

FROM HIROSHIMA TO TODAY

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GOOD MORNING. I AM VERY PLEASED TO BE ABLE TO BE HERE AND TO GIVE THIS TALK IN THE CONTEXT OF TECHNOLOGY AND THE HUMAN CONDITION. IT IS A SUBJECT THAT HAS FASCINATED ME FOR MANY YEARS. AN UNDERSTANDING OF THE RELATIONSHIP BETWEEN THE TWO IS OF THE UTMOST IMPORTANCE FOR AN INFORMED PUBLIC. MANY PEOPLE SEE ONLY THE NEGATIVE ASPECTS OF TECHNOLOGY, BELIEVING THAT ITS IMPACT ON THEIR LIVES IS OFTEN DETRIMENTAL: EXAMPLES ARE THE DEGRADATION OF THE ENVIRONMENT DUE TO INDUSTRIAL POLLUTION AND THE DESTRUCTION OF SENSITIVE NATURAL ECOSYSTEMS; MANY COMPLAIN THAT HAVING SOCIETY ORGANIZED AROUND THE AUTOMOBILE AND THE OMNIPRESENT TELEVISION FORCES US INTO AN UNHEALTHY LIFESTYLE. WHILE THE IRRESPONSIBLE USE OF TECHNOLOGY CAN INDEED HAVE BAD EFFECTS, I WOULD ARGUE THAT THE HUMAN CONDITION IS OVERWHELMINGLY BENEFITED BY SCIENCE AND TECHNOLOGY.

PERHAPS THE MOST OBVIOUS POINT TO BE MADE IS THAT IT IS MODERN AGRICULTURE THAT ALLOWS US TO BE HERE RATHER THAN WORKING IN THE FIELDS TO PRODUCE ENOUGH FOOD. THIS IS NOT A TRIVIAL POINT: IT WAS NOT SO LONG AGO THAT MOST PEOPLE WERE SO INVOLVED. FOR EXAMPLE, IN 1860 CLOSE TO 60% OF THE U.S. POPULATION WAS ENGAGED IN AGRICULTURE. TODAY, BECAUSE OF MODERN TECHNOLOGY, AMERICA HAS LESS THAN 4% OF ITS PEOPLE

SO EMPLOYED—FREEING THE REST OF US TO ENGAGE IN OTHER PURSUITS. THIS IS NOT THE CASE IN MOST OF THE REST OF THE WORLD. BUT TECHNOLOGY IS OFTEN A TWO-EDGED SWORD, AND BECAUSE ITS IRRESPONSIBLE USE CAN HAVE DELETERIOUS EFFECTS, WE REMAIN IGNORANT OF SCIENCE AND TECHNOLOGY AT OUR PERIL.

DURING THIS CENTURY, PEOPLE LIVING IN DEMOCRATIC SOCIETIES ARE GOING TO HAVE TO MAKE DECISIONS ON A VARIETY OF ISSUES THAT REQUIRE THEM TO HAVE SOME KNOWLEDGE OF SCIENCE AND TECHNOLOGY, AS WELL AS AN ABILITY TO THINK QUANTITATIVELY. THESE RANGE FROM CHOOSING SOURCES OF ENERGY TO MODIFYING THE HUMAN GENOME. IN THE PIPELINE ALREADY IS WHAT IS CALLED THERAPEUTIC CLONING AND THE EXTENSION OF LIFETIMES WITH ITS ENORMOUS SOCIAL AND POLITICAL IMPLICATIONS. DECISIONS ON THESE ISSUES WILL BE MADE. THE QUESTION IS BY WHOM. THAT IS WHY, IN A DEMOCRACY, IT IS NOT ACCEPTABLE THAT ONLY SOME 5 PERCENT OF THE POPULATION ARE SCIENTIFICALLY LITERATE.

I REMEMBER BACK IN 1979 WHEN I SERVED AS AN EXPERT WITNESS IN A FIRST AMENDMENT CASE WHERE NUCLEAR WEAPONS SECRETS COULD BE PUBLICLY RELEASED, SOMEONE SAID, “NEVER MIND ABOUT THE HYDROGEN BOMB SECRET, TO MOST PEOPLE THERE IS STILL AN ELECTRICITY SECRET.” THAT HASN’T CHANGED.

MODERN SCIENCE AND TECHNOLOGY HAVE ALSO HAD AN ENORMOUS IMPACT ON WARFARE. WHILE HIGHLY ACCURATE MUNITIONS HAVE DOMINATED THE NEWS IN THE LAST TWO U.S. CONFLICTS, THERE ARE MANY MORE REVOLUTIONARY DEVELOPMENTS ON THE HORIZON. TODAY, HOWEVER, I WILL FOCUS ON THE IMPACT OF NUCLEAR WEAPONS SINCE WW-II. IN DOING SO, I WILL SHOW YOU THAT IT IS

NOT ONLY WHAT WE KNOW ABOUT TECHNOLOGY THAT AFFECTS SOCIETY, BUT WHAT WE SCIENTISTS DON'T KNOW.

AT THE END OF WW-II WE HAD USED OUR ONLY TWO NUCLEAR WEAPONS TO BOMB HIROSHIMA AND NAGASAKI. BY THE END OF THE COLD WAR BOTH THE SOVIET UNION AND THE UNITED STATES HAD MANY THOUSANDS OF WEAPONS THAT COULD BE IRRETRIEVABLY LAUNCHED IN MINUTES. SINCE IT TOOK ONLY ONE OR TWO WARHEADS TO DESTROY ANY CITY IN THE WORLD, HOW DID WE END UP WITH SO MANY? I WILL SHOW YOU THAT THE OFFENSIVE ARMS RACE—WHILE IT MAY HAVE BEEN A MORAL FAILURE—WAS NOT A POLICY FAILURE, BUT TO A LARGE EXTENT A RESULT OF TECHNOLOGICAL IMPERATIVES AND IGNORANCE. I WILL ALSO SHOW YOU THAT THE RESULTING ARSENAL CONTAINING LARGE NUMBERS OF NUCLEAR WEAPONS WAS NOT IN AND OF ITSELF THE PRINCIPAL SOURCE OF DANGER. AND FINALLY, I WILL GIVE A VERY CURRENT EXAMPLE OF HOW A LITTLE TECHNICAL INFORMATION CAN HELP ONE UNDERSTAND TODAY'S DEBATES ON NUCLEAR WEAPONS POLICY.

EVEN WITHOUT THE REVOLUTIONARY MILITARY TECHNOLOGIES ON THE HORIZON, WE HAVE ALREADY COME A LONG WAY. IN 1939 WHEN WW-II STARTED IN EUROPE, THE U.S. WAS STILL IN THE GRIP OF THE GREAT DEPRESSION; IT HAD AN ARMY OF ONLY 174,000 THAT LACKED RIFLES AND AMMUNITION, AND STILL RELIED ON HORSES FOR TRANSPORT. BY THE END OF WW-II THE U.S. WAS THE PREEMINENT MILITARY POWER IN THE WORLD, ONE THAT HAD DEVELOPED AND USED THE FIRST NUCLEAR WEAPONS. AFTER THE WAR, THE GREATEST FEAR MANY WEST EUROPEAN AND AMERICAN LEADERS HAD WAS THAT THE U.S.—AS THE ONLY NUCLEAR POWER—WOULD RETREAT INTO ISOLATIONISM AS IT DID AFTER WW-I. IT WAS THE

BRITISH WHO FINALLY SUCCEEDED IN DRAWING AMERICA INTO AGREEING TO THE FORMATION OF NATO IN 1949.

TO PROVIDE AN EXAMPLE OF WHAT I MEAN WHEN I SAY TECHNOLOGY IS ITS OWN IMPERATIVE, LET'S RETURN TO THE WAR ITSELF AND ASK HOW IT WAS THAT CITIES AND THEIR POPULATIONS BECAME MILITARY TARGETS IN VIOLATION OF INTERNATIONAL CONVENTIONS.

THE BOMBING OF CIVILIANS WAS INEVITABLE GIVEN THE DEVELOPMENT OF THE AIRPLANE. HISTORICALLY—AND IRONICALLY, HOWEVER, IT BEGAN AS AN ACCIDENT IN 1940 WHEN A LOST GERMAN PILOT BOMBED NON-MILITARY SECTIONS OF LONDON: IN RETALIATION, THE BRITISH BOMBED BERLIN THE NEXT DAY. AND IN RESPONSE HITLER ORDERED THE FULL SCALE BOMBING OF LONDON AND OTHER CITIES.

A FEW YEARS AGO I HAD THE OPPORTUNITY OF VISITING A NUMBER OF JAPANESE CITIES AS PART OF SOME WORK FOR THE INTERNATIONAL ENERGY AGENCY. AS I TOURED FOUR OF THE ISLANDS OF JAPAN I NOTICED THAT MANY OF THE ANCIENT SITES I WAS SEEING HAD BEEN REBUILT SOME TIME IN THE 1950s OR 1960s. THE REASON FINALLY STRUCK ME: THE FIREBOMBING DURING WW-II. AROUND 100,000 TONS OF INCENDIARIES WERE DROPPED BETWEEN MARCH AND JULY OF 1945 ON SIXTY SOME JAPANESE CITIES. HOW THIS CAME ABOUT IS AN INTERESTING STORY FROM THE EARLY DAYS OF OPERATIONS ANALYSIS. GENERAL CURTIS LEMAY HAD FINALLY SUCCEEDED IN ACQUIRING AN AIRPLANE THAT COULD PENETRATE JAPANESE AIR DEFENSES—AT A COST GREATER THAN THAT OF THE MANHATTAN PROJECT—ONLY TO FIND THAT IT WAS NOT VERY EFFECTIVE IN DESTROYING JAPAN'S MILITARY CAPACITY AND WILL

TO FIGHT. THE B-29 WAS DESIGNED FOR HIGH-ALTITUDE, DAYLIGHT PRECISION BOMBARDMENT, USING HIGH-EXPLOSIVE BOMBS DROPPED FROM HEAVILY ARMED FORMATIONS OF PLANES ABLE TO DEFEND THEMSELVES. WHEN LEMAY ASKED THE OPERATIONS RESEARCH PEOPLE TO EXAMINE THE PROBLEM OF THE BOMBER'S INEFFECTIVENESS, THEY RECOMMENDED NIGHTTIME CARPET BOMBING OF JAPANESE CITIES WITH INCENDIARIES RATHER THAN PRECISION BOMBING OF WAR-SUPPORTING INDUSTRIES (REMEMBER, IN THOSE DAYS PRECISION BOMBING MEANT YOU WERE LUCKY IF YOU COULD HIT A BUILDING). HERE WE HAVE AN EXAMPLE OF BOTH A POLICY DECISION—THE IDEA BEING TO RAISE THE HUMAN TOLL AND THUS WEAKEN THE WILL TO FIGHT—AND A TECHNOLOGICAL IMPERATIVE SINCE PRECISION BOMBING WITH HIGH EXPLOSIVES WAS UNABLE TO DESTROY JAPAN'S WAR SUPPORTING INDUSTRY.

JAPANESE CIVILIAN CASUALTY ESTIMATES RESULTING FROM THIS CHANGE IN OPERATIONS RANGE FROM ABOUT HALF A MILLION TO WELL OVER A MILLION. SOME 10 TO 20 MILLION PEOPLE WERE ALSO RENDERED HOMELESS. THIS SHOULD BE COMPARED WITH THE APPROXIMATELY 350,000 PEOPLE WHO ULTIMATELY LOST THEIR LIVES AS A RESULT OF THE BOMBINGS OF HIROSHIMA AND NAGASAKI.

YET WE REMEMBER HIROSHIMA AND NAGASAKI, NOT THE BOMBING OF THE OTHER SIXTY SOME CITIES. WHY? THERE IS A GOOD REASON. WE REMEMBER HIROSHIMA BECAUSE IT MARKED THE BEGINNING OF AN ERA WHERE MODERN CIVILIZATION COULD NOT SURVIVE AN ALL OUT WAR. THE HORRORS OF WW-II AND I PALED IN COMPARISON WITH WHAT MIGHT BE. HIROSHIMA BECAME THE POSSIBLE FUTURE OF ALL CITIES.

GIVEN THE ENORMOUS DESTRUCTIVNESS OF NUCLEAR WEAPONS, IT WOULD SEEM THAT ACCURACY TO THE LEVEL OF INDIVIDUAL BUILDINGS WOULD NOT BE IMPORTANT, NOR WOULD VERY MANY BE REQUIRED FOR THE DEFENSE OF THE COUNTRY. YET WE ENDED UP WITH MANY THOUSANDS, MANY CARRIED BY HIGHLY ACCURATE BALLISTIC MISSILES.

PERHAPS THE MOST IMPORTANT STUDY OF HOW THE U.S. CAME TO DEPLOY THESE THOUSANDS OF WEAPONS IS THE SPRING 1983 ARTICLE IN *INTERNATIONAL SECURITY* WRITTEN BY DAVID ROSENBERG AND CALLED *THE ORIGINS OF OVERKILL*. IN IT ROSENBERG POINTS OUT THAT THE NAVY OBJECTED TO THE TARGETING CRITERIA DEVELOPED BY THE STRATEGIC AIR COMMAND (ESTAB. 1946) AND THE JOINT STRATEGIC TARGET PLANNING STAFF (ESTAB. 1960). THESE ORGANIZATIONS DOMINATED TARGETING UNTIL THEIR DISSOLUTION IN 1992. USING SAC'S TARGETING CRITERIA THE NAVY SAID, AND I AM QUOTING, "THE DAMAGE CAUSED BY A 13 KILOTON BOMB ON HIROSHIMA COULD ONLY BE ASSURED BY ASSIGNING 300 TO 500 KILOTONS OF WEAPONS TO A SIMILAR TARGET." THE NAVY ALSO OBJECTED TO SAC'S -QUOTE- "FAILURE TO CONSIDER THE SECONDARY EFFECTS OF BLAST, FIRE, AND RADIATION IN PROJECTING DAMAGE." BY 1967 THE U.S. HAD SOME 30,000 NUCLEAR WARHEADS AND BY 1986 THE SOVIET UNION HAD OVER 40,000.

ONE CAN ONLY WONDER WHAT POSSIBLE TARGETING CRITERIA COULD LEAD TO SUCH INCREDIBLY LARGE NUMBERS OF WEAPONS.

WHILE THE TARGETING OF NUCLEAR WEAPONS, ESPECIALLY WHEN THERE ARE MANY INVOLVED, IS A VERY COMPLEX PROCESS, TO ANSWER WHY SUCH LARGE NUMBERS ARE NEEDED TO DESTROY A GIVEN TARGET BASE IS EASILY EXPLAINED ONCE ONE UNDERSTANDS

TWO CONCEPTS: TARGET VULNERABILITY AND THE PROBABILITY OF DAMAGE.

TARGET VULNERABILITY CALCULATIONS RESULT IN A NUMBER REFLECTING THE TARGET'S HARDNESS—A MEASURE OF HOW DIFFICULT IT WOULD BE TO DESTROY THE TARGET RELATIVE TO A SPECIFIED DAMAGE-LEVEL CRITERION; A LETTER (Q OR P) INDICATING WHETHER THE TARGET IS SENSITIVE TO WHAT IS CALLED DYNAMIC PRESSURE—THE FORCE ASSOCIATED WITH THE STRONG WINDS FROM THE EXPLOSION—OR PEAK OVER PRESSURE; AND A FACTOR RELATED TO THE DURATION OF THE EXPLOSION. THE DETAILS REALLY DON'T MATTER FOR OUR PURPOSES. WHAT IS IMPORTANT IS THAT ONCE THE TARGET IS CHARACTERIZED BY A VULNERABILITY, THE PROBABILITY OF DAMAGE CAN BE CALCULATED.

THE PROBABILITY OF DAMAGE IS ALSO A NUMBER THAT CAN RANGE FROM 0 TO 1, WHERE 1 CORRESPONDS TO A 100% CHANCE OF ACHIEVING THE SPECIFIED DAMAGE LEVEL. IT IS CALCULATED FROM THE VULNERABILITY, THE YIELD OF THE WEAPON USED TO ATTACK THE TARGET, AND THE ACCURACY OF THE MEANS OF DELIVERY—SUCH AS A BALLISTIC MISSILE.

A VERY IMPORTANT TARGET, FOR EXAMPLE, MAY BE ASSIGNED A PROBABILITY OF DAMAGE OF 0.9. THE TARGETEER WILL THEN USE THE VULNERABILITY OF THE TARGET, THE YIELD OF THE ATTACKING WEAPON, AND THE ACCURACY OF SAY A BALLISTIC MISSILE TO ACHIEVE A PROBABILITY OF DESTRUCTION OF 0.9. IF THIS IS UNACHIEVABLE GIVEN THE AVAILABLE COMBINATIONS OF YIELD AND ACCURACY, ADDITIONAL WEAPONS WILL BE ASSIGNED TO THE TARGET UNTIL THE PROBABILITY OF DAMAGE REACHES 0.9.

USING THIS TARGETING METHODOLOGY, AND IT IS ESSENTIALLY THE ONE STILL USED TODAY, THE NUMBER OF NUCLEAR WEAPONS REQUIRED IS DETERMINED. FOR THE TARGET BASE OF THE OLD SOVIET UNION, THE NUMBER WAS IN THE THOUSANDS. FOR THE AREA WITHIN THE MOSCOW BELTWAY ALONE, YOU MIGHT GUESS THAT A FEW WEAPONS WOULD BE ASSIGNED BECAUSE OF THE NUMBER OF IMPORTANT LEADERSHIP TARGETS IN THE AREA. YOU MIGHT NOT THINK MORE THAN A FEW WOULD BE NEEDED SINCE THE SMALLEST WEAPONS ASSIGNED TO THE AREA HAD A YIELD OF 100 KILOTONS COMPARED TO THE 13 KILOTONS USED ON HIROSHIMA. YOU WOULD BE WRONG. MANY TENS OF WEAPONS WERE ASSIGNED TO THIS AREA AS A RESULT OF THE TARGETING METHODOLOGY. MORE THAN ENOUGH TO TURN THE AREA INTO A SHEET OF GLASS. AND THERE IS NO DOUBT THAT THE SAME METHODOLOGY WAS USED BY THE SOVIETS IN TARGETING THE U.S.

WHAT ABOUT THE NAVY'S COMPLAINT ABOUT THE -QUOTE- "FAILURE TO CONSIDER THE SECONDARY EFFECTS OF BLAST, FIRE, AND RADIATION IN PROJECTING DAMAGE"? THE FACT IS THAT NOBODY EVER FOUND A WAY TO DO THIS—NOTWITHSTANDING SEVERAL ATTEMPTS TO DO SO. NUCLEAR WEAPONS HAVE ALWAYS BEEN TARGETED AS IF THEY WERE LARGE STICKS OF DYNAMITE—ONLY THE PRESSURE DUE TO THE EXPLOSION AND ITS DURATION IS CONSIDERED IN CALCULATING THE VULNERABILITY OF A TARGET. THERMAL RADIATION AND RADIOACTIVITY ARE NOT TAKEN INTO ACCOUNT AT ALL.

WHEN THE TARGET IS DEEPLY BURIED—LIKE A COMMAND POST—THE SECONDARY EFFECTS OF NUCLEAR WEAPONS DON'T PLAY MUCH OF A ROLE, BUT THEY DO CAUSE ENORMOUS SO-CALLED "COLLATERAL

DAMAGE” AT THE SURFACE. WHEN THE TARGET IS AT GROUND LEVEL, AND MOST ARE, IT IS OUR TECHNOLOGICAL IGNORANCE ABOUT HOW TO TAKE INTO ACCOUNT THE UNIQUE PROPERTIES OF NUCLEAR WEAPONS WHEN TARGETING THEM THAT WAS RESPONSIBLE FOR THE LARGE NUMBER OF SUCH WEAPONS THAT EXISTED DURING THE COLD WAR.

DURING THIS PERIOD THE U.S. AND THE SOVIET UNION ALSO PURSUED A PROCESS OF ARMS CONTROL LEADING TO A VARIETY OF AGREEMENTS THAT LIMITED THE NUMBER AND TYPES OF BALLISTIC MISSILES. THESE AGREEMENTS WERE KNOWN AS SALT-I AND II AND START-I AND II. SALT-I—THE ACRONYM STANDS FOR “STRATEGIC ARMS LIMITATION TALKS,” ALSO RESULTED IN THE 1972 ANTI-BALLISTIC MISSILE, OR ABM TREATY. PEOPLE OFTEN THOUGHT OF THESE TREATIES AS A WAY TO REDUCE AND ULTIMATELY ELIMINATE NUCLEAR WEAPONS. BUT THIS WAS NEVER THEIR PURPOSE.

AS WE HAVE SEEN, THE TARGET BASE AND THE TARGETING CRITERIA DETERMINE THE NUMBER OF NUCLEAR WEAPONS NEEDED. BUT IT IS EASY TO OVER DO IT. ARMS CONTROL WAS A WAY TO PREVENT THIS FROM HAPPENING—AND WAS IN THE INTERESTS OF BOTH SIDES. WHAT WAS NOT PUBLICALLY UNDERSTOOD DURING THE COLD WAR WAS THAT ARMS CONTROL AND FORCE PLANNING ARE INTIMATELY RELATED—INDEED, THEY ARE OPPOSITE SIDES OF THE SAME COIN. ARMS CONTROL WAS A WAY FOR BOTH THE SOVIET UNION AND THE U.S. TO LIMIT AND DEFINE THE THREAT THEY FACED AND SAVE MONEY BY DOING SO.

FOR EXAMPLE, IF BOTH SIDES DEPLOYED AN ANTI-BALLISTIC MISSILE SYSTEM THAT WAS 50% EFFECTIVE, EACH SIDE WOULD SIMPLY DOUBLE THE NUMBER OF ATTACKING MISSILES TO OVERWHELM THE

ABM SYSTEM. CONSEQUENTLY, BOTH SIDES WOULD BE LEFT IN EXACTLY THE SAME POSITION THEY WERE IN BEFORE THE ABM SYSTEM WAS DEPLOYED—EXCEPT A GOOD DEAL MORE MONEY WOULD HAVE BEEN SPENT. BY CONCLUDING THE ABM TREATY BOTH SIDES BENEFITED.

TODAY THE BUSH ADMINISTRATION HAS WITHDRAWN FROM THE ABM TREATY. I HAVE ARGUED IN MY MOST RECENT BOOK, *THE PHANTOM DEFENSE*, THAT THIS WAS A BAD IDEA. BUT WHAT IS THE THINKING OF THE ADMINISTRATION? MANY BELIEVE THAT THERE ARE ELEMENTS WITHIN THIS ADMINISTRATION THAT HAVE NEVER SEEN A TREATY THEY LIKED—AND THERE IS SOME TRUTH TO THIS. BUT THE PRINCIPAL REASON IS THAT THE ADMINISTRATION IS LOOKING BEYOND THE COLD WAR AND NO LONGER SEES THE ABM TREATY AS HAVING VALUE. THEY BELIEVE THAT WITH RUSSIA BEING MORE AND MORE INTEGRATED INTO EUROPE, THEY FACE A MUCH MORE LIMITED THREAT FROM SO-CALLED ROGUE NATIONS, ONE THAT CURRENT TECHNOLOGY COULD EVENTUALLY DEFEND AGAINST.

THEY ARE HALF-RIGHT. THE VALUE OF THE ABM TREATY SHOULD INDEED NOT BE JUDGED SIMPLY IN TERMS OF THE COLD WAR, BUT CURRENT TECHNOLOGY HOLDS OUT LITTLE HOPE OF BEING EFFECTIVE AGAINST EVEN THE MUCH MORE LIMITED THREAT FROM SMALL COUNTRIES SUCH AS NORTH KOREA OR CHINA. AS FOR WHY I BELIEVE THE ABM TREATY WOULD RETAIN ITS VALUE TODAY, YOU WILL HAVE TO READ *THE PHANTOM DEFENSE*.

THE REAL QUESTION ABOUT ARMS CONTROL IN TODAY'S WORLD IS WHETHER OR NOT THE TREATIES BANNING BIOLOGICAL AND CHEMICAL WEAPONS ARE VIABLE, AND WHETHER THE NON-PROLIFERATION TREATY CONTINUES TO BE OF VALUE. TO BE SO,

THEY MUST CONTRIBUTE TO MUTUAL SECURITY NOT ONLY IN A WORLD OF COMPETING NATION STATES, BUT IN A WORLD WHERE SUB-NATIONAL GROUPS, OFTEN FUNDED AND SUPPLIED COVERTLY BY NATION STATES, ARE A GROWING THREAT.

IN THINKING ABOUT THIS ISSUE, DISTINCTIONS ARE IMPORTANT. CHEMICAL AND BIOLOGICAL WEAPONS ARE REALLY NOT “WEAPONS OF MASS DESTRUCTION” IN SPITE OF PENTAGON HYPE. THEY ARE RELATIVELY INEFFECTIVE AS WEAPONS AND ARE BEST CHARACTERIZED AS WEAPONS OF MASS TERROR. THE ONLY TRUE WEAPONS OF MASS DESTRUCTION ARE NUCLEAR.

OUR CURRENT MEANS OF PREVENTING THE SPREAD OF NUCLEAR WEAPONS IS THE NON-PROLIFERATION TREATY. ORIGINALLY, THE PURPOSE OF THIS TREATY WAS TO ALLOW THE SPREAD OF NUCLEAR TECHNOLOGY FOR PEACEFUL PURPOSES WHILE PROHIBITING THE DEVELOPMENT OF NUCLEAR WEAPONS. MANY BELIEVE THIS CANNOT BE DONE, BUT THIS REMAINS ONE OF THE CRUCIAL PROBLEMS FOR THIS CENTURY.

WITHOUT NUCLEAR POWER, THERE IS SIMPLY NO WAY TO PRESERVE THE ENVIRONMENT WHILE PROVIDING ENOUGH ELECTRICITY FOR A RISING STANDARD OF LIVING TO THE 10 BILLION PEOPLE ESTIMATED TO SOON BE POPULATING THE EARTH. THE ONLY REAL ALTERNATIVE TO NUCLEAR POWER IS COAL, AND BURNING COAL TO PROVIDE ELECTRICITY FOR SO MANY PEOPLE WOULD BE AN ENVIRONMENTAL DISASTER. ON THE OTHER HAND, THE SPREAD OF NUCLEAR TECHNOLOGY—WHILE IT NEED NOT, IN AND OF ITSELF, CONTRIBUTE TO THE SPREAD OF NUCLEAR WEAPONS—ALLOWS GOVERNMENTS TO CHOOSE THE NUCLEAR WEAPONS OPTION WHEN GEOPOLITICAL INCENTIVES TO DO SO EXIST. STRENGTHENING THE NON-

PROLIFERATION REGIME SO AS TO SAFELY FOSTER THE INTERNATIONAL DEVELOPMENT OF NUCLEAR POWER IS A CRUCIAL ENVIRONMENTAL AND SECURITY ISSUE FOR THIS CENTURY.

RETURNING TO THE COLD WAR, AS THE NUMBER OF NUCLEAR WEAPONS INCREASED TO THE POINT THAT WESTERN CIVILIZATION WOULD NOT SURVIVE AN ALL OUT EXCHANGE, THE REAL DANGER WE FACED DID NOT RESULT FROM THE NUMBER OF WEAPONS PER SE, BUT UNDER WHAT CONDITIONS THEY WOULD BE USED.

RESPONSIBLE PEOPLE IN BOTH THE SOVIET UNION AND THE U.S. FULLY UNDERSTOOD THAT NEITHER WOULD SURVIVE AN ALL OUT NUCLEAR EXCHANGE, AND BOTH SIDES KNEW THAT DESPITE HAVING SMALLER OPTIONS IN THEIR WAR PLANS, WAR GAMES OFTEN LED TO THE WORST POSSIBLE SCENARIO—AN ALL OUT EXCHANGE. ALTHOUGH THIS WAS CONTRARY TO THE INTENT OF U.S. DECLARATORY POLICY, WHICH WAS “MASSIVE RETALIATION” FROM 1953 TO 1961 AND “FLEXIBLE RESPONSE” FROM 1961 ON—INDEPENDENT OF WHAT IT WAS CALLED, THE WAR GAMES DID NOT INDICATE MUCH FLEXIBILITY.

DURING THE 1980s THERE WAS A NATIONALLY BROADCAST TELEVISION PROGRAM CALLED “THE DAY AFTER.” IT PURPORTED TO SHOW WHAT THE WORLD WOULD BE LIKE AFTER AN ALL OUT NUCLEAR EXCHANGE. IT FAILED. THE DAY AFTER THE “THE DAY AFTER” WAS BROADCAST, I WAS IN ONE OF THE LAUNCH CONTROL CAPSULES IN MONTANA TALKING TO THE CREW THAT WOULD ACTUALLY LAUNCH THE MISSILES IN CASE OF WAR. THEY KNEW A NUCLEAR EXCHANGE WOULD BE FAR WORSE THAN DEPICTED IN “THE DAY AFTER” AND GAVE ME SPECIFIC EXAMPLES OF HOW THIS WOULD

BE SO. NEVERTHELESS, THEY WOULD HAVE LAUNCHED THE MISSILES IF A PROPER ORDER WERE RECEIVED.

THE PEOPLE IN BOTH THE AIR FORCE AND NAVY THAT HAD RESPONSIBILITY FOR THE USE OF NUCLEAR WEAPONS DURING THE COLD WAR WERE AMONG THE FINEST THE NATION COULD PRODUCE—THE PROBLEM WAS HIGHER UP, WITH THOSE WHO HAD RESPONSIBILITY FOR THE COMMAND AND CONTROL OF THESE WEAPONS.

THE REAL DANGER WE FACED DURING THE COLD WAR RESULTED FROM THE FACT THAT THE LAND-BASED INTERCONTINENTAL BALLISTIC MISSILES COULD NOT SURVIVE A NUCLEAR ATTACK—EVEN THOUGH ATTEMPTS WERE MADE TO HARDEN THEM BY THE USE OF SILOS AND MOVING THE COMMAND CENTERS UNDERGROUND.

THAT MEANT THAT IF THE MISSILES WERE TO BE USED EFFECTIVELY THEY WOULD HAVE TO BE LAUNCHED ON WARNING OF AN ATTACK, BEFORE NUCLEAR DETONATIONS ACTUALLY OCCURRED ON U.S. TERRITORY, THUS CONFIRMING THAT THE ATTACK WAS REAL. AT FIRST, ONE COULD AT LEAST ARGUE THAT THIS POSTURE WAS NECESSARY SINCE NAVY MISSILES DEPLOYED ON SUBMARINES—WHICH WERE FULLY SURVIVABLE BECAUSE THE SUBMARINES WERE UNDETECTABLE—DID NOT HAVE THE ACCURACY OF LAND-BASED MISSILES. LATER, WHEN NAVY MISSILES ACHIEVED THE SAME OR BETTER ACCURACY THAN LAND-BASED MISSILES, THIS BECAME A MATTER OF INTER-SERVICE RIVALRY.

A LAUNCH UNDER ATTACK POLICY IS VERY, VERY DANGEROUS BECAUSE IT RELIES ON THE ACCURACY OF INFORMATION RECEIVED FROM SATELLITES AND RADAR. BOTH THE U.S. AND SOVIET UNION

DEPLOYED SATELLITES THAT COULD DETECT THE LAUNCH OF BALLISTIC MISSILES; AND IN ADDITION, BOTH HAD RADARS THAT WOULD DETECT INCOMING WARHEADS. ONE MIGHT THINK THAT GIVEN THESE VERY DIFFERENT AND REDUNDANT TYPES OF DETECTION SYSTEMS, RELYING ON A LAUNCH ON WARNING POLICY MIGHT NOT BE SO BAD. UNFORTUNATELY, THE INFORMATION FROM BOTH THESE SYSTEMS MUST BE BROUGHT TOGETHER IN THE COMMAND CENTER TO ASSESS WHETHER AN ATTACK WAS REALLY HAPPENING. AND FALSE ALARMS DID OCCUR. ONE HAPPENED WHEN A TRAINING TAPE WAS LEFT IN THE COMPUTER AND SOMEHOW GOT ACTIVATED. THE INFORMATION COMING TO THE PEOPLE ON DUTY SHOWED MASSIVE LAUNCHES FROM THE SOVIET UNION FOLLOWED BY CONFIRMATION BY RADAR. LUCKILY, THIS WAS A PERIOD OF LOW POLITICAL TENSION RAISING DOUBTS ABOUT THE ATTACK WITH THE PEOPLE ON DUTY. THE ERROR WAS CAUGHT.

THE LAND-BASED MISSILES STILL EXIST. THEY HAVE NOT BEEN PHASED OUT IN SPITE OF NO LONGER SERVING ANY REAL PURPOSE. WHILE RUSSIA IS NO LONGER AN ENEMY, THE POTENTIAL INSTABILITY INHERENT IN THIS VULNERABLE LEG OF THE NUCLEAR TRIAD OF FORCES STILL EXISTS. THE LAND-BASED MISSILES SHOULD BE PHASED OUT LEAVING THE MORE THAN ADEQUATE DETERRENT OF BALLISTIC MISSILE SUBMARINES AND BOMBERS.

IN THE END, DESPITE PAST INSTABILITIES IN THE COMMAND AND CONTROL OF NUCLEAR WEAPONS, THE SYSTEM WORKED AND THE WORLD SURVIVED THE FIRST HALF-CENTURY AFTER NUCLEAR WEAPONS WERE DISCOVERED WITHOUT THEM BEING USED AGAIN AFTER HIROSHIMA AND NAGASAKI. WE HAVE BEEN VERY LUCKY. IRONICALLY, THE BIPOLAR WORLD OF THE PAST HALF-CENTURY LENT A TYPE OF STABILITY TO INTERNATIONAL RELATIONS THAT NO

LONGER EXISTS. TODAY IT IS UP TO THE GREAT NATIONS OF THE WORLD TO FIND A NEW INTERNATIONAL SECURITY ARRANGEMENT TO REPLACE IT.

BUT INSTEAD THERE SEEMS TO BE A STRONG PUSH BY THE U.S.—IN ADDITION TO BALLISTIC MISSILE DEFENSE—TO DEVELOP AND USE NUCLEAR WEAPONS TO COUNTER SO-CALLED WEAPONS OF MASS DESTRUCTION. IS THIS A GOOD IDEA? IS IT POSSIBLE? AS YOU WILL SEE, A LITTLE TECHNICAL KNOWLEDGE GOES A LONG WAY.

THE ADMINISTRATION IS APPARENTLY SEEKING TO DEVELOP—AS OPPOSED TO EXPLORE THE OPTIONS FOR DEVELOPING—NEW LOW-YIELD NUCLEAR WEAPONS AND EARTH PENETRATING WARHEADS TO DESTROY DEEPLY BURIED CHEMICAL AND BIOLOGICAL WEAPONS.

ONE OF THE MOST IMPORTANT REASONS THAT PEOPLE BELIEVE THIS IS THAT THE ADMINISTRATION OPTED OUT OF THE COMPREHENSIVE NUCLEAR TEST BAN TREATY FOR UNCONVINCING REASONS. MOST PEOPLE INTERESTED AND KNOWLEDGEABLE ABOUT THE SUBJECT DO NOT BELIEVE NUCLEAR TESTING WILL BE NECESSARY IN THE FUTURE TO GUARANTEE THE VIABILITY OF THE STOCKPILE OR FIX ANY UNCOVERED PROBLEMS.

MUCH OF THIS CONFIDENCE IS BASED ON THE REPORTS AND TESTIMONY OF RAY KIDDER OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY. HIS WORK HAD A MAJOR POLICY IMPACT DURING THE CLINTON ADMINISTRATION. HIS KEY REPORT IS TITLED *MAINTAINING THE U.S. STOCKPILE OF NUCLEAR WEAPONS DURING A LOW-THRESHOLD OR COMPREHENSIVE TEST BAN*. [UCRL-53821, OCTOBER 1987 (UNCLASSIFIED VERSION IS UCRL-53820, OCTOBER 1987)]

THE CONCLUSION, AND I AM QUOTING, WAS THAT "A HIGH DEGREE OF CONFIDENCE IN THE RELIABILITY OF THE EXISTING STOCKPILE IS JUSTIFIED, AND THAT IT IS SUFFICIENTLY ROBUST TO PERMIT CONFIDENCE IN THE RELIABILITY OF REMANUFACTURED WARHEADS IN THE ABSENCE OF NUCLEAR EXPLOSIVE PROOF-TESTS."

THE REPORT REVIEWED THE –QUOTE– "PROBLEMS ENCOUNTERED WITH THE 14 NUCLEAR WEAPON DESIGNS SINCE 1958 THAT HAVE BEEN FREQUENTLY AND PROMINENTLY CITED AS EVIDENCE THAT A LOW-THRESHOLD TEST BAN . . . OR A COMPREHENSIVE TEST BAN . . . WOULD PRECLUDE THE POSSIBILITY OF MAINTAINING A RELIABLE STOCKPILE." THE REPORT FOUND THAT –QUOTE– "THE EXPERIENCE HAS LITTLE IF ANY RELEVANCE TO THE QUESTION OF MAINTAINING THE RELIABILITY OF THE STOCKPILE OF NUCLEAR WEAPONS THAT EXISTS IN 1987," THE YEAR THE REPORT WAS WRITTEN.

IN THE JULY 2001 JOINT DEPARTMENT OF DEFENSE AND DEPARTMENT OF ENERGY REPORT TO CONGRESS ON THE DEFEAT OF HARD AND DEEPLY BURIED TARGETS IT IS STATED THAT, AND I AM QUOTING, "NUCLEAR WEAPONS HAVE A UNIQUE ABILITY TO DESTROY BOTH AGENT CONTAINERS AND CBW AGENTS [MEANING CHEMICAL AND BIOLOGICAL WEAPONS]. LETHALITY IS OPTIMIZED IF THE FIREBALL IS PROXIMATE TO THE TARGET. THIS REQUIRES HIGH ACCURACY; FOR BURIED TARGETS, IT ALSO MAY REQUIRE A PENETRATING WEAPON SYSTEM. . . ." IT FURTHER GOES ON TO STATE THAT "THE CURRENT NUCLEAR WEAPONS STOCKPILE, WHILE POSSESSING SOME LIMITED GROUND PENETRATION CAPABILITY AND LOWER YIELD OPTIONS (NOT YET CERTIFIED), WAS NOT DEVELOPED WITH THIS MISSION IN MIND."

THE MEANING OF THIS REQUIRES SOME EXPLANATION. THE “LIMITED GROUND PENETRATION CAPABILITY” REFERS TO THE B61 MOD 11 GRAVITY BOMB—A BOMB THAT WAS DESIGNED TO BE DROPPED OUT OF AN AIRPLANE AND SURVIVE THE FORCES ENCOUNTERED WHEN STRIKING THE GROUND. THE B61 IS GIVEN A NOSE CONE TO ALLOW IT TO PENETRATE INTO THE EARTH. NORMALLY THE B61 IS CONFIGURED WITH THE “LOWER YIELD OPTIONS” AND TO SAY THEY ARE “NOT YET CERTIFIED” IS SOMEWHAT DISINGENUOUS AT BEST. IT IS TRUE THAT IT WASN’T DEVELOPED WITH THE MISSION OF ATTACKING BURIED CHEMICAL AND BIOLOGICAL WEAPONS. IT WAS DEVELOPED TO ATTACK DEEPLY BURIED COMMAND AND CONTROL CENTERS IN THE OLD SOVIET UNION.

SEN. JAMES INHOFE [R. OKLAHOMA] WAS REPORTED IN THE JULY 4, 2003 ISSUE OF *SCIENCE* AS SAYING WITH REGARD TO MINI-NUCS AND EARTH PENETRATING WARHEADS, “IF WE WERE ABLE TO DO THIS RESEARCH . . . WE WOULD BE ABLE TO KNOCK OUT CHEMICAL [AND] BIOLOGICAL THREATS . . . AND NOT CAUSE ANY COLLATERAL DAMAGE.”

A BIT OF HYPERBOLE AT BEST SINCE IN ORDER TO NOT CAUSE ANY “COLLATERAL DAMAGE”—WHICH IN THIS CASE MEANS NO VENTING OF RADIOACTIVE DEBRIS OR RELEASE OF CHEMICAL OR BIOLOGICAL AGENTS—A NUCLEAR EXPLOSION HAVING A 10 KT YIELD WOULD HAVE TO BE DETONATED AT A DEPTH OF ABOUT 260 METERS. AS YOU WILL SOON UNDERSTAND, THIS IS NOT POSSIBLE.

AND FINALLY, SECTION 221 OF THE DOD DRAFT DEFENSE AUTHORIZATION BILL FOR FY 2004 CALLING FOR REPEAL OF THE SO-CALLED PRECISION LOW-YIELD WEAPONS DESIGN LEGISLATION [OR “PLYWD”] STATES—QUOTE—THAT “THE CONGRESSIONALLY-

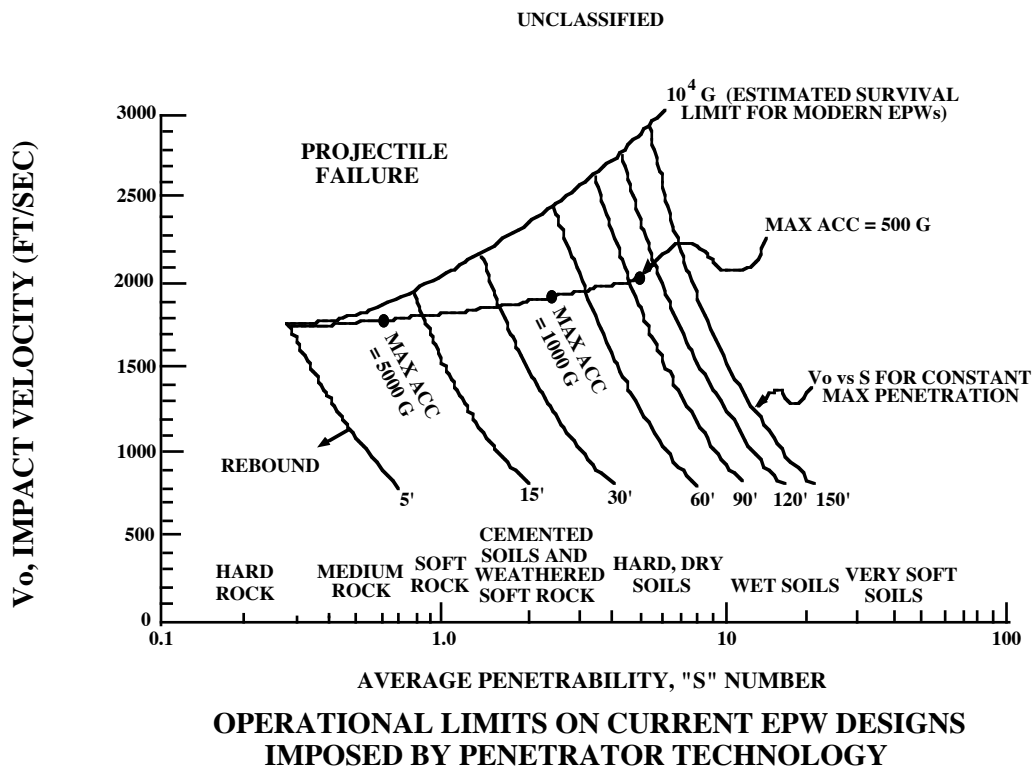
MANDATED NUCLEAR POSTURE REVIEW . . . URGED EXPLORATION OF WEAPONS CONCEPTS THAT COULD OFFER GREATER CAPABILITIES FOR PRECISION, EARTH PENETRATION (TO HOLD AT RISK DEEPLY BURIED AND HARDENED BUNKERS), DEFEAT OF CHEMICAL AND BIOLOGICAL AGENTS, AND REDUCED COLLATERAL DAMAGE. THE PLYWD LEGISLATION IMPEDES THIS EFFORT.”

TAKEN TOGETHER THESE STATEMENTS, AND OTHERS LIKE THEM, HAVE MADE A PRETTY STRONG PRIMA FACIE CASE THAT THE ADMINISTRATION INTENDS TO INITIATE TESTING AND DEVELOP LOW-YIELD EARTH PENETRATING WEAPONS WHEN IT BECOMES POLITICALLY EXPEDIENT TO DO SO.

LEST YOU THINK THE ISSUE IS CLOSED HOWEVER, AMBASSADOR LINTON BROOKS—THE HEAD OF THE NATIONAL NUCLEAR SECURITY ADMINISTRATION (ESSENTIALLY THE WHOLE NUCLEAR WEAPONS COMPLEX)—IN HIS APRIL 8, 2003 TESTIMONY BEFORE THE SENATE ARMED SERVICES COMMITTEE—HAS STATED THAT –QUOTE- “WE ARE NOT PLANNING TO RESUME NUCLEAR TESTING. THE PRESIDENT HAS MADE IT CLEAR THAT WE HAVE NO NEAR TERM REQUIREMENT FOR SUCH TESTING.” AND –QUOTE- “WE ARE NOT PLANNING TO DEVELOP ANY NEW NUCLEAR WEAPONS AT ALL. THE DEPARTMENT OF DEFENSE HAS NOT IDENTIFIED ANY REQUIREMENTS FOR SUCH NEW NUCLEAR WEAPONS.”

HE FURTHERMORE STATED THAT “WE ARE NOT SIGNALING THROUGH THESE PROGRAMS AN INTENTION TO LOWER THE NUCLEAR THRESHOLD OR TO BLUR THE DISTINCTION BETWEEN NUCLEAR AND NON-NUCLEAR WEAPONS. THE FACT REMAINS THAT ONLY THE PRESIDENT CAN AUTHORIZE THE USE OF NUCLEAR WEAPONS, AND THAT WILL NOT CHANGE.”

SO WHERE DOES THIS LEAVE US? DOES THE ADMINISTRATION PLAN TO DEVELOP LOW-YIELD EARTH-PENETRATING NUCLEAR WARHEADS TO DESTROY BURIED CHEMICAL AND BIOLOGICAL WEAPONS OR NOT? FROM THE VIEWGRAPH THAT I WILL NOW SHOW YOU, YOU WILL SEE THAT IT IS NOT POSSIBLE TO DO THIS.



WHAT THIS VIEWGRAPH—THE DATA FOR WHICH COMES FROM SANDIA NATIONAL LABORATORIES—DOESN'T TELL YOU IS THAT THE LIMIT FOR STRUCTURAL SURVIVABILITY IS SET NOT BY THE RELATIVELY FRAGILE NUCLEAR WEAPON WITHIN THE PENETRATOR, BUT BY THE PENETRATOR TECHNOLOGY ITSELF. FURTHER RESEARCH AND DEVELOPMENT WILL NOT MAKE A SIGNIFICANT DIFFERENCE IN THIS PICTURE.

AIR DROPPING A WEAPON, OR DELIVERY BY A CRUISE MISSILE IMPLIES A VELOCITY AT IMPACT OF 700 TO 800 FPS. IF WE DRAW A LINE HORIZONTALLY ACROSS THE CHART AT 800 FPS, WE SEE THAT AT THAT VELOCITY THE PROJECTILE WILL ONLY PENETRATE FIVE FEET INTO SOFT ROCK.

SO YOU SEE THAT UNLESS WE HAVE A COOPERATIVE ENEMY THE GOAL OF PENETRATING TO WHERE CHEMICAL AND BIOLOGICAL WEAPONS MAY BE BURIED IS UNOBTAINABLE AND THAT WHAT WE ARE SEEING IN THE ADMINISTRATION IS NOT A SERIOUS TECHNICAL DEBATE ON DESTROYING CHEMICAL AND BIOLOGICAL WEAPONS. THE ISSUES ARE POLITICAL.

I HOPE I HAVE SHOWN YOU THAT WITHOUT HAVING TO BE AN EXPERT IN EVEN A SUBJECT AS ESOTERIC AS NUCLEAR WEAPONS TECHNOLOGY IT IS POSSIBLE TO EVALUATE THE ISSUES OF THE DAY AND MEANINGFULLY PARTICIPATE IN THE DEBATE. A LITTLE TECHNICAL INFORMATION AND UNDERSTANDING GOES A LONG WAY.

I SAID EARLIER THAT WE REMAIN IGNORANT OF SCIENCE AND TECHNOLOGY AT OUR PERIL. I WOULD LIKE TO END WITH A QUOTE FROM THE SCIENCE HISTORIAN JACOB BRONOWSKY: "FOR ANY MAN [AND I WILL EXTEND HIS COMMENT TO INCLUDE WOMEN] TO ABDICATE AN INTEREST IN SCIENCE IS TO WALK WITH OPEN EYES TOWARD SLAVERY." THANK YOU.