History, Theory, & Technology of Missile Defense

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"Science does not have a moral dimension. It is like a knife. If you give it to a surgeon or a murderer, each will use it differently." ~ Wernher von Braun

The history of missile defense is extensive. In correlation to the creation of missiles, the defense against such technology has had to maintain advances that produce an accurate response to protect from attacks. The origin of missile defense can be traced back to World War II, when Germany created the first operational ballistic missiles in 1944. Missiles have the advantage of fewer maintenance, training, and logistic requirements than manned aircraft. Even limited use of these weapons could be devastating, because missiles can be armed with chemical, biological, or nuclear warheads.\(^1\) Although Germany's first ballistic missiles did not have accurate flight paths, and delivered only a limited payload; the United States identified a need for a defense system that could combat the threat of German attack. During World War II, Germany quickly revised their ballistic missiles in order to improve the reach, accuracy and power of their attacks. The early stages of the German ballistic missile, called the V-2 possessed only a range of two hundred miles, and was unleashed on targets in Great Britain, Belgium, France, Luxembourg and the Netherlands. By the end of the war, innovations in Germany's missiles furthered their development of the V-2 to hit intercontinental targets such as New York City. Some (Germans) also believed that if the war had lasted another two years, they could have developed a 15,000-mile range intercontinental ballistic missile (ICBM). The implications for the future were clear.

While long-range ballistic missiles might not have been a decisive weapon during World War II, they would pose a serious military and terror threat in years to come.\(^2\) After the end of World War II, the United States began allied efforts to create a defense against ballistic missiles, focusing on the German V-2 model. Upon communication with Great Britain, the United States became aware of operations that were already underway to defend against V-2 attacks. Great Britain was developing missile defense through the usage of radars that could detect V-2 launches, tracking their path in order to knock out a limited amount of V-2 missiles. General Sir Frederick Pile, chief of Britain's Anti-Aircraft Command, estimated it would take about 12,000 antiaircraft round to destroy one V-2 with existing means. He believed his defense initially could have destroyed between three and ten percent of attacking V-2s, and would have improved capability over time.\(^4\) General Pile's vision to establish a missile defense strategy prompted the United States to follow suit, and in 1945 the United States took the ingenuity of Great Britain's missile defense strategy to another level.

The U.S. Army Ground Forces Equipment Review Board, led by Major General Gilbert R. Cook, desired to develop a high velocity guided missile system that were capable of taking out ballistic missiles by intercepting them in their flight path. Major General Gilbert R. Cook's espouse of Britain's missile defense plan combined with his own forward thinking (deemed necessary because of intelligence that ballistic missiles would become more precise, travel at faster speeds, and deliver heavier blows than that of the V-2s of World War II) initiated projects Wizard and Thumper in 1946. In the summer of 1947 the Wizard missile project became a long-term study of $1,000,000 a year. A major part of the Wizard efforts concerned the overall system design needed to successfully attack missiles in flight, and BMEWS (GOR on November 7, 1957) was "designed to go with the active portion of the WIZARD system". To address this requirement, the Wizard program created the Air Defense Integration System, a computerized command, control, and coordination system for efficient direction of both manned interceptors and missile defenses. Furthermore, the planned Wizard missile was based on a missile design of 60 feet (18 m) long and 6 feet (1.8 m) in diameter, with a range of 550 miles (890 km) with speeds of 4,000 to 5,000 mph with a 50 percent kill probability against a V-2. In Spring 1947 the Thumper missile program determined "it would be five to ten years, AMC estimated, before the necessary long-range ground radar, long-range and highly accurate guidance systems and long-range radar seekers could be developed for the test support of any [Wizard] anti-missile missile."\(^5\)

In addition, Thumper was designed similar to that of the German aircraft guided missile which could then later adopt an atomic warhead. Although these projects were recognized for reaching an active defense against ballistic missiles, the U.S. Air Force determined that if

missile programs as such are supported to the maximum intelligent extent, the financial drain on
the AAF program would be such as to seriously compromise the development of all other types
of missiles. 6 Therefore they concluded that combining the two (Thumper and Wizard) would
ultimately begin a long-term study basis of missile defense due to the complex technical
challenges that were believed to take up to ten years to develop such an anti-ballistic missile
(ABM) system.

Shortly thereafter, the U.S. Air Force focused its attention on theater missile defense, a
term that applies to the identification, integration, and employment of forces supported by other
theater and national capabilities, to detect, identify, locate, track, minimize the effects of, or
destroy enemy theater missiles (TM s). 7 In the early 1950s, Project Plato was the army's first
effort to create a theater missile defense (TMD) system. Plato was quickly replaced by new
systems that included a Field Army Ballistic Missile Defense System (FABMDS) for the 1970s,
becoming the Surface-to-Air-Missile-Development, or "SAM-D". These new innovations led to
the development of the popular Phased Array Tracking Radar Intercept On Target (PATRIOT)
missile defense system. The PATRIOT was essentially the foundation for more advanced
missile defense throughout the course of the twentieth century.

In the illustration on the following page, a more recent version of the Patriot, named the
MIM-104 Patriot exhibits the innovation in technology that has been embraced by the U.S., and
the success of the missile defense projects of the Post World War, as well as the Cold War era.
The more modern missile launcher can carry up to four PAC-2 missiles or up to sixteen PAC-3

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missiles which are transported on, and launched from the M901 launching station. The missile is equipped with a track-via-missile (TVM) guidance system. The range of the missile itself is 70km and maximum altitude is greater than 24km. Modern PATRIOT Technology also has four operational functions: communications, command and control, radar surveillance, and missile guidance.

**Patriot air defense system**

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<th>MIM-104C (PAC-2) missile</th>
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<td>Flight altitude (min/max)</td>
<td>60 m - 24 km</td>
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<tr>
<td>Range (min/max)</td>
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POST WORLD WAR II & COLD WAR DETERRENCE STRATEGY

As illustrated above, the development of missile defense originated far before the Cold War era, but the strategy held by the U.S. during the Cold War notes how close humanity has come to complete annihilation in the 20th century. As early as 1945, the United Kingdom (U.K.) had proposed the first system to shoot down ballistic missiles, but the concept to use a radar-networked AAA with a 1-3% kill-rate was far too primitive. The PATRIOT assisted in pushing missile defense further. It was imperative to continue to construct more precise technology in order to combat the power of new and upcoming weapons.


DETERRENCE STRATEGY

The origin of deterrence strategy was exemplified during the Cold War era from 1949 to 1991. The rivalry of between the United States of America (U.S.A) and the Union of Soviet Socialist Republics (U.S.S.R) initiated an apparent need for a strong defense against the threat of ballistic, thermonuclear, chemical, biological, and nuclear weapons. As the Cold War unfolded after World War II, America determined that it faced a hostile and expansionist Soviet Union. The growing threat of Soviet long-range missiles in the 1950s posed an unprecedented challenge to defending America against attack. In 1955, intelligence reports of an impending Soviet ICBM
threat spurred the Department of Defense to launch a major ballistic missile development program to match the Soviets. The creation of weapons that have the potential to end civilization called for an overwhelming need to take measures to defend the possibility of such threats. Ironically, the desire to obtain the arsenal that the U.S.A. and the U.S.S.R. possessed during the Cold War was originally proposed to deter one another from using their own weapons against one another.

At the time it appeared feasible, but in hindsight it had the potential to worsen the relationship between the two sovereign states, as well as threaten the welfare of many other states at the time. Similar to other times in history, the technological advances of both the U.S.A. and the U.S.S.R. created alliances with other powers that shared the same values. The sheer strength and power of the weapons that the two states possessed created a stalemate of the deadliest of sorts. Nuclear bombs posed a terrifying situation for the world at large.

In addition, the two types of nuclear bombs, fission and fusion started a new era of fear that to this day, has yet to be met by more powerful methods of destruction. Nuclear bombs that are fission, or atomic have an immense energy release which are unstable, and cause an explosion equivalent to that of a 10KT to 500KT TNT paroxysm. Nuclear fusion bombs, or H-Bombs squeeze atoms together to form helium which can release one hundred times the amount

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of the energy that is used (up to 50MT TNT-equivalent yield). The U.S.A.’s strategy of deterrence was based upon the assumption that a leader of a state would not use nuclear weapons against an enemy based on the fact that they are rational, based on mirror-imaging; and this rationally would move them toward understandable, predictable behavior.\(^ {12} \)

U.S. leaders failed to take seriously the prospect for, and thus to prepare for, what seemed in Washington to be highly unreasonable foreign behavior. In several cases, despite considerate evidence, they failed to anticipate “out of the box” decision-making, and thus were surprised.\(^ {13} \) The assumption of the U.S.A. did not consider that foreign leader’s values and beliefs may play a crucial role in their decision-making. Also significant, the rationality of a leader’s decision-making process is not related to the question of whether the desired goals, or chosen routes to those goals, will be compatible with accepted norms, customs, and values. The goals and/or actions of a rational decision-maker may seem unreasonable to an outside observer, even bizarre, without compromising the rationally of the decision-making process.\(^ {14} \) Incredibly, during the Cold War era, the U.S.S.R. did not take militaristic action although both sides came very close due to the misinformation of their communication operations. Although by examining the strategy of the U.S. during the Cold War, it is clear that the stock piling of nuclear weapons, and the "finger on the trigger", or rather "resting above the button" mentality was much more dangerous than the vast majority of the Earth's population could of imagined at that time in world history.

\(^ {11} \) Staff, Nuclear Weapons Wikipedia.org. 17 August 2012 http://en.wikipedia.org/wiki/Nuclear_weapon#Fission_weapons
During the Cold War Era, there were also many interesting technological advances in ICBMs. The Minuteman I, II and III played an important role in the United States' Cold War Missile Program. The print below illustrates an exploded view of the Minuteman II, as well as the Minuteman II's Transporter Erector.

In addition, ICBMs possess four types of payloads including reentry(RVs), multiple reentry(MRVs), multiple independently-targetable reentry(MIRVs), and maneuvering reentry vehicles(MARVs); and ICBMs also have the potential to up to more than ten reentry missile

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payloads. ICBMs flight patterns can consist of up to four stages, but typically have three; boost; midcourse; and terminal phase.

THE PEACEKEEPER

"I would like to decrease our reliance on the threat of retaliation by offensive nuclear weapons and to increase the contribution of defensive systems to our security and that of our allies. To begin to move us toward that goal, I have concluded that we should explore the possibility of using defensive capabilities to counter the threat posed by nuclear ballistic missiles."

~ Ronald Reagan

During the time period between 1986 to 2005, the Peacekeeper, which was the U.S. Air Force's most powerful, accurate and technologically advanced ICBM, served as a deterrent. The USAF had began planning for a missile to replace Minuteman ICBMs in 1972, and named the projected weapon "missile X," or MX. It would use the latest targeting technology to deliver many independently targeted nuclear warheads by each missile. The ability to deliver several warheads on one missile is known as MIRV, or Multiple Independently targeted Re-entry Vehicles. MX eventually was named Peacekeeper and designated LGM-118A.16

The Peacekeeper also went through three stages after it was initially launched; solid fuel, Thiokol; solid fuel Aerojet; solid fuel, Hercules; and a storable liquid fuel, Rocketdyne. its first-stage solid-rocket motor ignited only after the missile cleared the silo. The next two stages, also solid-fuel rockets, boosted the missile's payload into space. The fourth stage, or post-boost

vehicle, contained the missile's guidance and re-entry systems. This liquid-fueled stage maneuvered in space to properly orient the re-entry system, which activated and released up to ten nuclear warheads. Each warhead was contained in a small MK-21 re-entry vehicle, and each followed an independent ballistic, or unpowered, path during descent to its target. Accuracy depended on the warheads being released in the right direction at the proper altitude and speed.  

Another couple technical notes worth mentioning; the Peacekeeper possessed a payload of 10 Avco MK-21 reentry vehicles, and could reach 15,000 mph in speed. The end of the Cold War significantly decreased the need for ICBMs such as the Peacekeeper. Once the Strategic Arms Reduction Treaty (START) II was signed in 1993, which comprised of removing any and all multiple-warhead ICBMs, the Peacekeeper became obsolete. Since the deactivation of these ICBMs was complete in 2005, they have only been used as satellite launch vehicles.

Furthermore, it was during the Reagan Administration that the United States' Strategic Defense Initiative (SDI) began to change the perspective on how to deal with an opponent's threat. Ronald Reagan's determination to focus on defense spending, as opposed to the Cold War Era mentality of accumulating weapons in order to deter an attack vastly paved the way into a new era of thinking. Fundamentally, defenses now

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can be considered in the context of shared problems rather than in the context of military competition. One common problem is the concern about the proliferation of ballistic missiles that can deliver to great ranges weapons of mass destruction, which are also proliferating throughout the world. Several proliferant states are led by political regimes that are either unstable or driven by ethnic hostilities—or both. Also concerns continue about the accidental or unauthorized launch of ballistic missiles, many of which remain on alert and pointed at the United States.¹⁹

**MODERN DAY MISSILE DEFENSE**

**ISRAEL’S IRON DOME**

"Iron Dome has altered the calculus of Israel’s political echelons in ways they have yet to understand. It allows Israel to resist internal public and military pressure for a quick end to the conflict, and keep bombing Gaza."

~ Former Israeli Senior Official

Israel's Iron Dome defense system is one of the most significant modern day missile defense system. It was created to intercept and destroy short-range rockets, artillery shells and

mortars fired from distances of up to 45 miles, to protect civilian areas in the path of such projectiles. The three piece system of interceptor batteries shoots rockets down by using a radar which tracks the rockets pattern once it has been fired across the border. The information is then communicated to guide the interceptor missiles at the predicted trajectory of the rocket. The system's success means that Binyamin Netanyahu, the Israeli prime minister, has been able to use Iron Dome to maintain his policy of conflict management, with less fear of retaliation. It also provides some degree of immunity against other neighbours armed with missiles, such as the Lebanese Shias' Hizbullah militia, or Syria, perhaps making the agreement of a lasting peace settlement seem less urgent. Nonetheless, as air-raid sirens sound, most Israelis are glad to have the protection of the Iron Dome.²⁰

THE U.S. AND RECENT MISSILE DEFENSE

"It is the policy of the United States to deploy as soon as is technologically possible an effective National Missile Defense system capable of defending the territory of the United States against limited ballistic missile attack (whether accidental, unauthorized, or deliberate) with funding subject to the annual authorization of appropriations and the annual appropriation of funds for National Missile Defense." ~ National Missile Defense Act of 1999 (106th Congress) January 22, 1999

The Project for the New American Century (PNAC), was established as a non-profit educational organization in 1997 to influence military and foreign policies with an emphasis on national security published a ninety page report entitled Rebuilding America's Defenses: Strategies, Forces, and Resources For a New Century. The report argues for an extension of

U.S. global leadership through the usage of militaristic defense strategies, modernizing current U.S. Forces selectively, proceeding with the F-22 program while increasing purchases of lift, electronic support and other aircraft; expanding submarine and surface combatant fleets; purchasing Comanche helicopters and medium-weight ground vehicles for the Army, and the V-22 Osprey "tilt-rotor" aircraft for the Marine Corps.

Also, canceling "Roadblock" programs such as the Joint Strike Fighter, CVX aircraft carrier, and the Crusader howitzer system that would absorb exorbitant amounts of Pentagon funding while providing limited improvements to current capabilities. Savings from these canceled programs should be used to spur the process of military transformation.

In addition, the PNAC's goals include developing and deploying global missile defenses to defend the American homeland and American allies, and to provide a secure basis for U.S. power projection around the world. Furthermore, it is their desire to control the new "International Commons" of space and "Cyberspace", and pave the way for the creation of a new military service – U.S. Space Forces – with the mission of space control. Including exploiting the "Revolution in Military Affairs" to insure the long-term superiority of U.S. conventional forces. Establishing a two-stage transformation process which:

- maximizes the value of current weapons systems through the application of advanced technologies, and,

- produces more profound improvements in military capabilities, encourages competition between single services and joint-service experimentation efforts.

Lastly, the PNAC's report suggests a need to increase defense spending gradually to a minimum level of 3.5 to 3.8 percent of gross domestic product, adding $15 billion to $20 billion
to total defense spending annually. Propositions alike the one filed in the PNAC’s report illustrate the various theories of how the U.S. should focus the defense both nationally, as well as internationally.

**RECENT U.S. BMD TESTS**

Much more recently, on June 23rd of 2014, The Missile Defense Agency (MDA) and its joint partners completed the first intercept using the second-generation exoatmospheric kill vehicle (EKV), during a test over the Pacific Ocean. Successfully all components seemed to perform as designed, MDA officials said in a statement, and program officials will spend the next several months assessing and evaluating system performance based on telemetry and other test data. About six minutes after target launch, the ground-based interceptor launched from Vandenberg Air Force Base, California. Then an operational crew of soldiers from the Army’s 100th Missile Defense Brigade at Schriever Air Force Base in Colorado remotely launched the interceptor, and a three-stage booster rocket system propelled

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the interceptor's EKV into the target missile's projected trajectory in space. The kill vehicle maneuvered to the target, performed discrimination -- or determined the difference between the warhead and a decoy -- and intercepted the threat warhead using only the force of the direct collision to destroy it.

Additionally, the test, called flight test ground-based interceptor-06b, or FTG-06b, will provide the data needed for the assessment and to assess the performance of many Ballistic Missile Defense System elements for homeland defense.\(^2\)

\(^2\) The test of an intermediate-range ballistic missile target concentrated upon potential threats to the U.S. homeland. The director of the MDA, Navy Vice Adm. James D. Syring stated that his, "highest priority remains the successful intercept flight test of the CE-II [variant] exoatmospheric kill vehicle."\(^3\)

\(^3\) The test was the 65th successful hit-to-kill intercept out of 81 attempts for the Ballistic Missile Defense System since 2001.

To conclude, the history of missile defense is extensive and it is the intention of this research to demonstrate how ICBMs have quickly resulted in a need for superior defense systems globally. Since WWI, the leaders of powerful nation-states have continued to evolve defense strategies in order to prevent the hostile threat of an opponent's missile payload. The future is uncertain, but it is clear that missile defense will continue to increase as long as wars continue to be fought.
