CITY BUSTING, THE NUCLEAR WEAPONS REVOLUTION, AND PRECISION GUIDANCE

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QUESTIONS TO BE ADDRESSED:

I. How was city busting viewed and done before and during WWII?

II. The nuclear weapons revolution: How was it first viewed? Why, initially, did developing ever larger nuclear weapons seem logical?

III. Precision guidance: How did its advent constitute a counter revolution and how has it affected nuclear weapons deployments?

IV. City busting: How is its morality still an issue today?

BRIEF ANSWERS

- I. Before WWII, city busting was done reluctantly and poorly. During WWII, it was done enthusiastically and brutally.
- II. The nuclear weapons revolution was an extension operationally of conventional city busting. Initially, ever larger yields seemed attractive for destroying larger portions of major cities.
- III. Precision guidance eliminated the need to rely on massive yields to destroy point targets. By the 80s, both Russian and U.S. deployed nuclear forces declined precipitously both in size and destructiveness.
- IV. When things go badly, we may still be tempted to kill large numbers of innocents.

I. HOW WAS CITY BUSTING VIEWED AND DONE BEFORE AND DURING WWII?

UNTIL MODERNITY, MILITARY THINKERS FROWNED UPON TARGETING CITIES

Sun Tzu, The Art of War, 500 BC

To subdue the enemy without fighting is the supreme excellence. Thus, what is of supreme importance in war is to attack the enemy's strategy. Next best is to disrupt his alliances by diplomacy. The next best is to attack his army. And the worst policy is to attack cities.

SHERMAN'S MARCH TO THE SEA: PRECURSOR TO CITY BUSTING



SHERMAN'S MARCH TO THE SEA: MORE DISCRIMINATE THAN GENERALLY PORTRAYED

ATLANTA, GEORGIA *Field Artillery and Fire* A six-month campaign Few, if any civilians, killed

Residences, churches, and hospitals spared





FRENCH SUBMARINE WARFARE THEORY:

FIRST MODERN MUSINGS ON STRATEGIC WEAPONRY

FRENCH NAVAL THEORY WAS CATALYZED BY J. VERNES' 20,000 LEAGUES UNDER THE SEA













FRENCH HOPED SUBMARINES MIGHT HELP NEUTRALIZE UK & ITS FLEET BY BLOCKADE



Gymnote class



Narval







Sirene class

GUSTAVE ZEDE SUBMARINE SINKS BATTLESHIP IN 1898



GERMAN UNRESTRICTED SUB WARFARE IN WWI, THOUGH, HAD MIXED RESULTS



WORLD WAR I TRENCH WARFARE:

ITS HORRORS REKINDLED INTEREST IN ATTACKING POLITICAL CAPITALS DIRECTLY

PITTING MILITARY AGAINST MILITARY: BATTLE OF THE SOMME WORLD WAR I

Trench Warfare, 4-plus months 300,000-plus dead Produced no strategic results







ZEPPELIN RAIDS: 1ST GERMAN ATTEMPT AT STRATEGIC AIR ATTACKS





GOTHA RAIDS: 2ND GERMAN ATTEMPT AT STRATEGIC AERIAL BOMBING WORLD WAR I

Conventional Bombs, 857 dead



INTERWAR AERIAL THEORISTS CHAMPION STRATEGIC BOMBING



Giulio Douhet

Hugh Trenchard

Billy Mitchell

RAF INTERWAR EXPERIENCE BACKED AIR POWER THEORIES



Waziristan - India's Northwest Frontier



Kurdistan



British Somaliland



DITTO, ITALIAN AERIAL BOMBINGS IN SECOND ITALO-ETHIOPIAN WAR









1937 GERMAN AND ITALIAN BOMBING OF GUERNICA: CLAIMED "MISTAKES"

Three quarters of the town destroyed Casualties: 300 civilians







JAPANESE BOMBING OF CHONGQING, CHINA, 1938: FIRST INTENTIONAL AREA BOMBING





Two days of incendiary bombings Casualties: 5,000 civilians

INITIAL WWII EXPERIENCE: FAILED ATTEMPTS AT PRECISION BOMBING

EARLY CITY BUSTING: POLITICAL REACTIONS AND "MISTAKES"



Wieluń, Poland: September 1939 Casualties: Several Hundred



Berlin: August 1940



Rotterdam: May 1940 Casualties: 900



Battle of Britain: Fall 1940 Casualties: Over 30,000

INITIALLY, RAF DAY-TIME RAIDS ON DEFENDED, FORTIFIED U-BOAT PENS HAD LITTLE SUCCESS



RAF NIGHT-TIME RAIDS OF INDUSTRIAL TARGETS WERE HIGHLY INACCURATE



The area around this rail yard is marked by stray bombs

BUTT REPORT SPOTLIGHTS BOMBING INACCURACIES AUGUST 1941

- Initially, RAF Bomber Command relied on crews' claims regarding how much damage they inflicted.
- By 1941, though, the Air Ministry developed infrared cameras that could be attached to the bombers to take aerial photographs of the targets being bombed.
- Lord Cherwell, Churchill's science advisor, instructed D.M. Butt of the War Dept. Secretariat to conduct a study of RAF German bombing runs using these cameras.
- Butt compared the damage reported by the bomber crews with that shown by night-time aerial photos taken of 633 targets in June and July of 1941.
- Report revealed only 10% of the bombers flying against night-time Ruhr industrial sites found their way to within 75 square miles of their intended targets, (let alone the 1,000 yards pilots claimed). Of all the bombing operations examined, only 5% of the bombers got as close to their targets.

CIRCLE OF ERROR PROBABLE (CEP): HOW WE MEASURE BOMBING AND MISSILE ACCURACY

CEP is the radius that describes a circle with the target at its center within which 50% of the bombs dropped or weapons aimed will fall.



THE DEHOUSING PAPER: RATIONALE FOR BOMBING INNOCENTS

MARCH 30, 1942

- The Butt Report prompted a debate over whether to reduce the bombing effort and transfer resources to the Army and Navy or to continue the bombings as before.
- In response, Lord Cherwell produced another study, the "Dehousing Paper," which argued that given the RAF's limited success in destroying precise targets, the most effective use of the bombers would be to destroy German housing because it would affect German morale.
- The Dehousing Paper estimated that if the UK dedicated 5,000 bombers to the task, they could turn one-third of Germany's population "out of house and home" by mid 1943.

COLOGNE: FIRST 1,000-BOMBER RAID

<500 KILLED, *MAY 30-31, 1942*



OPERATION GOMORRAH: FIRE BOMBING OF HAMBURG: 40,000+ KILLED, 1 MILLION HOMELESS

JULY 24-AUGUST 3, 1943



RAID ON DRESDEN: POSTER CHILD FOR CITY BUSTING

FEBRUARY 13-15, 1945 H.E. AND INCENDIARY BOMBS



25,000 INNOCENTS KILLED AS MILITARY TARGETS









DEADLIER STILL: U.S. FIREBOMBING OF TOKYO WORLD WAR II Firebombing, 85,000-100,000 dead





HIROSHIMA: LOGICAL CONCLUSION OF CITY BUSTING WORLD WAR II

Nuclear Bomb, 90-146,000 dead by December 1945, over 200,000 by 1950







II. THE NUCLEAR WEAPONS REVOLUTION: HOW WAS THE REVOLUTION FIRST VIEWED?

DESTRUCTIVE EFFICIENCY: FROM SIX MONTHS TO A SECOND



Atlanta, Civil War (took 6 months)



Tokyo fire bombing, WWII (took <u>3 hours</u>)



Dresden, WWII (took 2 days)


FORCES REQUIRED: FIRST ARMIES THEN JUST A SINGLE BOMBER

- **Battle of Atlanta**: ~75,000 troops; ~ 9,000 military casualties
- Fire Bombing of Dresden: >1,200 bombers, >800 fighters;
 8 bombers lost
- Fire Bombing of Tokyo: 334 B-29 bombers; 14 bombers lost
- Hiroshima: One B-29; no bomber losses

WHY, INITIALLY, DID DEVELOPING EVER LARGER NUCLEAR WEAPONS SEEM LOGICAL?

N. KOREA: US DROPPED MORE BOMBS ON IT THAN ON THE ENTIRE WWII PACIFIC THEATER, KILLED 1 MILLION OR MORE



CURTIS LEMAY ON TARGETING CIVILIANS

"There are no innocent civilians. It is their government and you are fighting a people, you are not trying to fight an armed force anymore. So it doesn't bother me so much to be killing the so-called innocent bystanders."

Sherry, Michael (September 10, 1989). *The Rise of American Air Power: The Creation of Armageddon*, p. 287 (from "LeMay's interview with Sherry," interview "after the war," p. 408 n. 108). Yale University Press

"We went over there and fought the war and eventually burned down every town in North Korea anyway, someway or another, and some in South Korea too.... Over a period of three years or so, we killed off — what — twenty percent of the population of Korea..."

Kohn and Harahan, eds. Strategic Air Warfare: An Interview with Generals Curtis E LeMay, Leon W. Johnson, David A. Burchinal, and Jack J. Catton, 88. Washington DC: Office of Air Force History, 1988.

EARLY COLD WAR THOUGHTS ON TARGETING CITIES

America's Strategic Air Command's Nuclear Target List in the mid 50s listed 1200 cities in the Soviet bloc

https://nsarchive2.gwu.edu/nukevault/ebb538-Cold-War-Nuclear-Target-List-Declassified-First-Ever/

"...it seems reasonable to assume that the destruction of, say, 25 percent of [the Soviet Union's] population (55 million people) and more than two-thirds of its industrial capacity... should serve as an effective deterrent."

> Defense Secretary McNamara Memo to Pres. Kennedy Nov. 21, 1962

QUANTIFYING THE NUCLEAR REVOLUTION: EARLY YEARS AND THE EXPLOSIVE INCREASE IN YIELDS

INCREASES IN MAJOR CONVENTIONAL AND NUCLEAR BOMB YIELDS: 1941 - 1961

• **500-lb nominal WWII bomb** (which carried about 113 kilograms of high explosive)

• **Grand Slam** (conventional bomb)—the largest conventional bomb used in WWII. It weighed 10 metric tons (10,000 kilograms) and carried 4,090 kilograms of high explosive (0.004 kt)

• **MOAB** (US conventional bomb named Massive Ordinance Air Blast) & FOAB (Russian conventional bomb, named The Father of All Bombs, also a fuel air explosive device)—roughly 11-44 tons of high explosive (0.011-.044 kt)

• Little Boy (Hiroshima)—uranium gun-barrel bomb had a yield of approximately 15 kt.

• Item Shot (boosted device)—it had a yield of 45.5 kt

• **Ivy Mike** (first thermonuclear weapons test)—had a yield of 10.4 mt and led to eventual deployment of an operational bomb, the B53 that had a yield of 9 mt.

• Tsar Bomba (nonoperational thermonuclear weapon)—had a yield of 50 mt

VISUALIZING A KILOTON



Source: Visualizing the Frightening Power of Nuclear Weapons http://www.visualnews.com/2012/04/24/visualizing-the-frightening-power-of-nuclear-bombs

VISUALIZING YIELDS OF SPECIFIC MUNITIONS

~4.1 tons = 0.0041 kilotons



15,000 tons = 15 kilotons



45,500 tons = 45.5 kilotons



CONTINUED



CONTINUED

IVY MIKE 10,400 KILOTONS FIRST FUSION DEVICE TEST (USA)

10,400,000 tons = 10,400 kilotons = 10.4 megatons TSAR BOMBA 50,000 KILOTONS



50,000,000 tons = 50,000 kilotons = 50 megatons

LOGARITHMIC PORTRAYAL OF INCREASING YIELDS: 1941-1961



HOW YIELD RELATES TO BLAST/LETHAL AREA

BLAST EFFECTS: ABOVE 2 PSI IS SIGNIFICANT

- 20 psi Heavily built concrete buildings are severely damaged or demolished; fatalities approach 100%.
- ¹⁵ psi Complete destruction of reinforced concrete structures, such as skyscrapers, will occur within this ring. Between 7 psi and 15 psi, there will be severe to total damage to these types of structures.
 - ⁷ psi Severe damage to complete destruction of reinforced concrete structures, such as skyscrapers, will occur within this ring.
- ⁵ psi Complete destruction of ordinary houses, and moderate to severe damage to reinforced concrete structures, will occur within this ring.
- ^{2 psi} Severe damage to ordinary houses, and light to moderate damage to reinforced concrete structures, will occur within this ring.
- ^{1 psi} Light damage to all structures, and light to moderate damage to ordinary houses, will occur within this ring.

BLAST AREA HIROSHIMA FISSION BOMB (15 KT), AIR BURST, 3,000 FT



BLAST AREA ITEM SHOT: FIRST BOOSTED-FISSION DEVICE (45.5 KT)



Estimated fatalities: 165,290 Estimated injuries: 287,600

In any given 24-hour period, there are on average 817,953 people in the light (1 psi) blast range of the simulated detonation.

Effect radii for 45.5 kt airburst

Air blast radius (20 psi): 340 m (0.36 km²)

Air blast radius (5 psi): 2.48 km (19.4 km²)

Thermal radiation radius (3rd degree burns): 3.261 km (33.5 km²)

BLAST AREA IVY MIKE: FIRST U.S. THERMONUCLEAR TEST (10,400 KT OR 10.4 MT)



SURFACE BLAST AREA

TSAR BOMBA: LARGEST SOVIET THERMONUCLEAR BOMB (50,000 KT OR 50 MT)



QUALIFYING THE NUCLEAR REVOLUTION: LETHAL AREA AND ITS RELATION TO YIELD

LETHAL AREA: ONLY A FRACTION OF A BOMB'S YIELD IMPACTS THE TARGET

Lethal Area describes a circle of a given amount of damage caused by a weapon's blast. Energy from a large explosive is released as a sphere, as a result much of it is both released in the air and "overkills" the target. Therefore, increasing the yield of the weapon does not directly increase the lethal area.



HOW YIELD RELATES TO LETHAL AREA

- The radius of the lethal area is proportional to the cube root of the weapon's yield, or $y^{1/3}$.
- Increasing the yield of a nuclear weapon does not directly increase its lethal radius but instead is subject to the y^{1/3} rule.

EXAMPLE:

If you increase your weapon's yield 1,000 fold, from 1kt to 1mt, you do not increase the lethal radius 1,000 fold (which would suggest a lethal radius that would reach from Washington, D.C. to Chicago) but only 10 fold (from downtown Washington, D.C. to Bethesda, MD).

Lethal Radius (LR) = Constant x y^{1/3}

For a 1kt weapon:	For a 1,000kt (1mt) weapon:
LR= 1 ^{1/3}	LR= 1,000 ^{1/3}
1 ^{1/3} = ∛1	$1,000^{1/3} = \sqrt[3]{1,000}$
LR = ~1km	LR = ~10km

AS A RESULT:

Increasing the yield of your weapon 1,000 fold, for example from 1kt to 1mt, only increases the lethal radius 10 fold.



1kt Yield Air Blast

Air blast radius (20 psi): 280 m (0.25 km²)

Air blast radius (3 psi): 0.99 km (3.08 km²)

1,000kt (1mt) Yield Air Blast



Air blast radius (20 psi): 2.82 km (25 km²)
 Air blast radius (3 psi): 9.91 km (308 km²)

U.S. CIVIL DEFENSE OFFICIALS USED BLACKETT'S ARGUMENTS

"Doubling bomb power does not double destruction"

"...if there were a bomb 100 times as powerful, it would reach out only a little more than $4^{1}/_{2}$, not 100 times as far."



"Beyond 2 miles, the explosion will cause practically no deaths at all."

"At Nagasaki, almost 70 percent of the people a mile from the bomb lived to tell their experiences."

III. PRECISION GUIDANCE: A COUNTER-REVOLUTION HOW HAS IT AFFECTED NUCLEAR WEAPONS DEPLOYMENTS?

AIMING INACCURACIES, 1941-2011: A THOUSAND FOLD REDUCTION



26,400 ft in 1941 vs roughly 2-3 ft today

CEP REVISITED

CEP is the radius that describes a circle with the target at its center within which 50% of the bombs dropped or weapons aimed will fall.



INCREASING AIMING ACCURACY DRAMATICALLY REDUCES THE NUMBER OF NUCLEAR WEAPONS NEEDED TO DESTROY A POINT TARGET

- For a probability of destruction (P_k) of <u>> 90%</u>
 with a 1kt yield weapon with a lethal area (LR) of 1km
- If CEP is 10km then 333 weapons are required
- If CEP is 1km then four weapons are required
- If CEP is .5km then one weapon is required

APRIL 27, 1972: 1ST CLEAR, PRACTICAL OF PRECISION GUIDED MUNITIONS (PGMS)

Laser-guided bombs, delivered by eight bombers Previous efforts to destroy the bridge entailed over 800 failed sorties







Thanh Hóa Bridge

TODAY, WITH PRECISION GUIDANCE, INNOCENTS NEED NOT SUFFER



R9X "The Flying Ginsu", Syria February 2017

PRECISION GUIDANCE MADE RELIANCE ON LOWER YIELD WARHEADS POSSIBLE

1962: Titan II W53 warhead 9 mt



1985: Pershing II W85 5 kt



...AS WELL AS MAJOR REDUCTIONS IN TOTAL U.S.-RUSSIAN ARSENAL WARHEADS & MEGATONNAGE

How U.S. And Russian Nuclear Arsenals Evolved

Estimated stockpiled nuclear warhead count by year*



* Excludes currently deployed warheads. Refers to active/inactive warheads in military custody and earmarked for future use. Source: Federation of American Scientists

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statista 🗹

https://www.statista.com/chart/16305/stockpiled-nuclear-warhead-count/



http://www.johnstonsarchive.net/nuclear/nwhmt.html

IV. CITY BUSTING: ITS MORALITY IS STILL AN ISSUE TODAY

THE PRINCIPLE OF PROPORTIONALITY

"[A]n attack which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated" violates the principle of proportionality.

Art 51 (5)(b)

Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977.

TARGETING CITIES TO MAKE FURTHER REDUCTIONS

"....the British have forsaken military targets and will achieve deterrence by threatening, explicitly or implicitly, to destroy the enemy's cities, industrial centers, and communications...It would appear that all the nuclear powers will have to follow the United Kingdom if or as they move toward a world without nuclear weapons.*The shift from military to civilian targeting, which seems barbaric, thus may be a feature of the path to 'global zero'* along with the phased, verified elimination of nuclear weapons."

Harold Smith and Raymond Jeanloz, "Britain Leads the Way to Global Zero," *Arms Control Today,* December 2010. (Emphasis added)

VALUE OF "STATIONARY" TARGETS (FROM 21:49 -- 22:56)


A REAL QUESTION FOR U.S. POLICY UNDER OBAMA

"A much steeper reduction, to around 500 warheads total, was debated within the administration but rejected, sources said. *Known as the 'deterrence-only' plan, it would have aimed U.S. warheads at a narrower range of targets related to the enemy's economic capacity* and no longer emphasized striking the enemy's leadership and weaponry in the first wave of an attack.... *Obama...'decided we did not need to do deterrence-only targeting now,' but did not rule it out.*"

R. Jeffrey Smith, "Obama Administration Embraces Major New Nuclear Weapons Cut," *Center for Public Integrity*, February 8, 2013. (Emphasis added)

AMERICANS STILL WILLING TO BOMB CITIES: IRAN

Hypothetical Scenario:

Iranians strike U.S. aircraft carrier conventionally, killing 2,403 Americans

Polled Response:

- 59.1% of Americans willing to nuclear bomb Tehran, killing 2 million civilians
- 63.1% of Americans willing to conventionally bomb Tehran, killing 100,000 civilians

<u>Study by Scott Sagan and Benjamin Valentino, "Revisiting Hiroshima in Iran"</u> 2017

AMERICANS STILL WILLING TO BOMB CITIES: N. KOREA

- 33% of Americans "preferred" a preventative nuclear first-strike.
 - There is no significant change in the percentage that prefer if North Korean fatalities increase from 15,000 to 1.1 million, including 1 million civilians.
- While only 33% "preferred" preventative nuclear first-strikes, 50% of respondents *approved*

 This assumes the success of a preventive strike remains at 90%. At 50%, support halves.

Study by Alida Haworth, Scott Sagan, and Benjamin Valentino, What do Americans really think about conflict with nuclear North Korea? June 2019

WHICH IS A WAR CRIME, WHICH IS A LEGITIMATE "PROPORTIONAL" ACT OF MILITARY "ADVANTAGE"?





ADDITIONAL SLIDES



FIREBOMBING OF DRESDEN A CENTRAL EVENT IN SLAUGHTERHOUSE-FIVE, BY KURT VONNEGUT





YIELD

- Yield = The amount of energy released by a weapon when detonated.
- Nuclear weapon yields are expressed as the amount of TNT needed to achieve the same energy discharge.
- The detonation of a nuclear weapon with a yield of one ton (i.e., .001 kilotons, or kt)
 = the energy released by the detonation of 1,000 kilograms (kg) of TNT.
- The detonation of a nuclear weapon with a yield of one kiloton (1 kt) = the energy released by the detonation of one million (1,000,000) kg of TNT.
- The detonation of a nuclear weapon with a yield of one megaton (mt) = the energy released by the detonation of one billion (1,000,000,000) kg of TNT.

INCREASES IN BOMB YIELDS: 1941-1961

Weapon Description/Name	Yield (kt)	Year
WWII high explosive (H.E.) 500-lb bomb	~0.000117	1941
Largest WWII H.E. bomb (Grand Slam)	~0.0041	1944
Hiroshima pure fission bomb (Little Boy)	15	1945
First U.S. boosted-fission device (Item Shot)	45.5	1951
First U.S. thermonuclear weapons test (Ivy Mike)	10,400	1952
Largest Soviet thermonuclear bomb (Tsar Bomba)	50,000	1961

EXAMPLE:

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LR = ~1km	LR = ~10km

PROBABILITY OF DESTROYING A TARGET (P_{K}) INCREASES DRAMATICALLY AS YOU INCREASE AIMING ACCURACIES

- Aiming accuracy depends on the relation of $\frac{LR}{CEP}$
- So, for a weapon with a LR of 1km:
- If CEP is $2km = P_{K} \sim 16\%$
- If CEP is $1 \text{km} = P_{\text{K}} 50\%$
- If CEP is $.5km = P_{K} \sim 94\%$

DISTINGUISHING BETWEEN CIVILIAN AND MILITARY TARGETS

"In order to ensure respect for and protection of the civilian population and civilian objects, the Parties to the conflict shall at all times distinguish between the civilian population and combatants and between civilian objects and military objectives and accordingly shall direct their operations only against military objectives."

<u>Art 48</u>

Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977.