeaters. Both tests took place with devices that were not designed to produce much of an EMP pulse, (there is some dispute over just exactly how ill-adapted to EMP production these devices were, but its clear that EMP production was never a design aim), and with equipment much less susceptible to electronic interference than todays microelectronics. While some have even doubted whether the Starfish Prime test did in fact cause the shutdown of Hawaii streetlights, a number of detailed technical studies leave little serious doubt that indeed it did. More recent studies suggest that Starfish Prime, had it taken place over the continental US or Europe would have produced much more dramatic and possibly catastrophic effects.

--Assuming EMP exists at all, just how serious is it really?

The EPRI (Electric Power Research Institute) in particular, has produced a series of studies (often using artificially low values for the EMP pulse and simulations that would make events that have already taken place, such as the March 1989 Quebec Hydro shutdown, impossible) – whose bottom line is invariably that EMP may not amount to much and that electrical utilities do not have to do all that much if anything at all about it. (Or if they do, a few more leisurely studies will be enough). Interestingly, in a recent series of workshops, held between EPRI and utilities, participants seemed to take EMP much more seriously. However the approach is still 'more studies, and then more studies'.

--What is the relationship between a potential (nuclear) EMP threat, and a potential threat to electric grids from geomagnetic storms/CME's/GMD's (Coronal Mass Ejections)?

A prominent expert in both EMP and coronal mass ejections says:

“The E3 HEMP is much larger (in induced peak fields) than the GMD waveforms (even the Carrington “level”), but they have a slightly shorter time waveform and a smaller area of impact than a big geomagnetic storm (the charged particles from the E3 HEMP comes from a single point in space, while a big geomagnetic storm will move around the Earth over hours due to the fact that particles can arrive at Earth over an extended time and the Earth is rotating), but the peak E3 electric field that can be generated is much larger (up to 40 times bigger than the fields produced in the Quebec storm).”

There is in fact a massive literature on the threat posed by solar mass ejections to the US (and other nations) grids, and it can be said that those who minimize the threat from nuclear EMP also tend to minimize the threat from CME's. EPRI has sponsored a cottage industry of studies minimizing, often in the very same study, the seriousness of both EMP and of CME's. While the signals from a nuclear-weapon-created HEMP are more powerful but less long-lasting than those from a CME, and while the CME lacks the E1 and E2 components, the fixes for both overlap to a

high degree.

Consideration of geomagnetic threats to electric grids doesn't formally come under the ambit of the NPT, though it has ample implications for nuclear- weapon -related EMP which does. The threat to electric grids from CMEs such as took place in 1859 with the Carrington Event, the 1921 'railway storm' event, (which drastically affected both telegraphs and railway signaling) or the March 1989 collapse of the Quebec Hydro grid, certainly has lessons for the protection of grids at least from the E-3 EMP/HEMP component, though not obviously for protection from the E-1 EMP/HEMP component. In general however, the amplitude of the HEMP E3 component will be much greater than that of a solar mass ejection/GMD, while its duration is much shorter. A solar mass ejection/CME has no E1 or E2 components.

In addition, study of these and other aspects of EMP (such as the potential for cascading systemic failures) starts to lead to deeper questions about the deeper resilience/fragility of hyper-hi-tech, hyper-wired, societies, questions that have weight with or without EMP, with or without nuclear weapons, and that are deeply unsettling in and of themselves. How many things have to go wrong to make a hyper-wired society cease to function? (What if, for example, for reasons that have absolutely nothing to do with either EMP or solar storms or nuclear weapons, the internet simply ceases to function?) (It turns out that much of the electric grids functioning now is internet-dependent when formerly it was autonomous. And the Internet in turn depends on the grid.)

--If EMP is even potentially real, if EMP does, even potentially, pose a threat to wired societies, is then, so – called 'Super-EMP' real? Is it even a technological possibility or just sci-fi? Do 'saturation effects' make super EMP impossible? (As Rabinowitz seemingly argues)

'Super-EMP' weapons are referred to without detailed definition from time to time, and there are some question-marks over this in my own mind even now. Indeed, its not precisely clear just what a 'Super-EMP' weapon even is, (or how it might differ from a plain vanilla 'EMP weapon',

except that its supposed to be able to disable even militarily- hardened systems. But note the EMP commission statement that the prime purpose of EMP/HEMP weapons (i.e. nuclear weapons optimized for EMP production) during the cold war was always to disable an opponents nuclear command and control. In that

sense if we define a 'Super-EMP' weapon as one designed to disable hardened military systems, they are hardly new.

One can make a guess that a weapon that had roughly the power of the Starfish Prime warhead in producing EMP would be an 'EMP weapon', but not a 'Super - EMP' weapon, though as pointed out, that warhead wasn't designed to maximize EMP production. It is arguable by some that its design actually minimized EMP production by the thickness of its casing and the double flash that a classic thermonuclear weapons produces, which is less than optimal for EMP production.

The DPRK and Russia HAVE made explicit claims to actually HAVE super-EMP weapons, (i.e able to disable hardened military systems) and these claims should be taken seriously.

Russia also believes -as we have seen- the US has 'super-EMP' weapons:

"From the early 1980s, U.S. military scientists...aimed at creating...a super- EMP [weapon] with intensified electromagnetic radiation output...They figure to use it to increase the intensity of the field at the Earth's surface to several hundred kilovolts per meter. In their calculations, the explosion of a 10 MT warhead at an altitude of 300-400 km above the geographic centre of the United States (state of Nebraska) can lead to the disruption of the operation of electronic equipment on almost the country's entire territory for the time necessary to disrupt retaliatory measures."⁴⁶ (General V. Belous, Military Thought, 1991)

However....the physics of EMP pulse creation in the upper atmosphere is mindbogglingly complex, and I've seen accounts that seem to suggest there may be an upper limit to the power of the pulse that can be created, due to the creation of a 'return current' in the magnetosphere, and to 'saturation' effects. (Rabinowitz argues this, also.) However, there is no guarantee that even this is correct, and the ability of the return current to diminish the EMP current also depends on complex issues of pulse timing that are highly mathematical and difficult even to comprehend, let

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alone to determine.

...And there are yet more fiendish complexities. It seems that a DOUBLE pulse of gamma rays, such as is created by a standard two-stage thermonuclear warhead, (like Starfish Prime or the warheads used in the Kazakhstan tests) is just about the worst way to create EMP, as the initial

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pulse (from the fission primer) pre-ionizes the air in a way that decreases the power of the subsequent pulse.(via the hard to comprehend 'return current', and 'saturation effects'). What is required is plenty of gammas for sure, but they must be in a single narrow coherent pulse. Two pulses nanoseconds apart seem to work against each other.

ALL the larger tests in which EMP has been an issue – Starfish Prime, other US tests in space, AND the 1962 Russian tests in Kazakhstan – have been with weapons that (as previously noted) were the very opposite of EMP – optimized. Yet even these weapons produced levels of EMP that would be problematic for the hyper-wired societies of today.

These bombs had thick metal casings that limited gamma emissions, large chemical explosives surrounding the fissile core, AND a double-pulse. A weapon optimized for EMP presumably would have no massive metal casing and as thin a layer of explosive as possible, and would be a single-stage weapon (Maybe fusion-boosted), or would in some way suppress the gamma emission from a fission primary. (In order to avoid a double pulse). What is optimal for EMP production seems to be a very fast, single, pulse of gamma rays.

Once more, some experts seem to think this may not matter that much. Others say it is crucial. According to one prominent expert (who didn't want to be named):

“It is possible in the future to reduce the effects of pre-ionisation, but again the field levels from “normal” devices are enough to create problems. The placement of the burst (altitude for a particular yield) is a more important aspect”

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According to this expert, other ways to enhance the EMP production from a high-altitude burst exist and minimizing pre-ionization is of lesser importance.

I assume there are answers to this somewhere, and I would guess that for good reasons they might be classified. As I don't wish to build a device myself or help anyone else do so I'll go no further.

So let's assume for the sake of the argument, that 'Super – EMP' devices CAN be built, or at least that devices can be built that would create a much larger EMP pulse than Starfish or Kazakhstan in 1962 produced. Devices that could seriously impact electronics across a large continent, or impact military C3I.

Let's assume for the sake of argument (and in order to be cautious), that the DPRK, China, and Russia have them. This doesn't prove that they do.

(I think I would also assume that (if they exist) the US has them, and would treat denials with skepticism. If super EMP is possible at all the technology would seem to be modest. I would hazard a guess that such devices have quietly been in existence for many decades, maybe categorized as neutron bombs)

According to Pry, as far back as 1999, Russia made threats against the US to use an EMP bomb against it. The DPRK as we have seen, has made vague and unspecific statements to the effect that it has a Super-EMP weapon.

Russia, China, and the DPRK have all made claims also that their weapon **may be able to disable hardened, military C3I systems**

. Anything powerful enough to disable military systems would seem able to disable most civil systems including relatively robust ones.

Its been taken more or less for granted since the 1960s that any nuclear attack would start with a high altitude or space explosion that would incapacitate command and control. This has even

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figured in the films The Day After and Threads, both from 1983. So it's not exactly new.

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...Since 1990, much less attention has been paid to EMP hardening, at least in the US. Many military communications are, it seems, now routed through Non-EMP hardened commercial carriers.

What then, could be the implications of the use of 'super' EMP?

Lets do a bit of scenario building.

Assume you are Kim Jong Un.

Assume you do in fact have at your disposal somewhere between 2 and 5 'Super-EMP' weapons, which you could deliver to a point vaguely over the geometric middle of the US.

Assume that Donald no longer tweets 'we fell in love' but instead 'Kim's not gonna be around

much longer'.

Assume you are reasonably sure that US Missile Defense would have no more than a 30% probability of intercepting one of your missiles.(a reasonable, indeed a pessimistic, assumption)

Assume you think you might not survive the next 48 hours unless you do something radical. A monster US navy task force (maybe backed up by UK, Japanese and Australian units) is heading your way.

But your generals are telling you that you still have a small chance – you might be able to send the US back to the 18th century in a nanosecond, and paralyze its military – including (maybe) making it impossible even to send an order to destroy you. **It might or**

might not work, maybe it's 50-50

, but if you do nothing you figure you are finished anyway. You are desperate. You do not need to be certain that what you do will actually work, but there's a chance however small that it might. Automatic pre-delegation might kick in and doom you - or that too, might not function. You do not, cannot, know for sure.

There is a chance – will you take it?

Probably you will. You will hope at least to paralyze the capability of the US even to transmit an order to destroy you.

However...while Pry thinks that such a use of an EMP weapon might be standalone, and much discussion seems to proceed on this basis, I am doubtful that it would in fact, end there.

Even a desperate and cornered DPRK would probably elect also to target in a more conventional way, (i.e. with ground bursts) US command and control facilities both in the US itself (NORAD, STRATCOM, airforce bases, etc) – and critical command and control facilities outside the US such as Pine Gap and Northwest Cape in Australia, and Menwith Hill in the UK and Thule in Greenland.

For sure, ground bursts are more demanding. However I am one of those who thinks its more than 50% probable that the DPRK **CAN** do a ground-burst, maybe not reliably, maybe not accurately, but that they'd have at least some chance to hit targets such as Northwest Cape, Pine Gap, and maybe STRATCOM and NORAD. (NORAD is hardened, so more difficult.)

But incapacitating command and control would be a very high priority, and the DPRK, cornered or thinking itself cornered, would do everything to achieve that.

This would be likely to involve about a dozen warheads - not just one in space.

The same considerations apply to the strategic plans of China and Russia, and I am sure, to those of the US itself. (And to reiterate - an initial EMP burst in space has long been a standard part of

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operational plans).

So it is reasonable to ask 'Just how likely is a standalone EMP attack, or will it ALWAYS be simply the opening act of the apocalypse?'

If 'Super-EMP' fails to put US command and control out of action, and retaliation DOES take

place, then an EMP attack WILL simply be the opening act of the apocalypse.

If 'Super-EMP' is powerful enough to **prevent** retaliation, then the effects on civil infrastructure will be truly catastrophic in ways that an 'ordinary' (= Starfish Prime or Kazakhstan) pulse will not be, causing screens everywhere to go blank and (maybe) aircraft to crash, and putting out the lights for years or a decade.

One scenario takes us back to the 18th century. The other takes us back to the last ice age or maybe the proterozoic.

At this point it would be lovely to quote Prynne's 'Sic Transit Gloria Mundi' (so passes the glory of the world), but there's still more to be said.

Solutions? What solutions? - what is NOT the solution

Having just sketched a couple of apocalypses, its helpful to suggest ways out. However I'd like to focus on what are NOT ways out, as I suspect the ways out – or the ways to at least give ourselves a better chance – are pretty obvious, and will be useful even if EMP turns out to be nothing to worry about after all.

First of course, EMP is primarily a product of the use of nuclear weapons in space. From the point of view of an antinuclear weapons campaigner such as myself, this is just another very good reason to eliminate nuclear weapons. It's also a good reason to unambiguously ban the use of nuclear weapons in space. The Outer Space Treaty seems to unambiguously ban the positioning and testing of nuclear weapons in space, but may or may not ban their explosion in space in war, or their brief transiting space on the way to earthly targets.

A clear ban on all use of nuclear weapons in space in all circumstances including war would be useful.

A General Assembly resolution calling for such a ban, and for the negotiations of a treaty to implement such a ban, would be highly desirable.

With or without EMP, ANY use of nuclear weapons in space would destroy satellite infrastructure on which so much of hi-tech society depends.(communications, GPS are critical

functions) It would at the very least fill the Van Allen belts with radioactive ions which then destroy satellite electronics over a period of days to weeks.

Security policies adopted by nuclear-weapons-possessing states, that minimize the role played by nuclear weapons in them, and that adopt postures of No First Use (Remember, the EMP bomb **only** works if you use it **first**), and that lower the alert status of nuclear weapons so that accidents and computer glitches can no longer initiate an apocalypse, are helpful.

Of course, its possible that a 'first use' of nuclear weapons might be of a 'warning shot' variety, in which case an EMP riposte from, say, China, (which would now not be breaking its NFU policy) could be devastating. However its very possible that a 'warning shot' would itself explode in space - making an EMP impact.

Of course, the total elimination of nuclear weapons as envisaged in the TPNW, for which 2/3rds of all Governments voted last year in the GA, would take EMP completely off the agenda.

Security policies or postures designed to 'confront', or 'constrain' others or even to 'compel' them, seem unlikely to work and likely to worsen the situation beyond repair. **Such policies and postures are more likely to create the very situations they ostensibly try to prevent**

The closer US carriers are to Pyongyang, the more feverishly Pyongyang will work on a 'Super-EMP' weapon, and the closer itchy fingers will be to buttons. The same considerations apply (even more) to China and Russia.

So while Pry may be right, or partly right, over the EMP plans and capabilities of the DPRK, Russia, and China, - (

especially

if he is right) – aggressive actions and actions based on confrontation and 'compel-lance'

will merely create or escalate the very problem they seek to solve. The solutions lie at 180 degrees to this.

Many of the most sensible responses to the potential threat from EMP lie in the kinds of measures spelled out in the Trump executive order on EMP. The executive order makes a brief nod to deterrence and compel-lance policies that are more politically 'correct' and much less sensible but thankfully does not pursue them:

"...(ii) in coordination with the Secretary of Defense and the heads of other relevant agencies, strengthen nuclear nonproliferation **and deterrence** efforts, which would reduce the likelihood of an EMP attack on the United States or its allies and partners by limiting the availability of nuclear devices."

and:

“...(vii) defend the Nation from adversarial EMPs originating outside of the United States through defense **and deterrence**, consistent with the mission and national security policy of the Department of Defense.”

Are ‘defense and deterrence’ anything but delusional, either for the US or anyone else, against HEMP/EMP? What on earth would they look like? Surely we are not looking at Missile Defense, which every sensible analyst knows not only does not, but cannot ever, work? (and certainly can’t ever work with the 100% reliability it would have to, to constitute a defense against either EMP or any other kind of nuclear attack.)

As far as nonproliferation efforts are concerned, at least in the case of the DPRK, that horse has well and truly fled the stable. ‘Deterrence’ will have precisely the opposite effect to that desired - the more you try to prevent country X from doing Y, the more determined they will be to do it.

This does not mean however, that a multilateral approach based on GA resolutions and the creation of a multiyear treaty framework is not worth doing - it is profoundly so. It is the threat of negative consequences that is guaranteed to fail.

Much more sensibly, the order provides that:

“...(i) lead the coordination of diplomatic efforts with United States allies and international partners regarding **enhancing resilience to the effects of EMPs**; and...”

However the main approach of the Trump executive order is (correctly) strictly domestic. Its broad scope is spelled out in:

“...Policy. (a) It is the policy of the United States to prepare for the effects of EMPs through targeted approaches that coordinate whole-of-government activities and encourage private-sector engagement. The Federal Government must provide warning of an impending EMP; protect against, respond to, and recover from the effects of an EMP through public and private engagement, planning, and investment; and prevent adversarial events through deterrence, defense, and nuclear nonproliferation efforts.

To achieve these goals, the Federal Government shall engage in risk-informed planning, prioritize research and development (R&D) to address the needs of critical infrastructure stakeholders, and, for adversarial threats, consult Intelligence Community assessments.”

and very sensibly:

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“...(i) Within 90 days of the date of this order, the Secretary of Homeland Security, in

coordination with the heads of SSAs and other agencies as appropriate, shall identify and list the national critical functions and associated priority critical infrastructure systems, networks, and assets, including space-based assets that, if disrupted, could reasonably result in catastrophic national or regional effects on public health or safety, economic security, or national security. The Secretary of Homeland Security shall update this list as necessary.”

and:

“...(i) Within 1 year of the date of this order, and every 2 years thereafter, the Secretary of Homeland Security, in coordination with the Secretaries of Defense and Energy, and in consultation with the Director of OSTP, the heads of other appropriate agencies, and private-sector partners as appropriate, shall submit to the President, through the APNSA, a report that analyses the technology options available to improve the resilience of critical infrastructure to the effects of EMPs. The Secretaries of Defense, Energy, and Homeland Security shall also identify gaps in available technologies and opportunities for future technological developments to inform R&D activities.”

In general, the Trump EMP executive order, clearly not penned by Trump himself, provides a sensible, if at times underwhelming, framework that takes the issue seriously, while leaning a little too much on the side of yet more evaluations. It is a thousand times better than denial.

The Trump EO compares well with the first 5 recommendations of the 2017 EMP commission:

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Recommendation 1: The Commission recommends the President establish an Executive Agent with the authority, accountability, and resources to manage U.S. national infrastructure protection and defense against the existential EMP threat.

Recommendation 2: The Commission strongly recommends that implementation of cybersecurity for the electric grid and other critical infrastructures include EMP protection.

Recommendation 3: The Commission encourages the President to work with Congressional leaders to establish a joint Presidential-Congressional Commission, with its members charged with supporting the Nation's leadership to achieve, on an accelerated basis, the protection of critical national infrastructures.

Recommendation 4: The Commission recommends that Government agencies and industries adopt new standards to protect critical national infrastructures from damaging E3 EMP heave fields, with more realistic standards of 85 V/km.

Recommendation 5: The Commission recommends that the Department of Defense and the Department of Energy provide expedited threat-level, full-system testing of large power transformers in wide use within the bulk electric system and share key findings with the electric utility industry.

....Deeper questions

Finally, the entire EMP issue, says deep things about the fragilities and mutual interdependencies of modern societies. It has implications that go beyond EMP, beyond the effects of CME's, or solar mass ejections, to the very nature of technological progress,

so-called.

These mutual dependencies may be destructive. For example, if the power system is down for a very long time (whether because of E1 or E3 EMP, a CME, or because its been hacked, or because a tree has fallen onto EHV lines, (or squirrels have chewed them) and created a cascade of catastrophes) – then, telecommunications may also go down. However, the power system needs the telecommunications system in order to be able to start back up. But the telecommunications system is down because the power system is down....We need only look at what is taking place right now in Venezuela, either by mismanagement or cyberattack.

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30 years or so ago, power systems had their own internal analogue systems for load and frequency matching and could start with or without the external telecommunications system.

And 30 years ago telecommunications systems had their own dedicated power supplies. If the power went off, the phone would continue to work having its own quite independent power supply.

A situation in which nuclear – generated EMP had fried microelectronics continent-wide, or in which a CME had cooked EHV transformers on a similar scale (or globally) could indeed be ‘Sic Transit Gloria Mundi’, either for the US alone or for the world as a whole. (in the case of a global CME event.)

The best solutions lie in improved technical resilience at all levels, from resistance to EMP damage or upset in the first place to better black-start capabilities to many more spare transformers, to ways of doing things without electronics that all societies used to use, and which are largely forgotten these days. These resiliencies are worth having even if all of EMP turns out to be a myth, which I am sure it is not, and is worth having even if none of these apocalypses ever take place. After all, we do fervently hope and work to prevent them.

And by being a bit less attached to the often empty ‘Gloria’ (‘Glory’) in ‘Sic Transit Gloria Mundi’, and being a bit more humble, we might never have to say it.

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