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**Title:**

*"Hypersonic-Borne HEMP Threat Analysis, Wargaming Scenarios, and the Breakdown of Mutually Assured Destruction"*


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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 off, 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.

# Acronyms and Abbreviations

| | |
|---|---|
| ABM | Anti-Ballistic Missile |
| AFWL | U.S. Air Force Weapons Laboratory |
| C3 | Command, Control, and Communications |
| CBO | Congressional Budget Office |
| CCP | Chinese Communist Party |
| CRS | Congressional Research Service |
| DHS | U.S. Department of Homeland Security |
| DOD | U.S. Department of Defense |
| EMP | Electromagnetic Pulse |
| GMD | Ground-based Midcourse Defense |
| HEMP | High-altitude Electromagnetic Pulse |
| HGV | Hypersonic Glide Vehicle |
| ICBM | InterContinental Ballistic Missile |
| MDAA | Missile Defense Advocacy Alliance |
| NCC | National Coordinating Center for Communications, DHS |
| NERC | North American Electric Reliability Corporation |
| NORAD | North American Aerospace Defense Command |
| THAAD | Terminal High Altitude Area Defense |

## Introduction and Scenario Description

America is currently entering a new geostrategic paradigm, one determined by "information warfare," the most harrowing instance of which is a High-altitude ElectroMagnetic Pulse (HEMP) strike. Facilitated by hypersonic glide vehicles (HGVs), a HEMP strike upon America would be ineffably, irrevocably, and irredeemably cataclysmic. Just one to three HEMPs, delivered by currently uninterceptable HGVs, would cripple the American electrical grid, and, consequently, the U.S. financial system, industry, and supply chain for months or years, ultimately resulting in the deaths of up to 90% of Americans from starvation or societal collapse while leaving Washington in a retaliatory quandary (Pry, 2017b, p. 28). Evading existing detection dragnets, HGVs retain maneuverability at their signature velocities (Mach 5-to-20), readily dodging the United States' Ground-based Midcourse Defense (GMD), Terminal High Altitude Area Defense (THAAD), and Aegis anti-ballistic missile systems (Brockmann & Schiller, 2022; Wright and Tracy, 2021). Even if America innovated a *hypersonic* ABM system, the interceptor perpetually pursues its mark, leaving the initiative firmly in the incoming missile's grasp – a slight flight deviation throws the pursuer wildly off-course. Furthermore, USAF generals and DoD undersecretaries repeatedly warned Congress that HGV detection is problematic (Vergun, 2023, CRS, 2023). America may never even notice its incoming doom. While a single burst suffices in blanketing the entire nation (Fig. 1), three regional bursts maximize the electric field strength enveloping America (Savage et al., 2010, p. 37).

According to two Russian generals – both EMP experts, in a credible conversation with their American counterparts – the Soviets provided North Korea plans for a neutron bomb (i.e., HEMP) capable of generating 200 kV/m fields (Pry, 2021, p. 13; Vaschenko, 2006). Considering

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

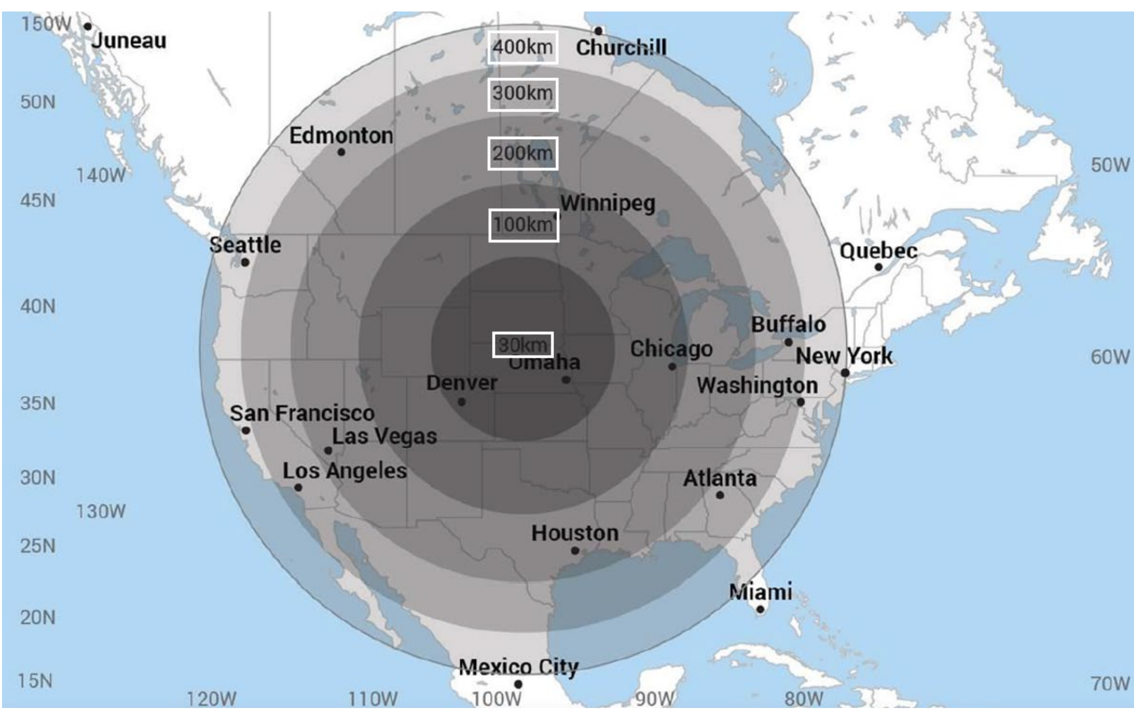


Figure 1: HEMP burst coverage at various altitudes. Source: (Pry, 2017b, p. 20)

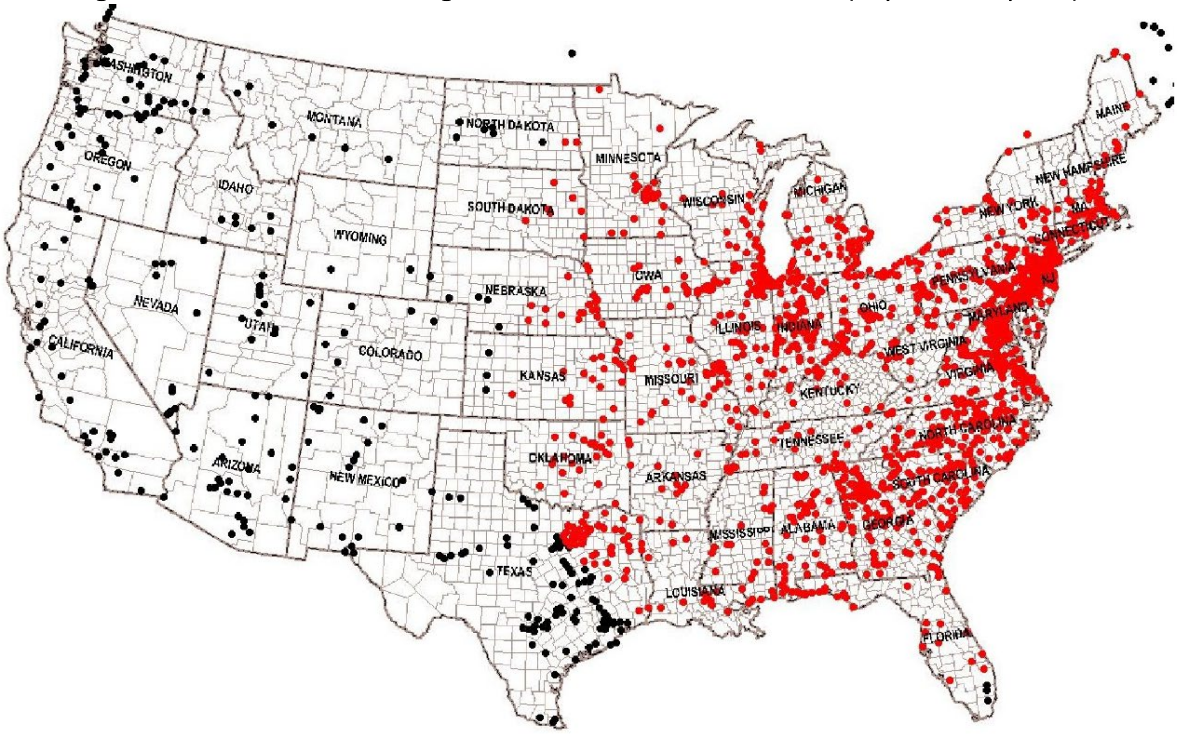



Figure 2: The 1,765 EHV substations exposed (red dots) to a HEMP burst of 170 km centered over Ohio, about 83% of America's EHV substations. (EHV indicates 345 kV or higher). Source: (Savage et al., 2010, p. 140)

substations prompts a cascading failure and generates a protracted nationwide blackout (Smith, 2014). These EHV substations distribute over 90% of America's electricity (DHS, 2022). An EMP burst at 170 km in altitude centered over Ohio decimates 1,700 such EHV substations (Fig. 2) – for four to ten *years* (*The EMP Threat,* 2012). During the half-decade long blackout, America disintegrates. In the words of the Congressional EMP Commission's Report:

> Everything is in blackout and nothing works. The EMP sparks widespread fires, explosions, all kinds of industrial accidents. Firestorms rage in cities and forests. Toxic clouds pollute the air and chemical spills poison already polluted lakes and rivers. In

> seven days, the over 100 nuclear power reactors run out of emergency power and go Fukushima, spreading radioactive plumes over the most populous half of the United States. There is not even any drinking water and the national food supply in regional warehouses begins to spoil in three days. There was only enough food to feed 320 million people for 30 days anyway. In one year, as some EMP experts have warned for over a decade, 9 of 10 Americans are dead from starvation, disease, and societal collapse. The United States of America ceases to exist. (Pry, 2017b, p. 58)

Even if the Congressional EMP Commission's estimate that 90% of the American populous dies in a HEMP scenario is overly morose, a lesser figure (say 40% – or 130 million citizens) is still catastrophic. Since Canada and Mexico are also consumed in the HEMP burst, no aid exists over the horizon. In a HEMP burst scenario, America is alone in the dark. This paper outlines an HGV-borne HEMP strike game tree – virtually non-existent in the declassified domain – demonstrating how mutually assured destruction crumbles in this nascent domain of warfare.

Possible impacts to infrastructures resulting from High-altitude EMP (HEMP) UNCLASSIFIED

| **Infrastructure** (rating assumes not EMP protected) | Days ⟺ Months |
|---|---|
| **Undersea Cable Infrastructure** (main risks: E1 + E3) | Upset and damage |
| **Satellite in space** (System Generated EMP (SGEMP) + radiation belts) | Upset/degradation |
| **Satellite terminals/support** (vulnerable to HEMP E1) | Upset and damage |
| **HF radio equipment** (vulnerable to HEMP E1) | Upset and damage |
| **HF sky wave media** (heals in hours); HF groundwave not impacted | HF propagation |
| **Computers and Ethernet Interfaces** (vulnerable to HEMP E1) | Upset and damage |
| **Desk phones** (vulnerable to E1 EMP conducted on power/data cords) | Upset and damage |
| **Cell phones** (risk to towers/backhaul from E1; handsets generally OK) | Upset and damage |
| **Routers and phone switches** (vulnerable to HEMP E1) | Upset and damage |
| **Radio and TV stations** (likely to go off-air immediately due to E1) | Upset and damage |
| **Portable battery operated radios** (eventual power problem) | Battery dependent |
| **Land mobile radios** (OK if not trunked; eventual power problem) | Power dependent |
| **Unprotected parts of the electric grid** (main risks: E1 + E3) | Upset and damage |

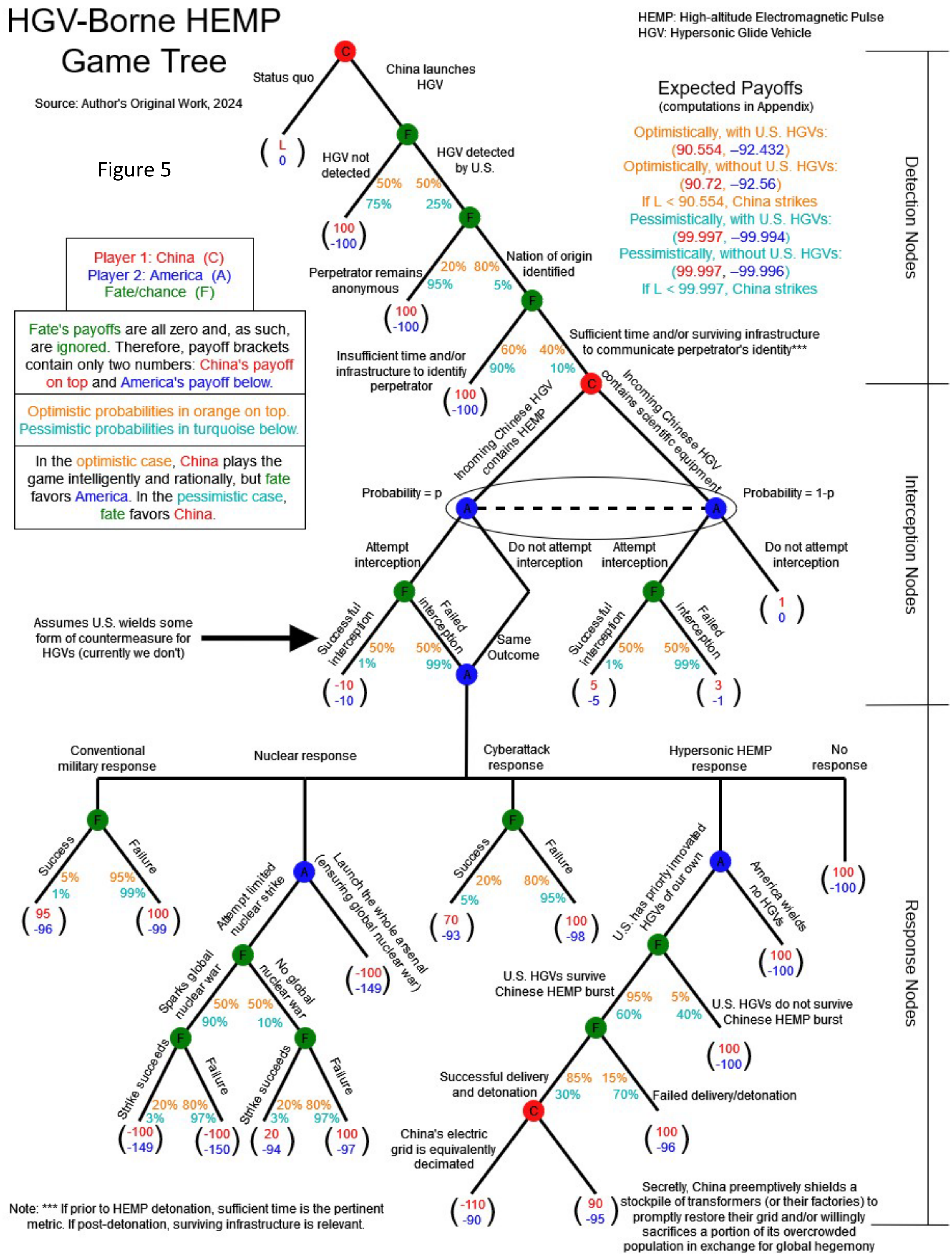
Figure 3: National Coordinating Center for Communications, Department of Homeland Security presentation on devices impacted by HEMP. Source: (NCC, 2019, p. 116).


Figure 4: Truck-based DF-ZF Chinese hypersonic glide vehicle mounted atop the DF-17 ballistic missile. Source: (Wikimedia, 2022)

# Game Tree Model

Consider the game tree presently posited (Fig. 5). The two players are China and America, with those aspects of the game not under the direct control of either player determined by "Fate." Fate's probabilities are exogenously given and assumed common knowledge to each player, allowing the game to reflect various relevant scenarios (optimistic vs pessimistic). Chronologically, all three of China's nodes occur first (i.e., China makes the first three moves: shielding their transformers/factories, determining the HGV's payload, then ordering a launch), but logically and sequentially it makes the most sense to intersperse them throughout the game tree, placed at the nodes in which they become pertinent. Do note, however, that the initiative rests firmly in China's hands, as they make the first three moves without American interplay. While America and China may remain uncertain about or disagree on the exact values of each payoff, this streamlined model merely calculates Nash Equilibrium, assuming that the uncertainty surrounding payoffs is negligible.

Once the HGV launches, the game commences. Since subgame perfect Nash equilibrium for the simultaneous nodes renders expected American payoffs of (–95.393) optimistically and (–95.82) pessimistically (see computations in Appendix A) in the advent of no/failed interdiction, interception is at least attempted, and the game continues. From America's



HGV-Borne HEMP Game Tree
Source: Author's Original Work, 2024
Figure 5
HEMP: High-altitude Electromagnetic Pulse
HGV: Hypersonic Glide Vehicle
Expected Payoffs
(computations in Appendix)
Optimistically, with U.S. HGVs: (90.554, –92.432)
Optimistically, without U.S. HGVs: (90.72, –92.56)
If L < 90.554, China strikes
Pessimistically, with U.S. HGVs: (99.997, –99.994)
Pessimistically, without U.S. HGVs: (99.997, –99.996)
If L < 99.997, China strikes
Player 1: China (C)
Player 2: America (A)
Fate/chance (F)
Fate's payoffs are all zero and, as such, are ignored. Therefore, payoff brackets contain only two numbers: China's payoff on top and America's payoff below.
Optimistic probabilities in orange on top. Pessimistic probabilities in turquoise below.
In the optimistic case, China plays the game intelligently and rationally, but fate favors America. In the pessimistic case, fate favors China.
Status quo
China launches HGV
HGV not detected
HGV detected by U.S.
Perpetrator remains anonymous
Nation of origin identified
Insufficient time and/or infrastructure to identify perpetrator
Sufficient time and/or surviving infrastructure to communicate perpetrator's identity***
Incoming Chinese HGV contains HEMP
Incoming Chinese HGV contains scientific equipment
Probability = p
Probability = 1-p
Attempt interception
Do not attempt interception
Successful interception
Failed interception
Same Outcome
Assumes U.S. wields some form of countermeasure for HGVs (currently we don't)
Conventional military response
Nuclear response
Cyberattack response
Hypersonic HEMP response
No response
Success
Failure
Attempt limited nuclear strike
Launch the whole arsenal (ensuring global nuclear war)
Sparks global nuclear war
No global nuclear war
Strike succeeds
U.S. has priorly innovated HGVs of our own
America wields no HGVs
U.S. HGVs survive Chinese HEMP burst
U.S. HGVs do not survive Chinese HEMP burst
Successful delivery and detonation
Failed delivery/detonation
China's electric grid is equivalently decimated
Secretly, China preemptively shields a stockpile of transformers (or their factories) to promptly restore their grid and/or willingly sacrifices a portion of its overcrowded population in exchange for global hegemony
Detection Nodes
Interception Nodes
Response Nodes
Note: *** If prior to HEMP detonation, sufficient time is the pertinent metric. If post-detonation, surviving infrastructure is relevant.

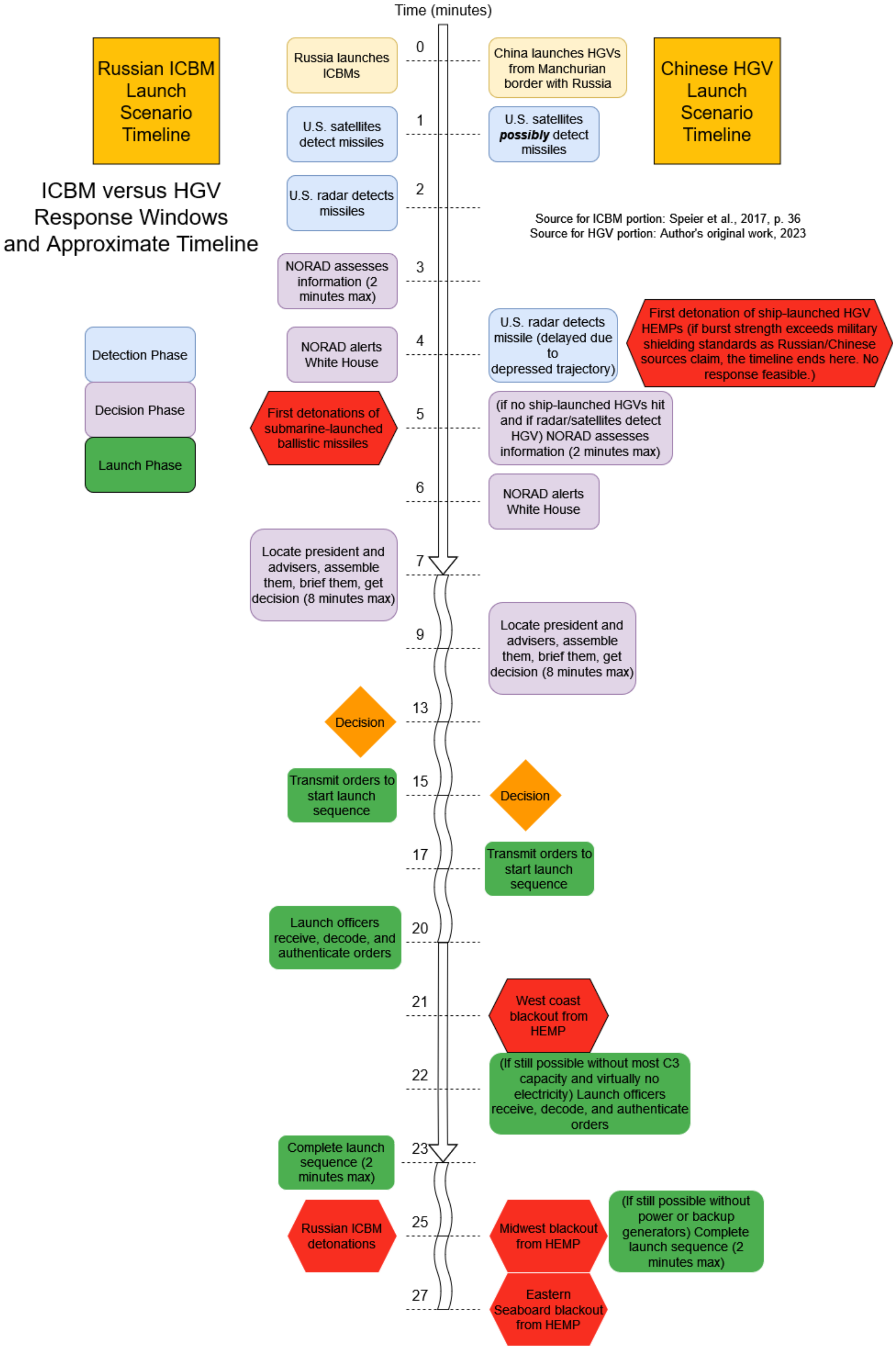
perspective (with imperfect information as to the incoming HGV's payload), there exists a simultaneous game with a probability *p* that the inbound HGV contains a HEMP and a probability *1-p* that the payload is innocuous (i.e., scientific or surveillance equipment). The final equation for each of the computed scenarios is included in Appendix A. To concisely present the expected payoffs, *p*=1 is substituted into these equations (i.e., America *definitively* knows that the inbound HGV contains a HEMP), rendering the final numeric payoffs without any variables. For instance, the optimistic payoff for an American HGV reciprocation is (90.554, –7.952p – 84.48) which becomes (90.554, –92.432) with *p*=1.

In total, four eventualities' payoffs are computed: 1) optimistic case where America wields HGVs 2) pessimistic case where America wields HGVs 3) optimistic case where America, without HGVs, resorts to the next best retaliation alternative (cyberattack) 4) pessimistic case where America, without HGVs, resorts to the next best retaliation alternative (cyberattack). The resultant four strategy profiles are displayed in Figure 5 and are further explicated in the Nash Equilibrium for Four Salient Instances section. These scenarios assume China operates under the Rational Actor Model. Lastly, a point of technicality. Rather than redraw the entire Response portion of the game tree after the "Incoming Chinese HGV contains HEMP", "Do not attempt interception" node, for brevity's sake the line reconnects to the "Failed interception" branch. Both nodes result in identical subsequent branches, therefore only one of these otherwise twin trees is included.

Realistically, fate leaves America with, at best, one or two viable retaliation alternatives, especially considering the abbreviated timeframe afforded by HGV scenarios (see Fig. 6). Since

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 relation to one another*, although this game is certainly not ordinal in nature. For any eventuality where China walks away with an undisputed victory to America's demise, the payoffs are normalized to (100, –100). For instance, 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 the dark ages (–100 payoff). In two instances, payoffs dip below the –100 threshold. First, America's payoffs plummet to the negative 150s if Washington is responsible for igniting a global nuclear holocaust. Second, if China's electric grid is *equivalently* decimated (with no hope of recovery), their payoff is –110, since destruction of their national electric grid likely entails a breakup of Beijing's consolidated, authoritarian government and potential fracturing into multiple nations, even after the lights come back on. In a sense, China has more to lose in a prolonged nation-wide blackout than the U.S., whose citizens are generally more self-sufficient and likely to reestablish some continuation of The Great American Experiment even in darkness. In China, the government sustains the populous. In America, the people sustain the government.

Figure 6: ICBM vs. HGV Timeline

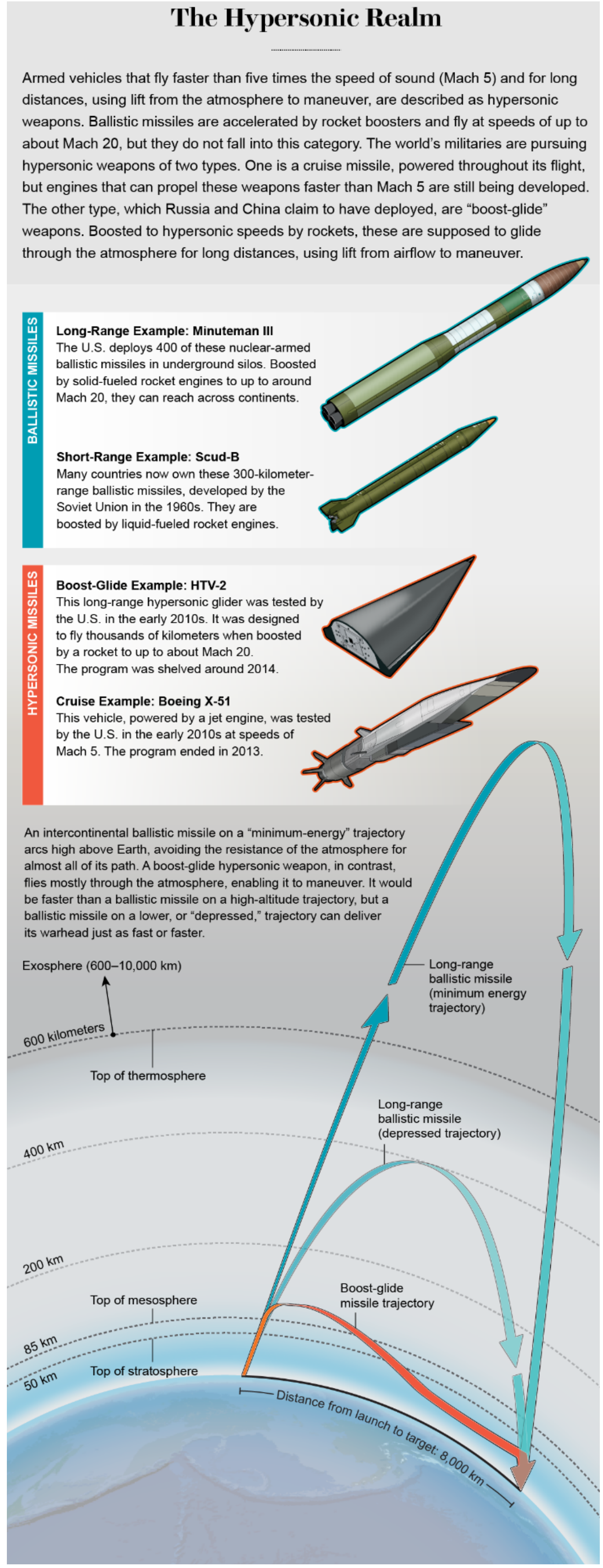


Furthermore, note that while a continuous spectrum of outcomes between "success" and "failure" is possible for the Response Nodes, only success and failure are modeled, as they are the minimums and maximums of the payoff function. For instance, a *partially* successful conventional military response may render a payoff of (97, –98), but since this is not the maximum or minimum payoff, it is not explicitly considered in the model. The payoffs also exist in a spectrum between the two extremes. For instance, between cyberattack success with a payoff of (70, –93) and failure with a payoff of (100, –98) exists a continuum of outcomes with payoffs of (71, –93), (72, –93), (72, –94), etc. Any critic of the assigned payoffs and probabilities can readily recalculate based upon values within these continuums (or just beyond their bounds) and uncover largely identical results. The cards are currently stacked against America in the hypersonic HEMP domain. If, however, a novel technology (i.e., revitalization of Reagan's Strategic Defense Initiative) enters the equation, then the whole game tree's calculus changes, decreasing China's expected payoff from launching a HEMP strike and incentivizing a preservation of the status quo.

## Detection Nodes

Optimistically, there is a 50/50 chance that America detects an inbound HGV. This percentage is gauged according to statements by the U.S. Undersecretary of Defense for Research and Engineering in 2020 and Air Force General Glen VanHerck before the Senate Armed Services Subcommittee on Strategic Forces in May 2023 (CRS, 2023, Vergun, 2023). Realistically, detection chances rest at about 25%, especially if China strikes from the south, taking advantage of the fact that America's detection dragnet is oriented northwards, eastwards, and westwards to counter the now-defunct Soviet Union (Pry, 2017b, p. 54). In the optimistic paradigm, there is an 80% chance that China launches from a readily-identifiable position and Washington (or NORAD's Cheyenne Mountain) identifies Beijing as the culprit. If China launched from the Manchurian border with Russia (or a cargo ship off the U.S. coastline, before promptly scuttling the ship), however, the chances of accurate identification (i.e., which side of the border initiated the hypersonic strike) dwindle to a measly 5%. If China plays their cards intelligently, America never discerns the launcher's identity.

If the U.S. is anything short of *perfect* in its response procedure, if the incoming HGV is launched from a boat off the U.S. coast (shortening the time-to-detonation to 90 seconds), or if insufficient infrastructure survives the burst to communicate the perpetrator's identity, then the HEMP culprit remains anonymous (60% chance optimistically, 90% chance pessimistically). With the variety of scenarios for a HEMP strike (i.e., North



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).

## Interception Nodes

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 bluff its way into a politically desirable situation by sending an HGV containing scientific equipment on a HEMP-like trajectory over the U.S., then protest if/when America attempts interception. Failed interception of a Chinese scientific HGV also slightly benefits China, as it allows the craft to successfully carry out its mission while also subtly testing America's defenses (hence the slight payoff 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 multi-million-dollar anti-ballistic missile (therefore, America's payoff is –1 in the case). Also, it gifts China some political leverage, as America attempted to shoot down a Chinese craft outside of the legal boundaries of US airspace. A successful US interception of a Chinese scientific HGV – currently unfeasible (Speier et al., 2017, pp. 30-35), but potentially salient in the future – is even more beneficial to the Chinese Communist Party (payoff of 10), as it puts America in a diplomatic embroglio, again gifting Beijing political leverage.

## Response Nodes

If successful, cyberattack is America's preferred non-HEMP response (with an expected payoff of –93), but China likely retains some powered regions from which the digital virus can be combated and ultimately extirpated, returning the nation to a fully powered state. If any transformers or electrical components are damaged in the cyberattack or its rolling blackouts, China simply manufactures replacements, as they possess the world's electronics and electric grid component factories (Campbell, 2021). Cyberattacks rest at about a 20% chance of success if enough hardened electrical infrastructure survives to launch an assault, but drop to approximately 5% if American infrastructure collapses, requiring assistance from an allied NATO nation who would likely prefer to cower in self-preservation rather than risk China's ire. A failed cyberattack is more readily concealed from the world than a failed military invasion, which is why its failure payoff is slightly higher (i.e., –98) than that of the conventional military option (–99). A conventional military response's failure costs additional American lives, eviscerates morale, and humiliates the remnants of the nation on the world stage, therefore netting a –99 payoff. Even a successful, sizable military strike – whose probability remains between 1-5% without C3 (Command, Control, and Communications) capabilities – is unmaintainable and extremely limited in scope. Without power, the homeland is unable to coordinate a sustained campaign or replenish wartime losses, which grants even a successful American military strike a payoff of –96. Either eventuality – cyber or conventional – undermines the applicability of mutually assured destruction. The payoffs for no response revert to the baseline outcome scores for a successful, unreturnable Chinese HEMP strike.

Obviously, launching America's entire nuclear arsenal in response to a HEMP strike sparks global nuclear holocaust, but perhaps a limited nuclear reprisal is feasible. Considering a limited nuclear strike, two paths persist – one which inadvertently sparks global nuclear war, one which averts it. In either eventuality, America's nuclear strike could either A) succeed or B) fail. If a few missiles are launched, they are readily intercepted by Chinese ABM systems (97% chance, comparable to U.S. GMD system) (MDAA, 2023), but may avert worldwide nuclear war (50% chance). If more ICBMs are launched, the chances of a successful strike increase (20%), but the odds of global nuclear war also spike (90% chance). This sandwiches America between two impossible options – neither of which delivers proper retaliation. Of course, it is unlikely that America's ICBM launch capacity survives a HEMP strike in the first place, as the burst fries all low-earth-orbit navigational satellites and vast swathes of digital infrastructure. Once a

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 *directly* kill any American citizens, only the blackout's *aftermath* kills 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 *identical* 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. *attempted* retribution, 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 *equivalently* 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 *successful* 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 over China. A successful American EMP burst that ultimately culminates in little damage (–95) is slightly more desirable than a U.S. HEMP that fails to detonate (–96). No matter the eventuality, mutually assured destruction is *far* from assured, fundamentally undermining the paradigm which preserved global peace through the previous half-century. Due to a cacophony of factors stacked against a reciprocal HEMP burst causing comparable damage to China, mutually assured destruction doctrine is inapplicable to the current state of HGV-borne HEMP warfare. China retains the initiative, unequivocally.

## Nash Equilibrium for Four Salient Instances

Crunching the numbers (see Appendix A for full calculations), so long as L < 90.554, China selects the pure strategy profile of {launch, HEMP, shield factories/transformers} with an expected payoff of 90.554 if fate is favorable to America or 99.997 if fate is unfavorable. If America wields HGVs capable of delivering a reciprocal HEMP strike upon China, Washington's pure strategy profile is {attempt interception, priorly innovate HGVs} for an optimistic (i.e., favorable fate) expected payoff of –92.432 and a pessimistic (i.e., unfavorable fate) expected payoff of –99.994. Conversely, if the U.S. has not priorly innovated HGVs of our own, then the pure strategy profile becomes {attempt interception, cyberattack} with optimistic expected payoffs of (90.72, –92.56) and pessimistic expected payoffs of (99.997, –99.996). The other retaliation alternatives are even bleaker, even in the optimistic case. Traveling down the nuclear path provides America with an expected payoff of –123.1, while the conventional military response provides an expected payoff of –98.85. Horrifically, there is a distinct possibility that the game terminates before America is even capable of launching *any* of these retaliations, rendering a (100, –100) outcome.

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 affairs experts to estimate. Further research on the topic is certainly warranted – Western Civilization may depend upon it.

## Findings and Conclusion

Unfortunately, no retribution remains ideal or even viable. Mutually assured destruction fatally fractures in the advent of hypersonic HEMP warfare. A conventional military response is unsustainable without C3 capabilities or factories to replenish losses, cyberattacks are largely impossible without electricity (and their outcome's scale is uncontrollable), and traditional nuclear strikes are likely ineffective but risk global nuclear holocaust in the process. Even hypersonic parity is ultimately immaterial for HEMP considerations, as both mutually assured destruction and deterrence paradigms fatally fracture in HGV scenarios. Especially in a situation where China launches an HGV from its border with Russia, concealing the missile's nation of origin, response is essentially impossible. Uncertainty in detection and ambiguity in launcher's identity and intent clouds hypersonic HEMP reciprocation, eroding away the foundations of mutually assured destruction. The truncated timeline for a Presidential decision in the face of inbound HGVs forces abbreviated response windows, straining American retaliation capacity to the brink. In the aftermath of a HEMP burst, C3 capacities irretrievably collapse, preventing the President and military from communicating to identify the perpetrating nation and coordinate post-HEMP retaliation (or America's recovery). Even if the U.S. miraculously manages a hypersonic HEMP reprisal and it connects (i.e., avoids being fried mid-flight by the Chinese burst and is able to navigate an electrically-perturbed ionosphere), China wields the capacity to restore their urban power grid within weeks rather than months or years by either hardening their EHV transformer factories or secretly stowing away a shielded stockpile of electric grid apparatuses. Abandoning swathes of their population (especially in rural areas) to the blackout, China callously, calculatingly trades a portion of its surplus population in exchange for global hegemony. Under such circumstances, the game's Nash equilibrium shifts from maintaining the status quo (i.e., $L > 90.554$) to Beijing launching a HEMP (i.e., $L < 90.554$), effectively undermining the application of MAD and deterrence paradigms in the emergent but increasingly salient HGV domain. Harrowingly, this L-value diminishes with time as China decreasingly depends upon the United States, increasing the likelihood of a HEMP strike as time progresses. Ultimately, even if America innovates HGV-borne HEMPs identical to China's, mutually assured destruction still collapses due to the novel nature of this nascent domain and China's unique recovery ability. Overall, the first-strike instigator retains the initiative – the unequivocal advantage – in hypersonic HEMP warfare. Assiduously pursuing hypersonic weapons of our own is simply an ineffective deterrent against HGV HEMP strikes. Preventative remediation must be taken, lest our lack of imagination enable a catastrophe that eclipses even 9/11. To borrow from the 2017 Congressional EMP Commission Chairman, Dr. William Graham's, words, "The 'New Blitzkrieg' is, literally and figuratively, an electronic 'Lightning War' so potentially decisive in its effects that an entire civilization could be overthrown in hours" (Graham, 2017).

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# Appendix A – Mathematical Computations

## Expected Payoffs Calculations for Optimistic Probabilities (fate favors America)

Computations for China are in red, denoted by $P_C$. Computations for America are in blue, denoted by $P_A$. Again, fate's payoffs are all zero, and are, therefore, excluded altogether.

### Response Nodes

Conventional Military: $P_C$= 0.05(95) + 0.95(100) = 99.75 $P_A$ = 0.05(–96) + 0.95(–99) = –98.85

Nuclear:

- Sparks global nuclear war:
  $P_C$ = 0.20(–100) + 0.80(–100) = –100 $P_A$ = 0.20(–149) + 0.80(–150) = –149.8
- Avoids global nuclear war:
  $P_C$ = 0.20(20) + 0.80(100) = 84 $P_A$ = 0.20(–94) + 0.80(–97) = –96.4
- Limited nuclear strike:
  $P_C$ = 0.50(–100) + 0.50(84) = –8 $P_A$ = 0.50(–149.8) + 0.50(–96.4) = –123.1

Cyberattack: $P_C$ = 0.20(70) + 0.80(100) = 94 $P_A$ = 0.20(–93) + 0.80(–98) = –97

Hypersonic HEMP:

- Successful/Failed delivery of U.S. HGV:
  $P_C$ = 0.85(90) + 0.15(100) = 91.5
  $P_A$ = 0.85(–95) + 0.15(–96) = –95.15
  - U.S. HGVs survive HEMP burst:
  $P_C$ = 0.95(91.5) + 0.05(100) = 91.925
  $P_A$ = 0.95(–95.15) + 0.05(–100) = –95.393

Response Nodes Outcome: America selects HGV HEMP retaliation (expected payoff of –95.393), if this technology is available to Washington, otherwise, the U.S. pursues a cyberattack response (expected payoff of –97).

### Interception Nodes

Since the subgame perfect Nash equilibrium is for America to attempt interception, regardless of the incoming HGV's payload, only the "Attempt Interception" payoffs are pertinent from here through the remainder of the optimistic game tree's backwards induction process. Since China knows its missile's payload, the payload probabilities are ignored for Player 1 (China).

Scientific/spy HGV, interception attempted: $P_C$ = 0.50(5) + 0.50(3) = 4 $P_A$ = 0.50(–5) + 0.50(–1) = –3

- HEMP HGV, interception attempted (when America wields HGVs):
  $P_C$ = 0.50(–10) + 0.50(91.925) = 40.963 $P_A$ = 0.50(–10) + 0.50(–95.393) = –52.6965
- Chinese decision as to HGV payload (when America wields HGVs):
  $P_C$ = 40.963 $P_A$ = (p)( –52.6965) + (1–p)( –3) = –49.697p – 3

Alternatively, without HGVs, America attempts a cyberattack

- HEMP HGV, interception attempted (when America attempts cyberattack):
  $P_C$ = 0.50(–10) + 0.50(94) = 42 $P_A$ = 0.50(–10) + 0.50(–97) = –53.5

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

$P_C$ = 42 $P_A$ = (p)(–53.5) + (1–p)( –3) = –50.5p – 3

## Detection Nodes

If American HGV retaliation is possible:

- Sufficient time/surviving infrastructure:
  $P_C$ = 0.60(100) + 0.40(40.963) = 76.385
  $P_A$ = 0.60(–100) + 0.40(–49.697p – 3) = –19.879p – 61.2
- Nation of origin identified:
  $P_C$ = 0.20(100) + 0.80(76.385) = 81.108
  $P_A$ = 0.20(–100) + 0.80(–19.879p – 61.2) = –15.903p – 68.96
- HGV detected by USA:
  $P_C$ = 0.50(100) + 0.50(81.108) = 90.554
  $P_A$ = 0.50(–100) + 0.50(–15.903p – 68.96) = –7.952p – 84.48
  For a definitive HEMP launch, p=1, so $P_A$ = –92.432

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

- Sufficient time/surviving infrastructure:
  $P_C$ = 0.60(100) + 0.40(42) = 76.8
  $P_A$ = 0.60(–100) + 0.40(–50.5p – 3) = –20.2p – 61.2
- Nation of origin identified:
  $P_C$ = 0.20(100) + 0.80(76.8) = 81.44
  $P_A$ = 0.20(–100) + 0.80(–20.2p – 61.2) = –16.16p – 68.96
- HGV detected by USA:
  $P_C$ = 0.50(100) + 0.50(81.44) = 90.72
  $P_A$ = 0.50(–100) + 0.50(–16.16p – 68.96) = –8.08p – 84.48
  For a definitive HEMP launch, p=1, so $P_A$ = –92.56

Overall, the expected optimistic payoffs for China launching a HEMP strike upon the USA are similar, with an HGV response netting a (90.554, –92.432) and a cyberattack response scoring a (90.72, –92.56).

## Expected Payoffs Calculations for Pessimistic Probabilities (fate is unfavorable to America)

### Response Nodes

Conventional Military: $P_C$ = 0.01(95) + 0.99(100) = 99.95 $P_A$ = 0.01(–96) + 0.99(–99) = –98.97

Nuclear:

- Sparks global nuclear war:
  $P_C$ = 0.03(–100) + 0.97(–100) = –100 $P_A$ = 0.03(–149) + 0.97(–150) = –149.97
- Avoids global nuclear war:
  $P_C$ = 0.03(20) + 0.97(100) = 97.6 $P_A$ = 0.03(–94) + 0.97(–97) = –96.91
- Limited nuclear strike:
  $P_C$ = 0.90(–100) + 0.10(97.6) = –80.24 $P_A$ = 0.90(–149.97) + 0.10(–96.91) = –144.66

Cyberattack: $P_C$ = 0.05(70) + 0.95(100) = 98.5 $P_A$ = 0.05(–93) + 0.95(–98) = –97.75

Hypersonic HEMP:

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

$P_C$ = 0.30(90) + 0.70(100) = 97

$P_A$ = 0.30(–95) + 0.70(–96) = –95.7

- U.S. HGVs survive HEMP burst:

$P_C$ = 0.60(97) + 0.40(100) = 98.2

$P_A$ = 0.60(–95.7) + 0.40(–96) = –95.82

Response Nodes Outcome: America selects HGV HEMP retaliation (expected payoff of –95.82), if this technology is available to Washington, otherwise, the U.S. pursues a cyberattack response (expected payoff of –97.75).

## Interception Nodes

Since the subgame perfect Nash equilibrium is for America to attempt interception, regardless of the incoming HGV's payload, only the "Attempt Interception" payoffs are pertinent from here through the remainder of the pessimistic game tree's backwards induction process. Since China knows its missile's payload, the payload probabilities are ignored for Player 1 (China).

Scientific/spy HGV, intercept attempted: $P_C$ = 0.01(5) + 0.99(3) = 3.02 $P_A$ = 0.01(–5) + 0.99(–1) = –1.04

- HEMP HGV, interception attempted (when America wields HGVs):
  $P_C$ = 0.01(–10) + 0.99(98.2) = 97.118 $P_A$ = 0.01(–10) + 0.99(–95.82) = –94.962
- Chinese decision as to HGV payload (when America wields HGVs):
  $P_C$ = 97.118 $P_A$ = (p)( –94.962) + (1–p)( –1.04) = –93.922p – 1.04

Alternatively, without HGVs, America attempts a cyberattack

- HEMP HGV, interception attempted (when America attempts cyberattack):
  $P_C$ = 0.01(–10) + 0.99(98.5) = 97.415 $P_A$ = 0.01(–10) + 0.99(–97.75) = –96.873
- Chinese decision as to HGV payload (when America attempts cyberattack):
  $P_C$ = 97.415 $P_A$ = (p)(–96.873) + (1–p)( –1.04) = –95.833p – 1.04

## Detection Nodes

If American HGV retaliation is possible:

- Sufficient time/surviving infrastructure:
  $P_C$ = 0.90(100) + 0.10(97.118) = 99.712
  $P_A$ = 0.90(–100) + 0.10(–93.922p – 1.04) = –9.392p – 90.104
- Nation of origin identified:
  $P_C$ = 0.95(100) + 0.05(99.712) = 99.986
  $P_A$ = 0.95(–100) + 0.05(–9.392p – 90.104) = –0.470p – 99.505
- HGV detected by USA:
  $P_C$ = 0.75(100) + 0.25(99.986) = 99.997
  $P_A$ = 0.75(–100) + 0.25(–0.470p – 99.505) = –0.118p – 99.876
  For a definitive HEMP launch, p=1, so $P_A$ = –99.994

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

- Sufficient time/surviving infrastructure:
  $P_C$ = 0.90(100) + 0.10(97.415) = 99.742
  $P_A$ = 0.90(–100) + 0.10(–95.833p – 1.04) = –9.583p – 90.104
- Nation of origin identified:
  $P_C$ = 0.95(100) + 0.05(99.742) = 99.987
  $P_A$ = 0.95(–100) + 0.05(–9.583p – 90.104) = –0.479p – 99.505
- HGV detected by USA:
  $P_C$ = 0.75(100) + 0.25(99.987) = 99.997
  $P_A$ = 0.75(–100) + 0.25(–0.479p – 99.505) = –0.120p – 99.876
  For a definitive HEMP launch, p=1, so $P_A$ = –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) and a cyberattack response scoring a (99.997, –99.996).