The “Golden Dome”

The dream of a technical fix lives on

Physicists Coalition for Nuclear Threat Reduction

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Context

Even a single nuclear weapon exploded over a city could immediately kill millions of people.

Intercontinental ballistic missiles (ICBMs) armed with nuclear weapons make us vulnerable to sudden attack and devastation from far away.

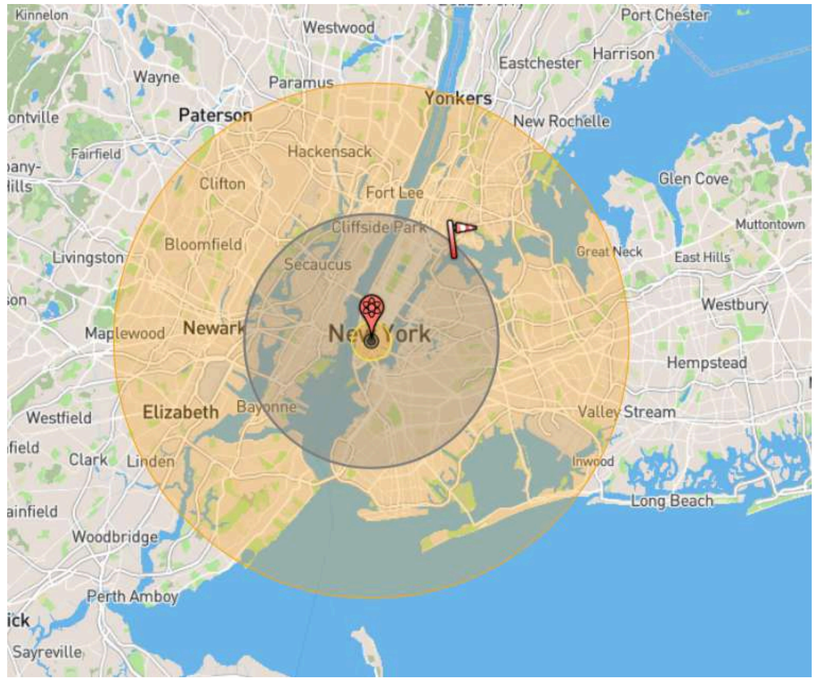
A natural reaction is to attempt to intercept these missiles or their warheads, to prevent their warheads from reaching their targets.

During the past 70 years, the United States has spent over $400 billion on ballistic missile defense, mostly on systems intended to intercept nuclear-armed ICBMs that might be launched against the United States.

The ability of any of these systems to intercept even a single warhead under the conditions expected during a nuclear attack has not been demonstrated.

Immediate effects of a 5 Mt airburst over New York, NY

Fatalities: 3.2 million Injuries: 4.6 million



Additional fatalities would be caused by firestorms, fallout radiation, injuries, the lack of shelter and food, failure of medical, social, public health services.

The Golden Dome Proposal

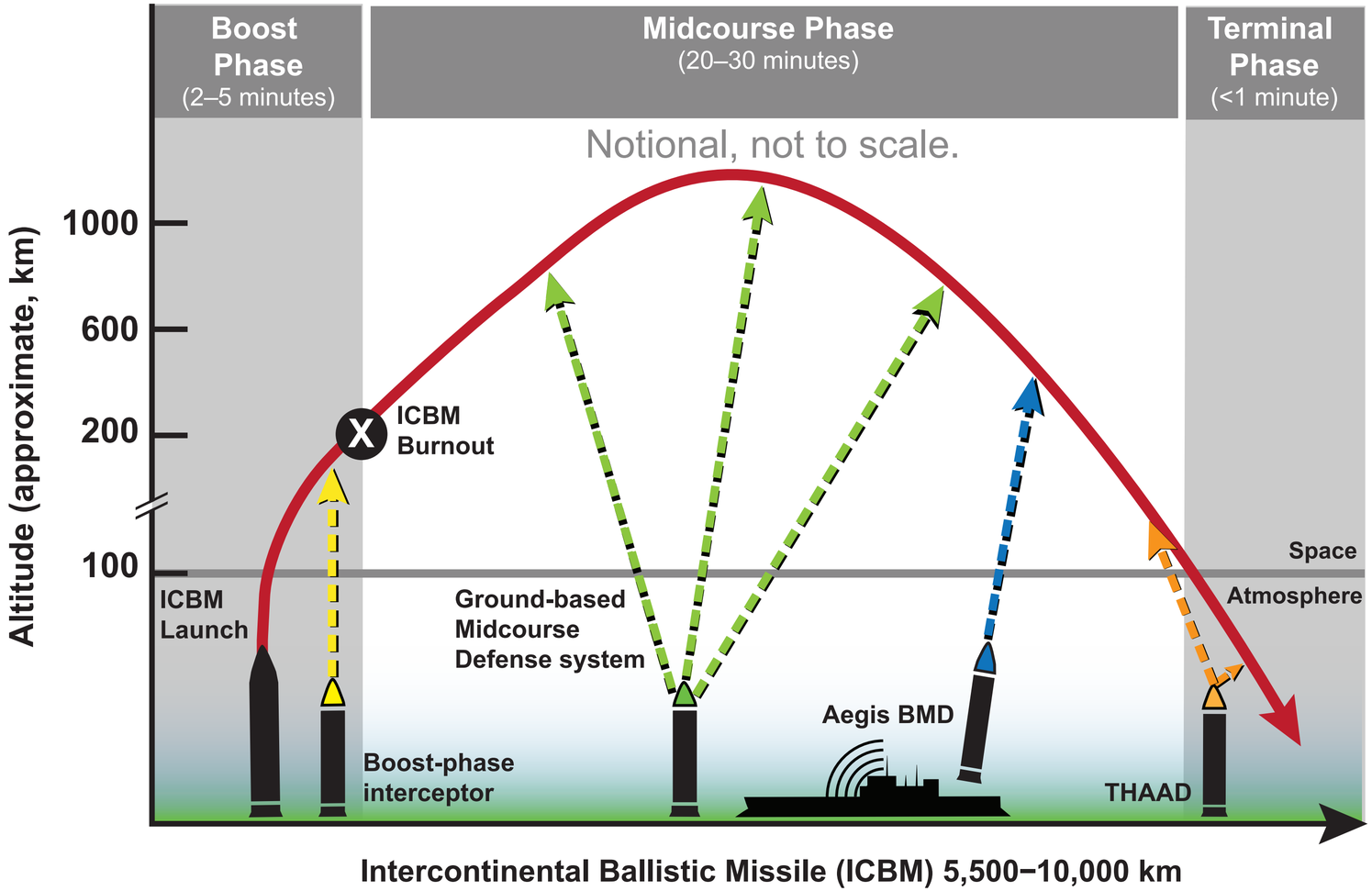
To defend the United States and its allies and their armed forces against attack by aircraft, ballistic missiles, hypersonic glide vehicles, cruise missiles, and drones fired against them at any time from anywhere by any adversary, including peer and near-peer adversaries.

This goal is clearly beyond reach anytime soon.

Today's webinar focuses on three aspects of defending against nuclear-armed ICBMs:

- The prospects for boost-phase intercept defenses (this talk)
- The prospects for midcourse intercept systems (Laura Grego)
- The many costs of ballistic missile defense (Igor Moric)

ICBM phases of flight and possible intercept systems



Source: *Strategic Ballistic Missile Defense*, APS 2025

Boost phase (~ 3–5 min)
Target: missile in flight
(warhead not yet deployed)
Missile engines burning
Accelerating and climbing

Midcourse (~ 20–30 min)
Target: warhead only
Follows a ballistic trajectory
In space (no air drag)
Current system: GMD

Terminal phase (~ 30 sec)
Target: warhead only
Warhead descends, reenters
Atmospheric drag increases
Current system: THAAD

The challenges of defending against nuclear-armed ICBMs

Israel's Iron Dome

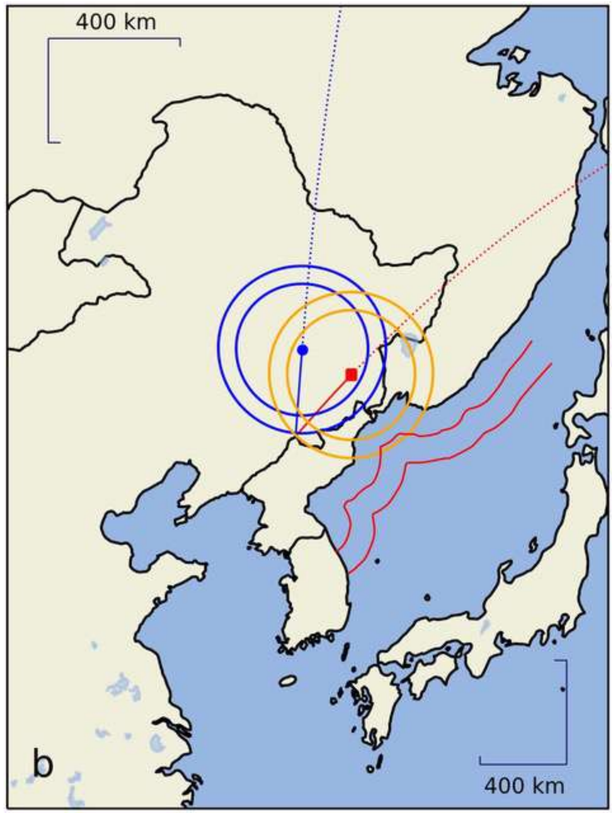
- Iron Dome was developed to defend against artillery and mortar shells and simple, very short-range, highly inaccurate home-made rockets that typically travel 7–70 km at speeds of 1 km/s or less and have warheads with 10 kg or less of TNT.
- For comparison, a nuclear-armed ICBM can travel 10,000–13,000 km at 7 km/s and carry a warhead with an explosive power a million times greater.
- The Iron Dome system is now claimed to disable about 80%–90% of the home-made rockets it engages, or about 40%–45% of the rockets launched against the area it is defending.
- Iron Dome would fail catastrophically if used to defend against an attack by nuclear-armed ICBMs.

Defenses against medium-range missiles

- During Iran's retaliations against Israel in April and October 2024, with advance warning and time to prepare the combined missile defenses of Israel, the US, and their allies were able to intercept 70%–80% of Iran's medium-range ballistic missiles.
- This was labeled a success, but if these missiles had been aimed at cities instead of air bases, the result would have been far worse. If even one had been carrying a nuclear weapon, reached its target, and exploded, the result would have been catastrophic.
- In April and October 2024 and June 2025, the US helped protect Israel by firing large numbers of its THAAD and SM-3 missiles. In June 2025 the US moved 5 guided missile destroyers to the Eastern Mediterranean to use their SM-3 missiles. The US and Israel fired large numbers of these interceptors, significantly depleting their stocks.

Boost-phase intercept of ICBMs launched from even a small country like North Korea is very challenging

Even 5 km/s airborne interceptors could not defend any of the continental United States against North Korea's Hwasong-18:



Source: *Strategic Ballistic Missile Defense*, APS 2025

- The reach-versus-time challenge

  ICBM boost phases are short (4–5 min for liquids, 3 min for solids).

  Intercept points for ICBMs from North Korea are > 500 km from potential interceptor basing locations.

  The defense has little time to decide whether to fire and interceptors have little time to reach the ICBM (~ 100 to ~ 200 seconds).

- There are many other challenges that must be met for a boost-phase intercept system to be successful—hitting the final stage, defeating countermeasures such as programmed evasion, etc.

- But *if a boost-phase defense system cannot meet the reach-versus-time challenge successfully, all other issues are irrelevant—the defense will fail.*

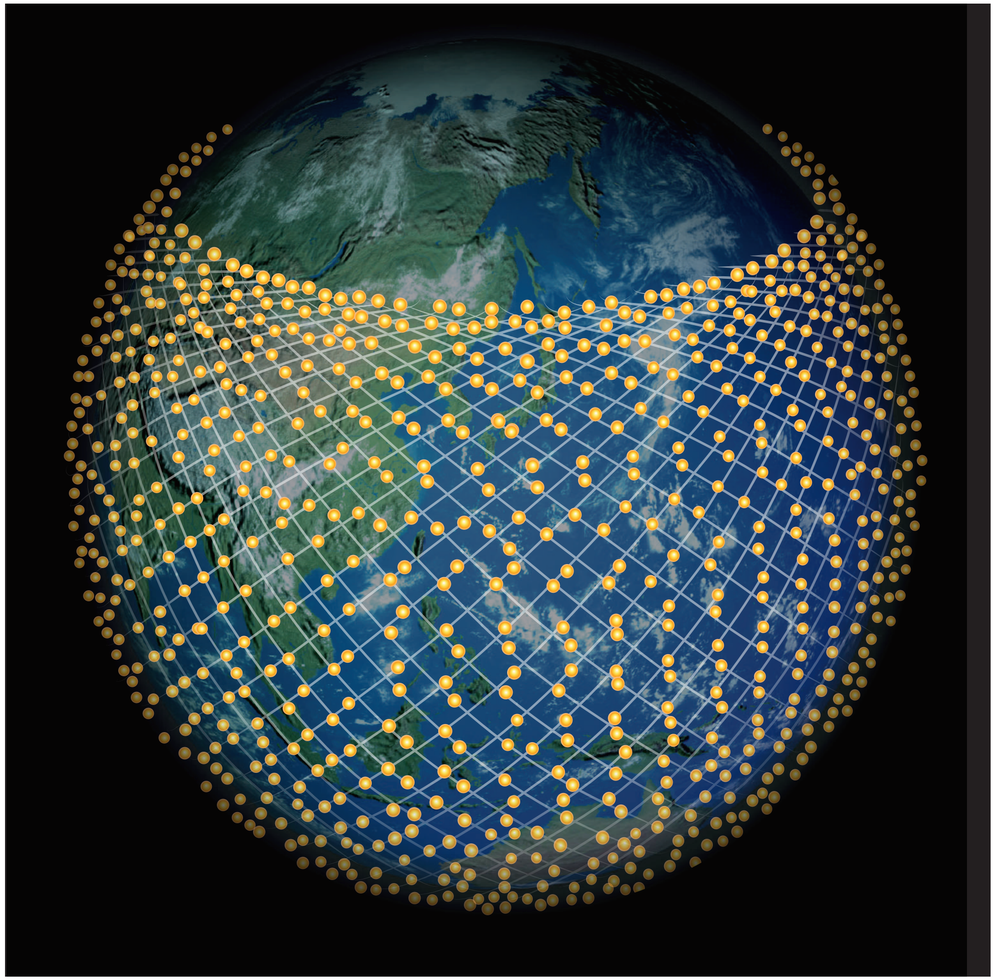
Boost-phase intercept using space-based interceptors – 1

Because each space-based interceptor (SBI) moves rapidly around its orbit and any given launch site rotates under its orbit as Earth rotates, a given SBI will usually not be in a position that would allow it to reach an ICBM before it deploys its warhead(s). This is the “absentee” problem. It means that a large constellation of SBIs is required to insure at least one is in the right position to attempt an intercept.

To defend against a salvo launch of 4 slow, liquid-propellant ICBMs from North Korea against targets in the middle- and lower-latitude U.S. states—trajectories that make them easier to intercept—would require at least 1,600 SBIs, if the system is designed to fire interceptors automatically without checking the system or verifying the threat and there is only one SBI to intercept each ICBM.

To counter a salvo launch of 10 solid-propellant ICBMs and prevent spoofing would require about 40,000 orbiting interceptors to defend all of the continental United States.

What a constellation of 1,600 space-based rocket interceptors would look like:



Source: *Strategic Ballistic Missile Defense*, APS 2025

Boost-phase intercept using space-based interceptors – 2

Estimates of SBI Constellation Costs

- *Congressional Budget Office (May 2025)*

  The decrease in launch costs from ~ $10,000 per lb. in 2012 to ~ $1,000 per lb. now could reduce the 20-year costs of the various SBI constellations by 30%–40%.

  Hence for the constellation of 2,000 SBIs that would be needed to theoretically defend against 1 or 2 liquid-propellant ICBMs launched by North Korea, assuming only one SBI per ICBM, the estimated 20-year cost is now $542 billion, down from $830 billion.

- *APS BMD Report (March 2025)*

  For the 40,000 SBIs needed to theoretically defend against a salvo of 10 solid-propellant ICBMs launched by North Korea, again assuming only one SBI per ICBM, the construction and initial launch cost could be ~ $1 trillion.

  In this case, to counter 1 additional ICBM the defense would need to spend ~ 1,000 times the cost of that ICBM.

Countermeasures

- Salvo or staggered launch of ICBMs.
- Launch decoy rockets to confuse the defense and deplete the defense's interceptor stock.
- Deploy the warhead(s) before the final stage has stopped burning.
- Deploy rocket-propelled decoys, flares, and jammers during the flight of the ICBM's upper stages.
- Program the ICBM's upper stages to fly evasive maneuvers, possibly in conjunction with decoys.

Laser weapons

- APS 2003: Need 3 MW laser at 300 km for 5–20 s.
- The US Navy is testing a 60 kW laser on ships.
- The US Army is hoping to develop 100–300 kW lasers for use against mortars, drones, and aircraft.

The dream of a technological solution to the threat of nuclear-armed long-range ballistic missiles

- Over the past 70 years the U.S. has spent more than $400 billion in 2021 dollars on technologies intended to intercept nuclear-armed long-range ballistic missiles in flight.
- We are now considering spending hundreds of billions to trillions of dollars more on this effort.
- This huge and costly effort has never produced a system that could defend the continental United States against nuclear-armed long-range ballistic missiles and there is no prospect of deploying such a system in the near future.
- Wishful thinking, ideology, ignorance, and efforts to seek political advantage have repeatedly led to programs that ignore scientific and technical realities.
- Moreover, misplaced faith in the current system is dangerous and impedes more realistic and effective efforts to improve our security.