6OEFSHSBEVB
3FTFBSDI
'FMMPXTIJQ
8PSLJOH
1BQFS 4FSJFT

Title:

"+\SHUVRQLF %RUQH
7KUHDW $QDO\VLV :D
6FHQDULRV DQG WKH
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Author(s):

0LFDK +ROVWRQ
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Abstract

Borne by Chinese hypersonic glide vehicle, a High-altitude ElectroMagnetic Pulse (HEMP) weapon detonated in the atmosphere over the continental U.S. eviscerates the American electrical grid for 4-10 years, incurs trillions of dollars in damage, and results in the death of up to 90% of Americans within a year, all according to the Congressional EMP Commission's report. As "competition below the threshold of war" which also happens to nullify America's war-waging capacity, ElectroMagnetic Pulse (EMP) assaults place the United States in an awkward quandary, without electricity, communications, or viable retaliatory options. Existing detection dragnets strain to track hypersonic glide vehicles and, due to various EMP scenarios, if the lights were to suddenly flicker on, there may remain uncertainty as to the perpetrator's identity. Even once America eventually attains hypersonic parity with China and Russia, due to the nuanced nature of hypersonic HEMP warfare, traditional mutually assured destruction and deterrence paradigms implode. Ensuring an equitable outcome – where China's electrical grid is equally inoperable – is simply unfeasible considering the first-strike nation's intrinsic advantage, ambiguity in launcher's intent, the truncated timeline for response (when compared with traditional ICBMs), and China's unique manufacturing and policy positioning which allow them to weather EMP reprisal essentially unphased.

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ABM	An t-Ballis t c Missile
AFWL	U.S. Air Force Weapons Laboratory
C3	Command, Control, and Communica t ons
CBO	Congressional Budget O ce
CCP	Chinese Communist Party
CRS	Co Ţ C v

l v š Œ } µ a n ÿ d } S v cenario • Œ] ‰ Ÿ } v

America is currently entering a new geostrategic paradigm, one determined by

Beijing's nuclear program (and close cooperation with North Korea), the Chinese almost surely wield a similar weapon. Staggeringly, the HEMP's peak electric currents are strong enough to penetrate even military shielding, which is approximately 50 kV/m (Pry, 2021, p. 13), the international shielding standard and supposed limit in early Cold War-era calculations (AFWL, 1980, p. 666, 690). In these insurmountable electric fields, the majority of electronical components connected to the power grid fry or physically melt (NCC, 2019, pp. 28, 108, Savage et al., 2010, p. 37). In modern integrated chips, if even a single component is faulty, the entire device fails, often in unexpected ways at inopportune times. Devices that survive are rendered inoperable due to the absence of a reliable power supply. The electric grid itself collapses. Coupling to power lines, induced current surges to remote corners of the grid, prompting cascading effects and overloading any circuits which evade or endure the initial burst (NERC, 2003; Smith, 2014). According to a Wall Street Journal report on a classified federal analysis, disabling just 9 of the United States' approximately 2,000 extra-high voltage (EHV) transformer

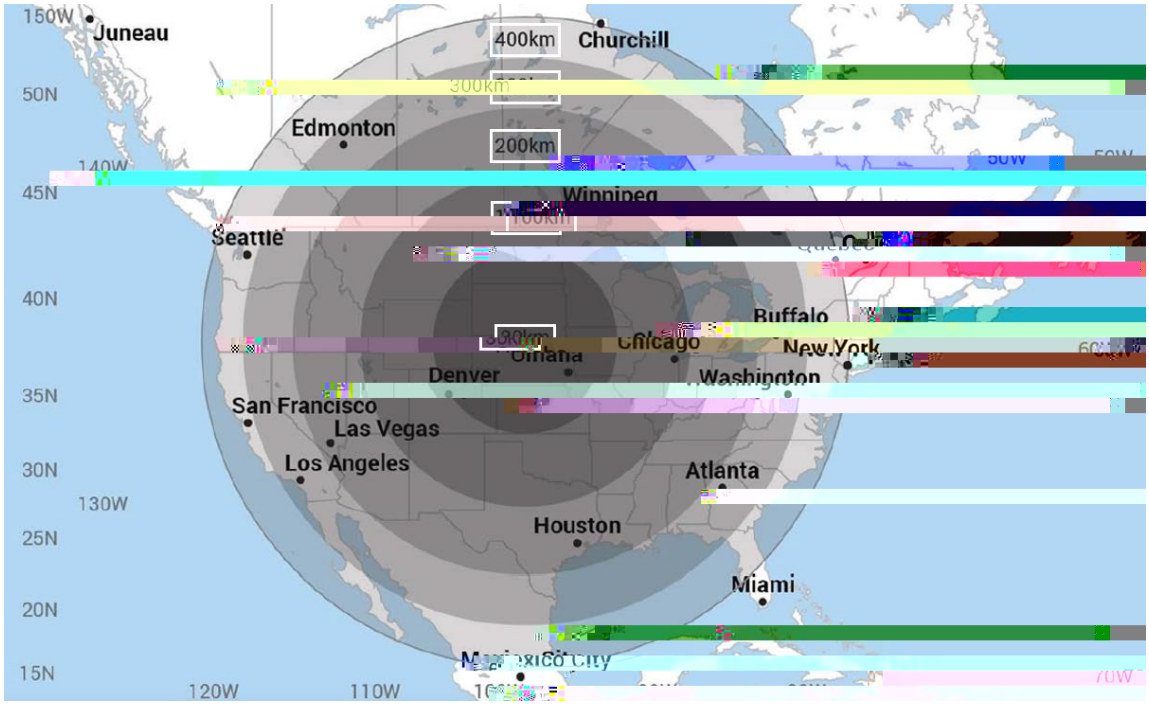


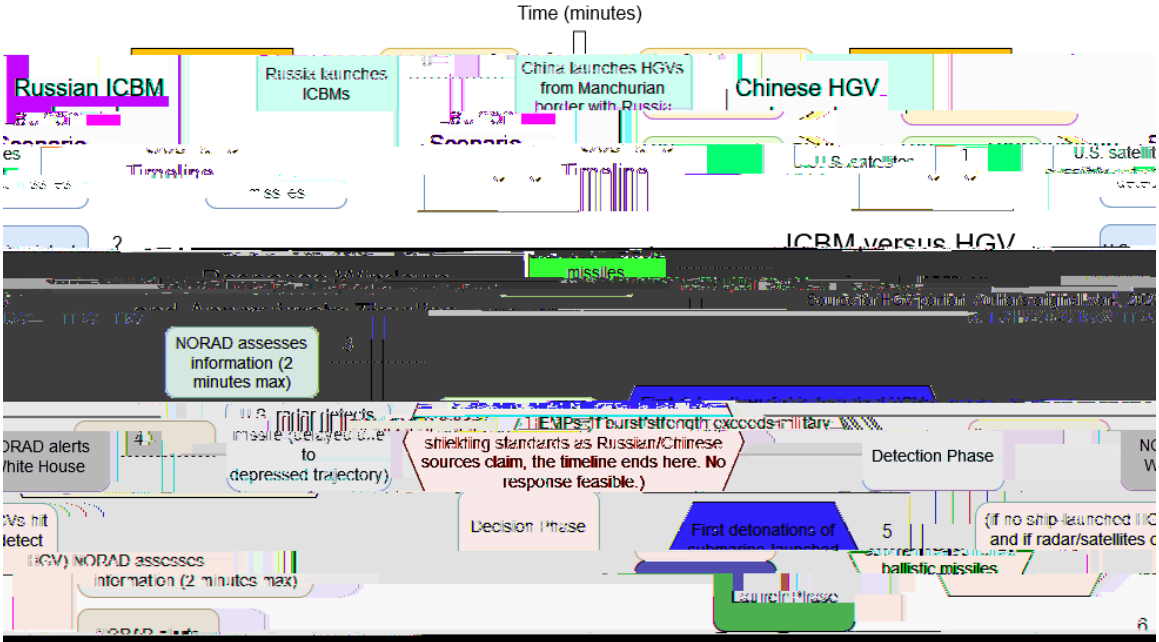
Figure 3: nD <3re oo ų R Ŗ ų

Game Tree Model

Figure 5

Washington's options are severely limited, it is reasonable to assume that Player 1 (China) possesses perfect knowledge of Player 2's (America's) payoffs but incomplete information regarding fate's selections. Similarly, assume that Player 2 wields perfect comprehension of Player 1's payoffs, but only the probabilities of fate's outcomes (not their definite realizations). While an accurate gauge is attempted to keep the calculation for Nash Equilibrium mathematically reasonable, the exact numeric values of the payoffs are not as critical as their ordinal values, although this game is certainly not ordinal in nature. For any

Figure 6: ICBM vs. HGV Timeline



Furthermore, n

optmistc paradigm, there is an 80% chance that China launches from a readily-identfiable positon and Washington (or NORAD's Cheyenne Mountain) identfies Beijing as the culprit. If China launched from the Manchurian border with Russia (or a cargo ship o the U.S. coastline, before promptly scutling the ship), however, the chances of accurate identficaton (i.e., which side of the border initated the hypersonic strike) dwindle to a measly 5%. If China plays their cards intelligently, America never discerns the launcher's identty.

If the U.S. is anything short of perfectin its response procedure, if the incoming HGV is launched from a boat o the U.S. coast (shortening the tme-to-detonaton to 90

Korean/Iranian/Russian/Chinese cargo liner with Scud-based HEMPs, Russian/Chinese with HGVs), surviving U.S. military assets would have no way of knowing which nation to strike in retaliation (Pry, 2017b, p. 26).

The first three post-launch terminal nodes' payoffs contain identical values, as the outcomes are practically identical. China walks away unblemished with an unequivocal, absolute victory (+100 payoff) and America plummets into a pre-industrial state without any semblance of civilization (–100 payoff).

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Now consider the interception nodes. This information set marks the sole simultaneous subgame (i.e., a game in which one player possesses imperfect information as to their opponent's moves) in the entire tree. America cannot possibly discern the incoming HGV's payload and must make a judgement call in the moment whether or not to attempt interdiction, assuming interception is even technologically possible. In the optimistic estimation, the U.S. possesses a classified HGV interceptor with 50% chance of successful interdiction, a reasonable estimate considering the single-missile success rates of traditional ABM systems such as GMD, THAAD, and Aegis (MDAA, 2023). Frankly, however, this scenario is unlikely. HGV interceptors fail to contribute to deterrence doctrine unless the world knows about them. Thus, if America possessed interceptors, the fact would be highly publicized, like ICBM capacities were during the Cold War. In the pessimistic evaluation, where the U.S. possesses no HGV interceptors, there is a 99% probability of China's missile penetrating our airspace, with a 1% chance of failure (perhaps it loses navigation systems, hits a bird, or fails to detonate).

Conceivably, China could blu its way into a poli t cally desirable situa t on by sending an HGV containing scien t fic equipment on a HEMP-like trajectory over the U.S., then protest if/when America a t empts intercep t on. Failed intercep t on of a Chinese scien t fic HGV also slightly benefits China, as it allows the cra f to successfully carry out its mission while also subtly tes t ng America's defenses (hence the slight payo in China's favor). In this eventuality, America marginally loses, as key intel about our defenses is elucidated to the Chinese and Washington is down a mul t-million-dollar an t-ballis t c missile (therefore, America's payo is –1 in the case). Also, it gi f s China some poli t cal leverage, as America a t empted to shoot down a Chinese cra f outside of the legal boundaries of US airspace. A successful US intercep t on of a Chinese scien t fic HGV – currently unfeasible (Speier et al., 2017, pp. 30-35), but poten t ally salient in the future – is even more beneficial to the Chinese Communist Party

Chinese HEMP is airborne, America cannot deliver an ICBM strike before the EMP's detonation fries Washington's missile mid-air. If the U.S. arsenal survives the HEMP burst but sparks global nuclear holocaust – effectively annihilating humanity – the payoffs are actually lower than –100, set at –149 for a "successful" strike upon China and –150 for a "failed" strike on China. Ultimately, the success/failure of America's strikes in the advent of global nuclear war is irrelevant, as other nations' nuclear warheads or their fallout still decimate China. As the U.S. Military's Proud Prophet wargaming exercises demonstrated in 1983, any use of nuclear weapons – even limited, tactical ones – ultimately culminates in total nuclear annihilation (National Defense University, 1983). "Limited" nuclear war is largely a myth.

From China's perspective, a successful American nuclear strike is certainly the least desirable retaliation outcome, but America is deterred from this path due to concerns about sparking global nuclear war – and Beijing knows Washington's hesitancy to risk such a fate. Also, a Maoist hardliner might willingly sacrifice a few Chinese cities to wipe America off the globe. Therefore, the payoff for China, even when American nukes annihilate a handful of major Chinese cities, remains at minimum a positive 20. Lastly, one final ethical factor to contemplate is that China, as discussed above, did not [illegible] American citizens, only the blackout's [illegible] Americans as society collapses. Risking annihilation of humanity for an electronic warfare incursion is wholly unjustified and largely irrational – assuming the U.S. hierarchy would uphold such virtues in such dire straits – further lowering American nuclear payoffs. Beijing is sure to account for this in their strategic calculus, eroding away the bulwark of mutually assured destruction doctrine which currently averts ICBM launches.

Ultimately, even if America innovates] v Ÿ HGV-borne HEMPs that China currently wields, mutually assured destruction still collapses due to the novel nature of this nascent threat. As of December 2023, American HGVs remain in the developmental stage (Feickert, 2023; CBO, 2023), repeatedly encountering engineering obstacles (Hollings, 2022; Bugos, 2023), but the HGV HEMP retaliation alternative assumes America gains HGV capacity in the near future. If America's HGVs (either in silos or airborne during China's HEMP burst) fail to survive the Chinese HEMP burst (5% optimistically; 40% pessimistically), then America's payoffs revert to the baseline failure outcome. If, however, Washington launches a reciprocal strike but it fails due to atmospheric perturbations from the Chinese HEMP burst (15-70% chance), at least the U.S. © u ‰ šetribution, granting America a payoff of –96 (which is preferable over failures in any of the other response avenues). In the advent of a successful burst which ‹ µ] À o v š o Ç decimates China's electric grid (with no hope of recovery), the payoff is –110, since destruction of their grid likely entails a breakup of Beijing's strong, consolidated, centralized government and potential fracturing into multiple nations, even when/if the lights come back on. Obviously, America prefers to mete out justice in this reciprocal fashion – a prolonged nationwide blackout for a prolonged nationwide blackout – but the technology must be within Washington's grasp to allow for such a choice, even if its success is somewhat a longshot. But even a • µ • • (µ o retaliatory HEMP burst fails to assure mutual destruction, since China and Taiwan (China's first conquest after vanquishing America) manufacture the majority of the world's electric grid infrastructure (Campbell, 2021). With a bit of forethought, Beijing priorly stockpiles backup electric grid components in a hardened location or shields the appropriate transformer factories (and/or if it willingly sacrifices a portion of its already overcrowded population), neutralizing the

threat of even a successful American HEMP burst

Ultimately, the deciding factor that determines whether China launches a hypersonic HEMP against America is the payoff value of maintaining the status quo L versus wiping out America (optimistically, 90.554; pessimistically 99.997). The status quo remains geostrategic Nash Equilibrium so long as $L > 90.554$, but if $L < 90.554$, then a Chinese HEMP launch becomes the game's equilibrium. Obviously, since America remains China's largest trading partner, Beijing is not too keen on eviscerating their economy's customer base, but with Europe rising to replace the U.S., America's economic shielding may be transient. Also, Xi Jinping may slowly become – or be succeeded by – an irrational ideologue who prioritizes permanently eradicating an "evil" America over the short-term wellbeing of his own people. Decreasing with time, the value of L is slowly dwindling, as America's economy and trade partnership dims in comparison with European, African, and Middle Eastern opportunities for Beijing. In the 1990s and early 2000s, L soared to a high value – say, 200 – but has been slowly reducing ever since. One pertinent question – the one whose answer determines the fall of America and the rise of a new world order centered around Beijing – is at what rate is L decreasing. The determination of L's current value and its rate of decline is beyond the scope of this inquiry and requires an amalgamation of economists, political scientists, and international a tion

nuclear strikes are likely ine ec t ve but risk global nuclear holocaust in the process. Even

hypersonic parity is ul t mately immaterial for HEMP considera t ons, as both mutually assured

destruc t on and deterrence paradigms fatally fracture in HGV scenarios. Especially in a situa t on
s.
where China launches an HGV from its border with Russia, concealing the missile's na t on of

origin, respo , Ņ Őu Ť n HG Ł ' rs N rt 8

progresses. Ult mately, even if America innovates HGV-borne HEMPs iden t cal to China's,

Pry, P. (2017b). E µ o Œ D W © l • v Œ] } • Œ u v • Ç u] v. 2 nd Congressional EMP Commission. h t p://www.firstempcommission.org/

Wikimedia. (2022, October 20). Z] v • -17& [Online Image] https://commons.wikimedia.org/wiki/File:DF-17_Missile_20221020.jpg Accessed July 4, 2023.

Wright, D. and Tracy, C. (2021). The physics and hype of hypersonic weapons. Scientific American. https://www.scientificamerican.com/article/the-physics-

Appendix A –D š Z u Ÿ o } u ‰ µ š Ÿ } v •

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Computa t ons for China are in red, denoted by 2¼. Computa t ons for America are in blue, denoted by 2ò.
Again, fate's payo s are all zero, and are, therefore, excluded altogether.

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Conven t onal Military: 2¼ = 0.05(95) + 0.95(100) = 99.75 2ò = 0.05(–96) + 0.95(–99) = –98.85

Nuclear:

- Sparks global nuclear war:
  2¼ = 0.20(–100) + 0.80(–100) = –100 2ò = 0.20(–149) + 0.80(–150) = –149.8 A ` t ^ ‰ • o" P ` E µ Á

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x Chinese decision as to HGV payload (when America attempts cyberattack):

$2_{¼} = 42$ $2_{¾} = (p)(-53.5) + (1-p)(-3) = -50.5p - 3$

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Hypersonic HEMP:

- Successful/Failed delivery of U.S. HGV:

2¼=

If America, without HGVs, is forced to employ a cyberattack response:

- Sufficient time/surviving infrastructure:
  $2_{¼} = 0.90(100) + 0.10(97.415) = 99.742$
  $2_{¤} = 0.90(–100) + 0.10(–95.833p – 1.04) = –9.583p – 90.104$
- Nation of origin identified:
  $2_{¼} = 0.95(100) + 0.05(99.742) = 99.987$
  $2_{¤} = 0.95(–100) + 0.05(–9.583p – 90.104) = –0.479p – 99.505$
- HGV detected by USA:
  $2_{¼} = 0.75(100) + 0.25(99.987) = 99.997$
  $2_{¤} = 0.75(–100) + 0.25(–0.479p – 99.505) = –0.120p – 99.876$
  For a definitive HEMP launch, p=1, so $2_{¤} = –99.996$

Overall, the expected optimistic payoffs for China launching a HEMP strike upon the USA are virtually identical, with an HGV response netting a (99.997, –99.994) [illegible] cyberattack (99.994, –99.996).