

Air and Missile Defense at a Crossroads



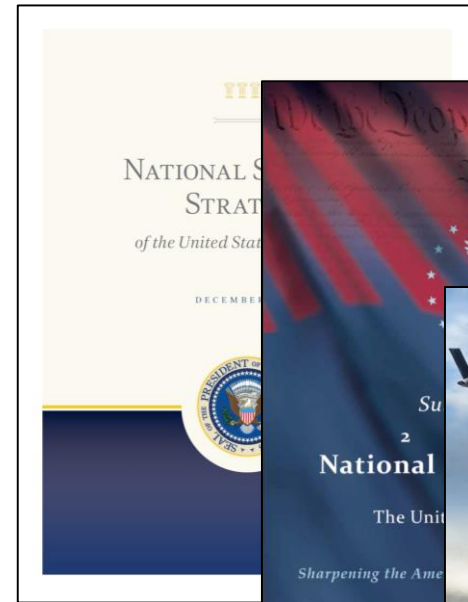
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- **Why this report now?**
- **Understanding the challenge**
- **A concept to defend U.S. theater bases against air and missile threats**
- **Comparing alternatives**
- **Recommendations**

Why now?

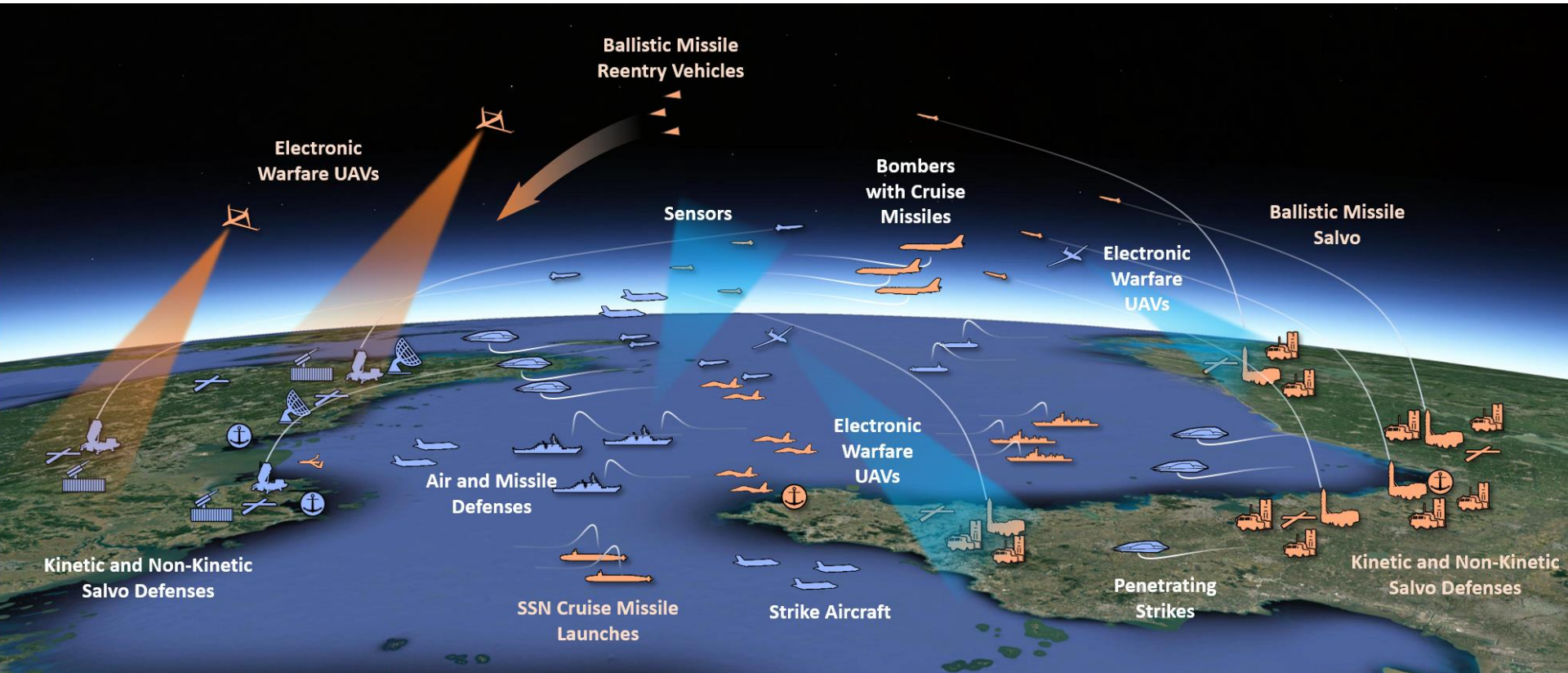
- **Shift toward great power competition**
- **Growing threat to U.S. and allied / partner bases in Europe, the Pacific, and other regions**
- **Maturing technologies that could create higher capacity base defenses**



Our objective: assess concepts and capabilities that could improve our military's ability to operate from bases in contested areas in the near- to mid-term

From U.S. dominance in precision strike to a mature precision strike regime

We are in the era of salvo competitions, which is the dynamic between competitors that have the ability to strike & defend against strikes with precision



Competitors continually seek to gain advantages by increasing the size and survivability of their strikes and their capacity to defend against strikes

The growing threat to U.S. bases: not just ballistic missiles



DF-26



CJ-20

H-6 with cruise missiles

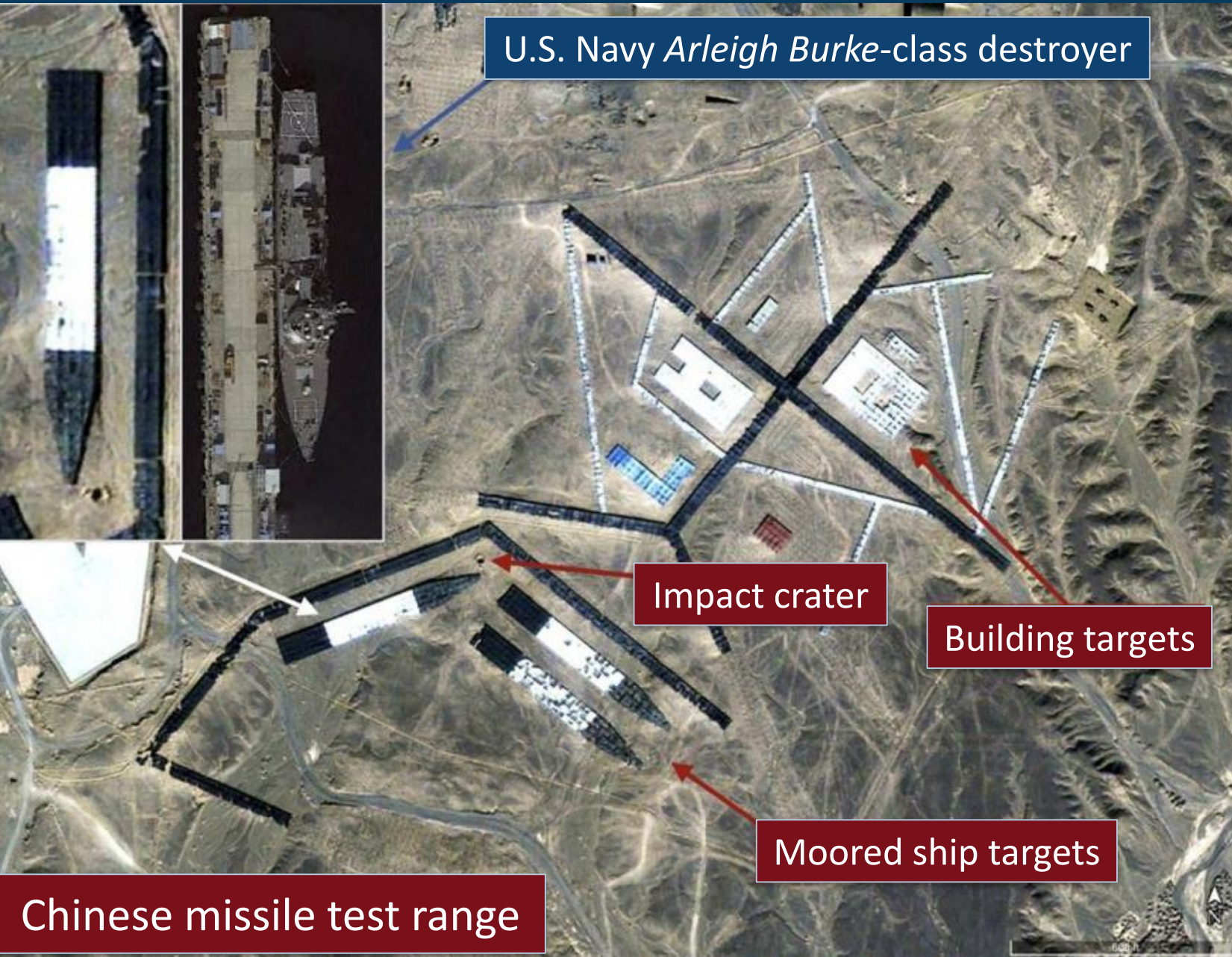


H-20 (illustration)



- China's ballistic missile arsenal includes 1,200 SRBMs, 200-300 MRBMs, and IRBMs like the DF-26 that can reach the 2nd Island Chain
- The PLA has 1,000s of cruise missiles, including GLCMs like the CJ-10; its CJ-20 air-launched version has a range of ~1,500 km
- China's H-6 bombers are capable of launching cruise missiles
- Next-generation H-20 bombers could extend China's conventional airstrike capability to intercontinental range

Attacking U.S. and allied bases is a key element of China's A2/AD strategy



U.S. Navy Arleigh Burke-class destroyer

Impact crater

Building targets

Moored ship targets

Chinese missile test range

Attacking U.S. and allied bases is a key element of China's A2/AD strategy



Mock airfield

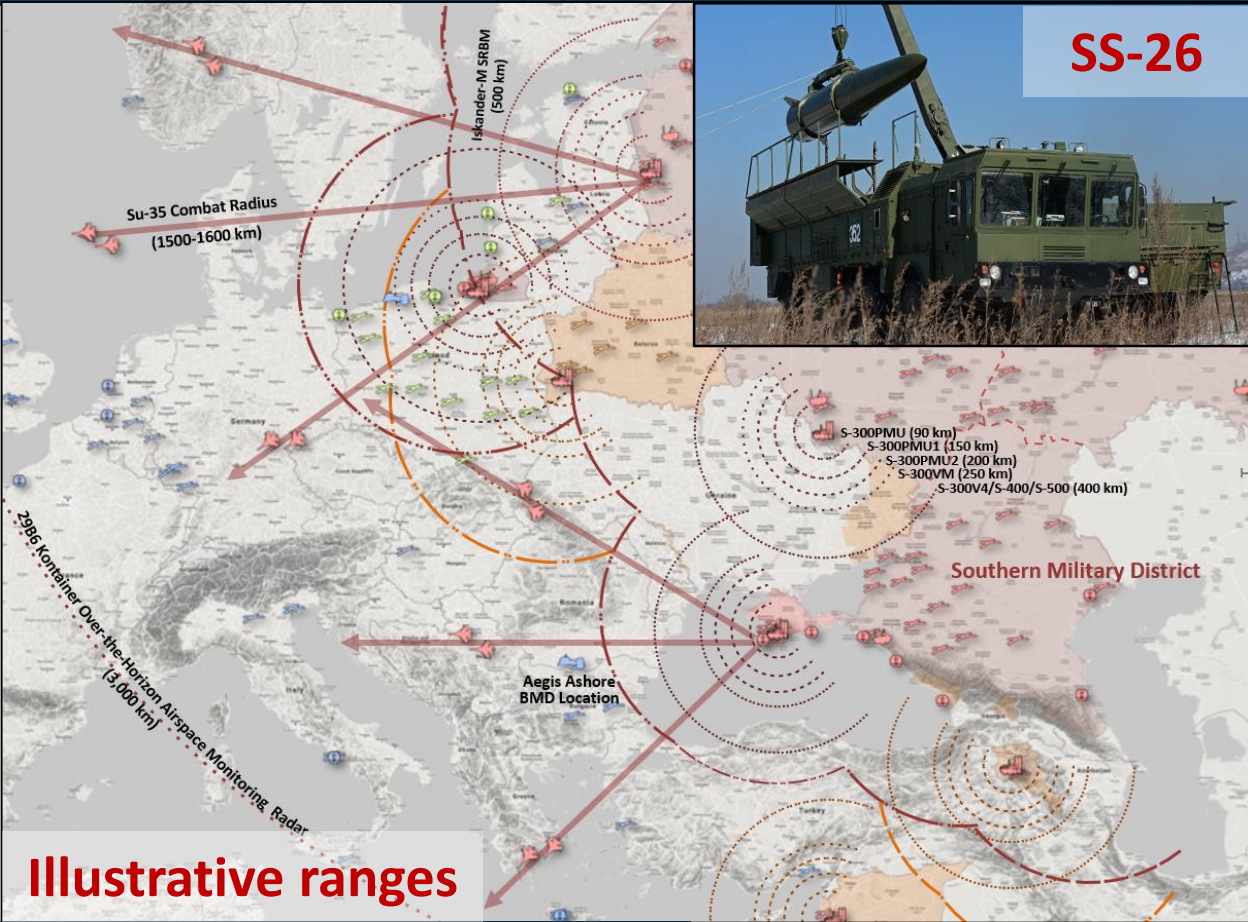
Damaged parked aircraft target

U.S. Air Force F-22 at Kadena Air Base in Japan

Chinese missile test range



There are no rear-area sanctuaries in Europe



- Russia has multiple SRBM variants, such as the 9K920 Iskandar-M (SS-26 Stone)
- Air-, ground-, and sea-launched LACMs, including a land-based GLCM that violates the 1987 INF Treaty, are a major threat to NATO bases located throughout Europe



- LACMs launched by Russia's long-range bombers could reach targets in North America
- Maturing threats: air- and ground-launched hypersonic weapons

- **Lack of sufficient networked sensors and integrated fire control systems to detect and cue intercepts of cruise missile salvos and swarms of unmanned aircraft**
- **Current defenses are weighted toward defeating a small number of ballistic missiles launched by a rogue state**
 - Lack capacity for salvos launched by great power aggressors
 - Insufficient land-based capacity for cruise missile defense
 - Affordability of defenses remains a major concern
- **Significant factor: continuing debate over which DoD organizations should fund programs needed to defend theater bases against air and missile threats**

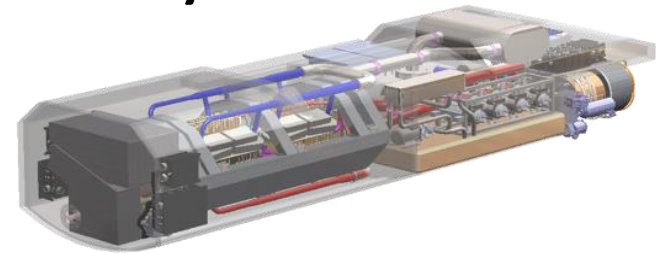


Concepts for future base defenses

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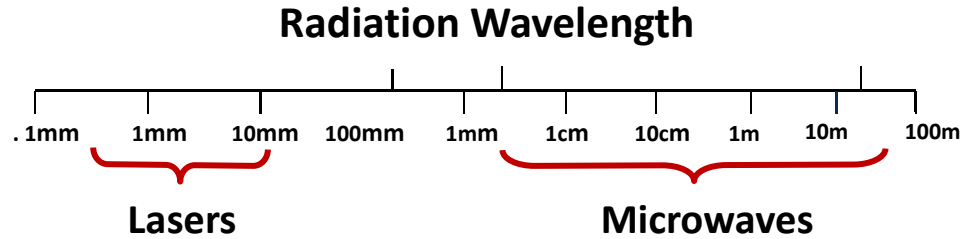
Center for Strategic and Budgetary Assessments

- **DoD's shift toward developing solid state lasers (SSLs) has accelerated its development of practical operational HEL weapons**
 - Multiple SSLs are approaching maturity
- **DoD and the U.S. defense industry are making progress toward reducing the size, weight, power, and cooling required by lasers, and are maturing their beam control and beam director systems**
 - Will soon allow SSLs to be integrated into manned and unmanned aircraft, including combat aircraft
 - Art of the possible: 100-150 kW-class HELs on military aircraft and 300 KW-class HELs on the ground within the next five years
- **SSLs carried by high-value aircraft could increase their survivability against air-to-air and surface-to-air missile threats**

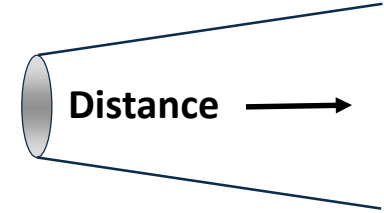


High power microwave (HPM) defenses

Small, tightly focused laser spots on targets



HPM systems have larger beam widths

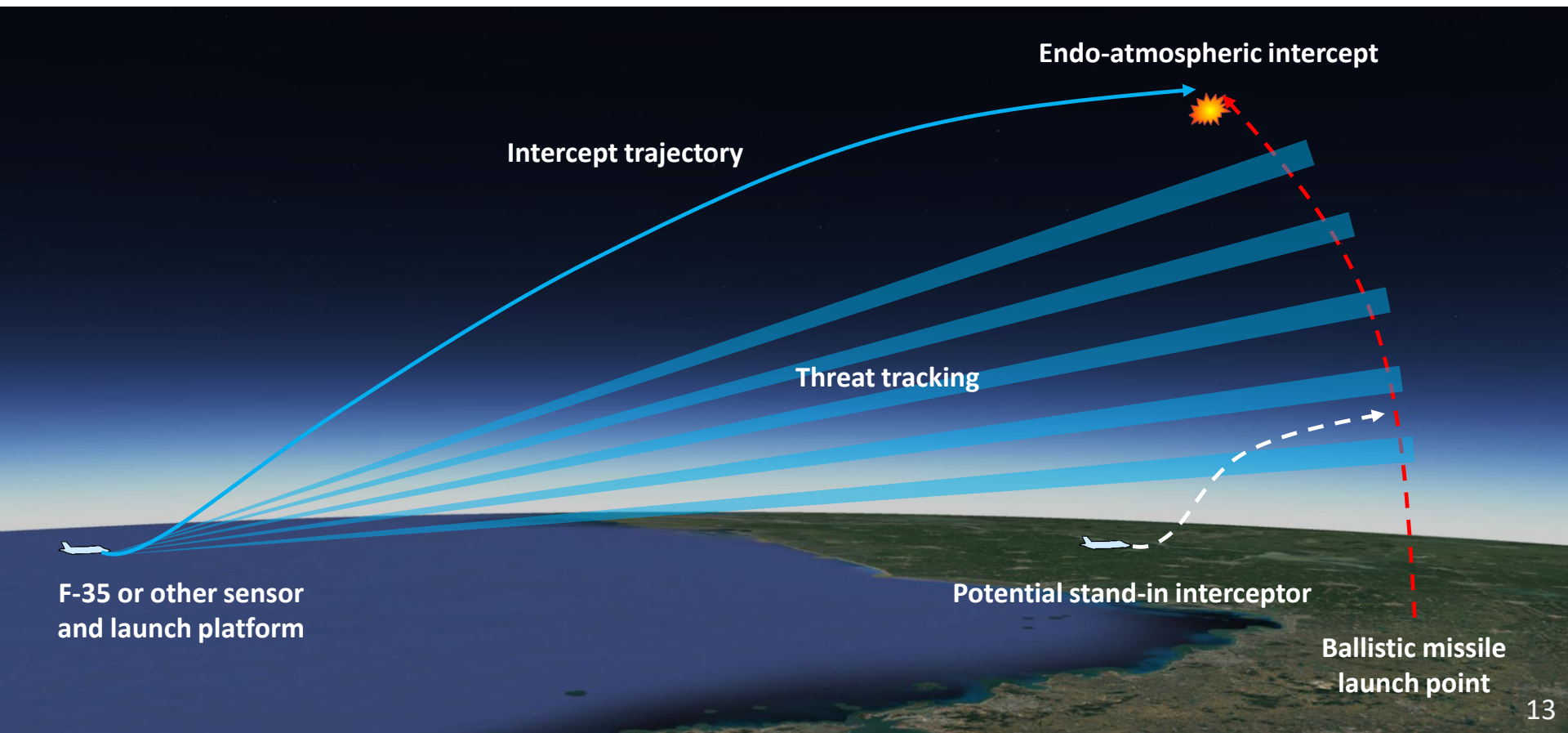


- HPM systems use short duration, high-power pulses of EM energy to damage internal electronic components of weapons such as PGM seekers, guidance components, and control systems
- May need only microseconds to create desired effects, so could engage more threats in an incoming salvo than a laser
- Future ground-based HPM systems could engage cruise missiles, unmanned aircraft and other threats
 - Could near-simultaneously disrupt / destroy multiple unmanned aircraft



Extended range air-to-air missiles for boost phase ballistic missile intercepts

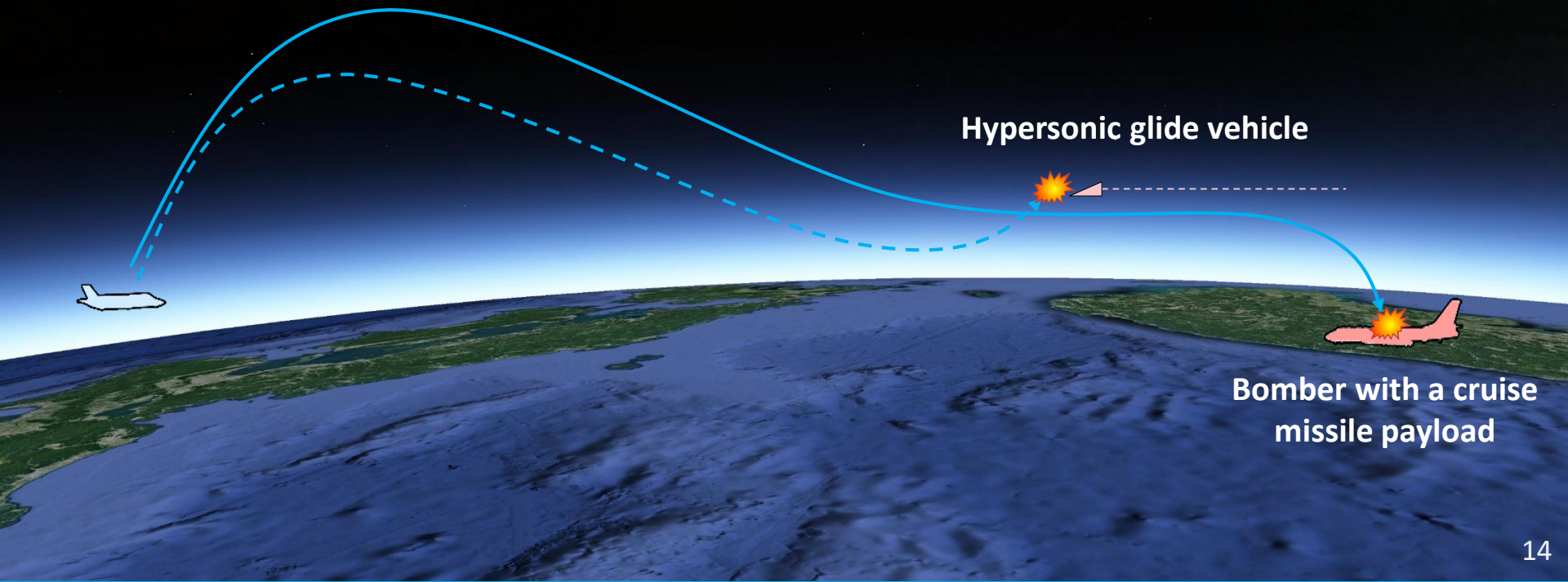
- Fighter-sized manned or unmanned systems carrying 2-4 interceptors could be a first line of defense against salvos
- Could be cued by on-board or off-board sensors; interceptors may require inflight target updates depending on range to threats



Extended range air-to-air missiles to defeat the “archers” and other threats

- Unmanned or manned aircraft with extended range interceptors could intercept enemy bombers before they launch their payloads
- May also be capable of intercepting challenging threats such as ballistic missile RVs and hypersonic glide vehicles (HGVs)

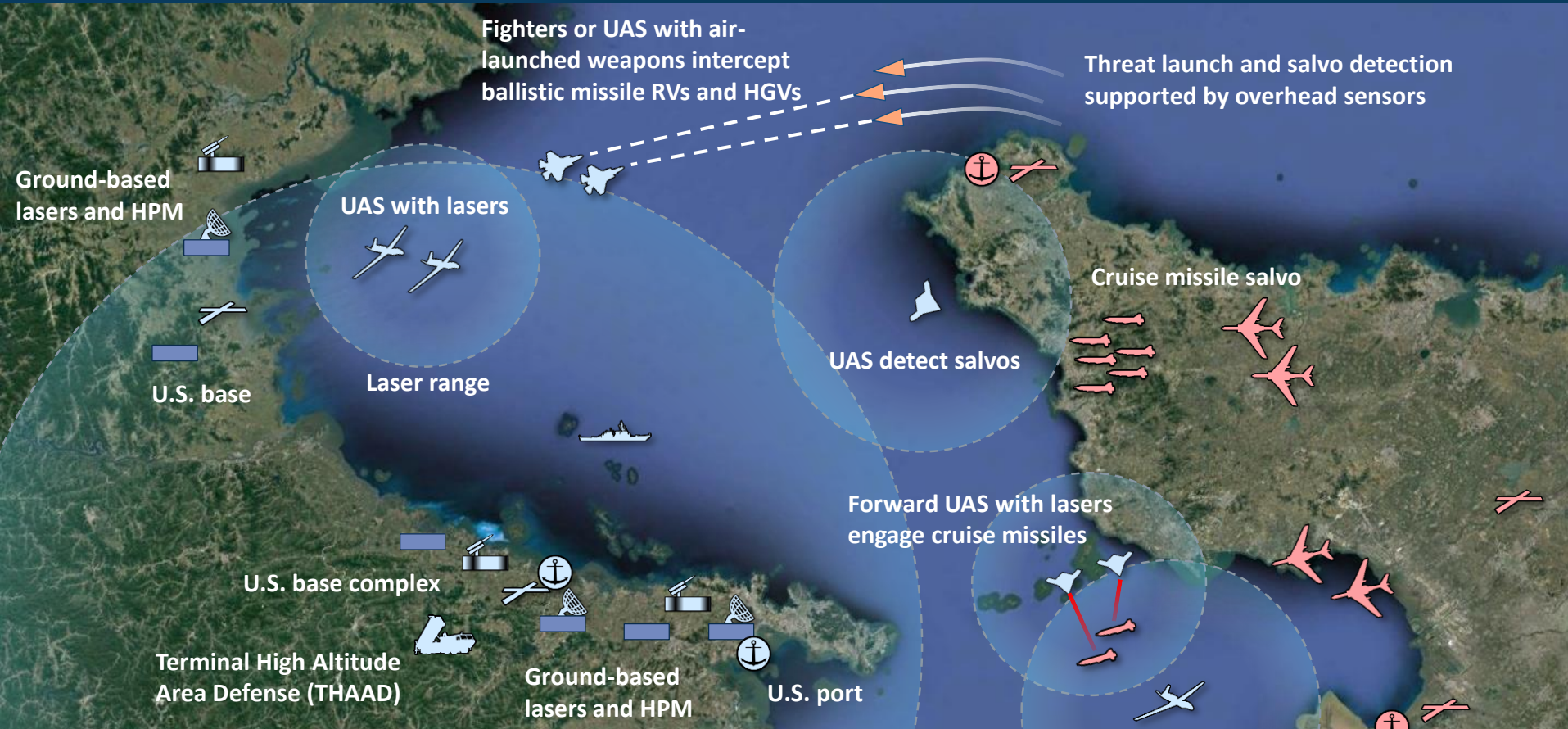
UAS or fighter with multi-stage,
air-launched interceptors



Hypersonic glide vehicle

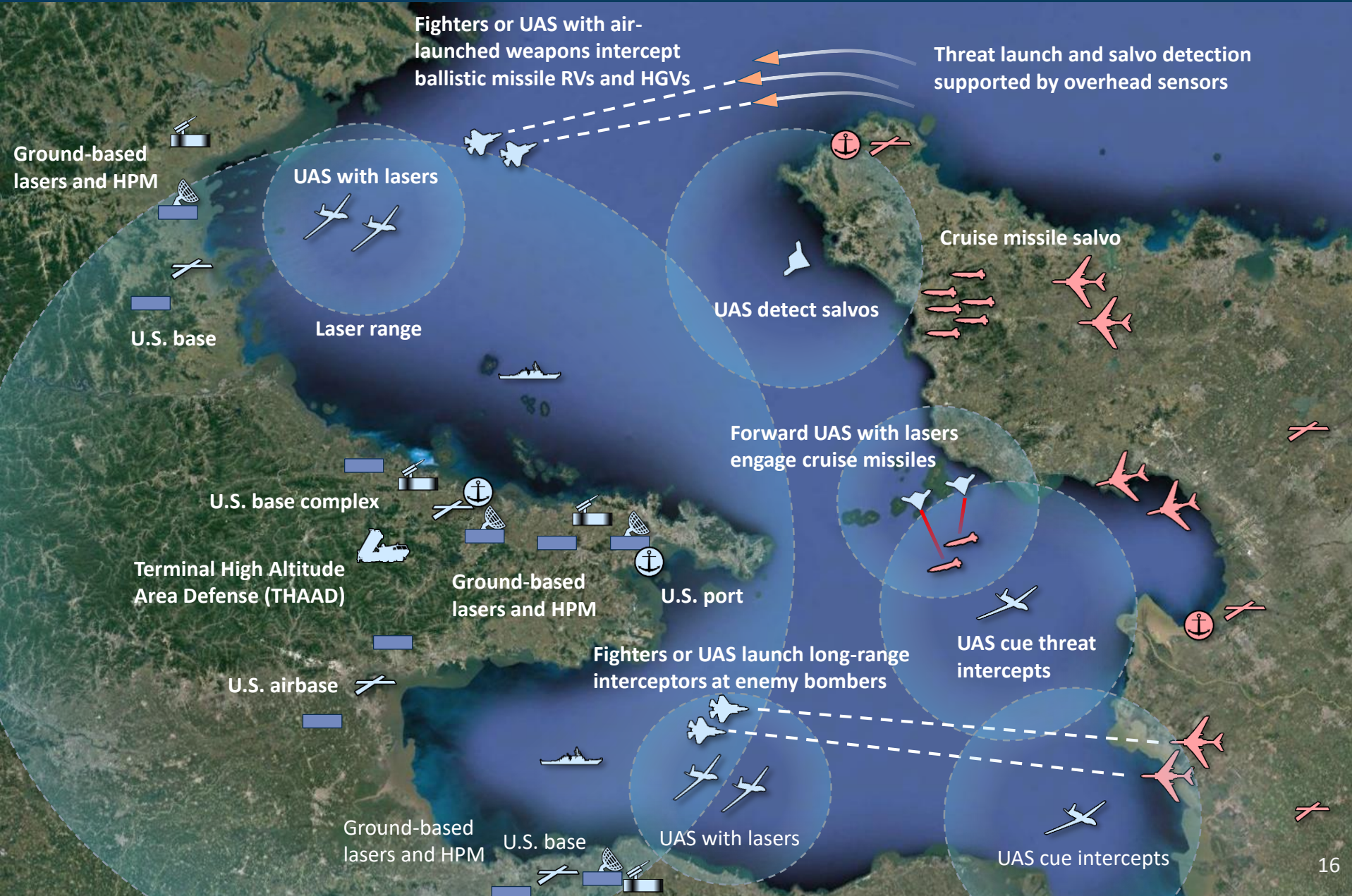
Bomber with a cruise
missile payload

Concept: An "outer ring" layered defense to counter enemy salvos

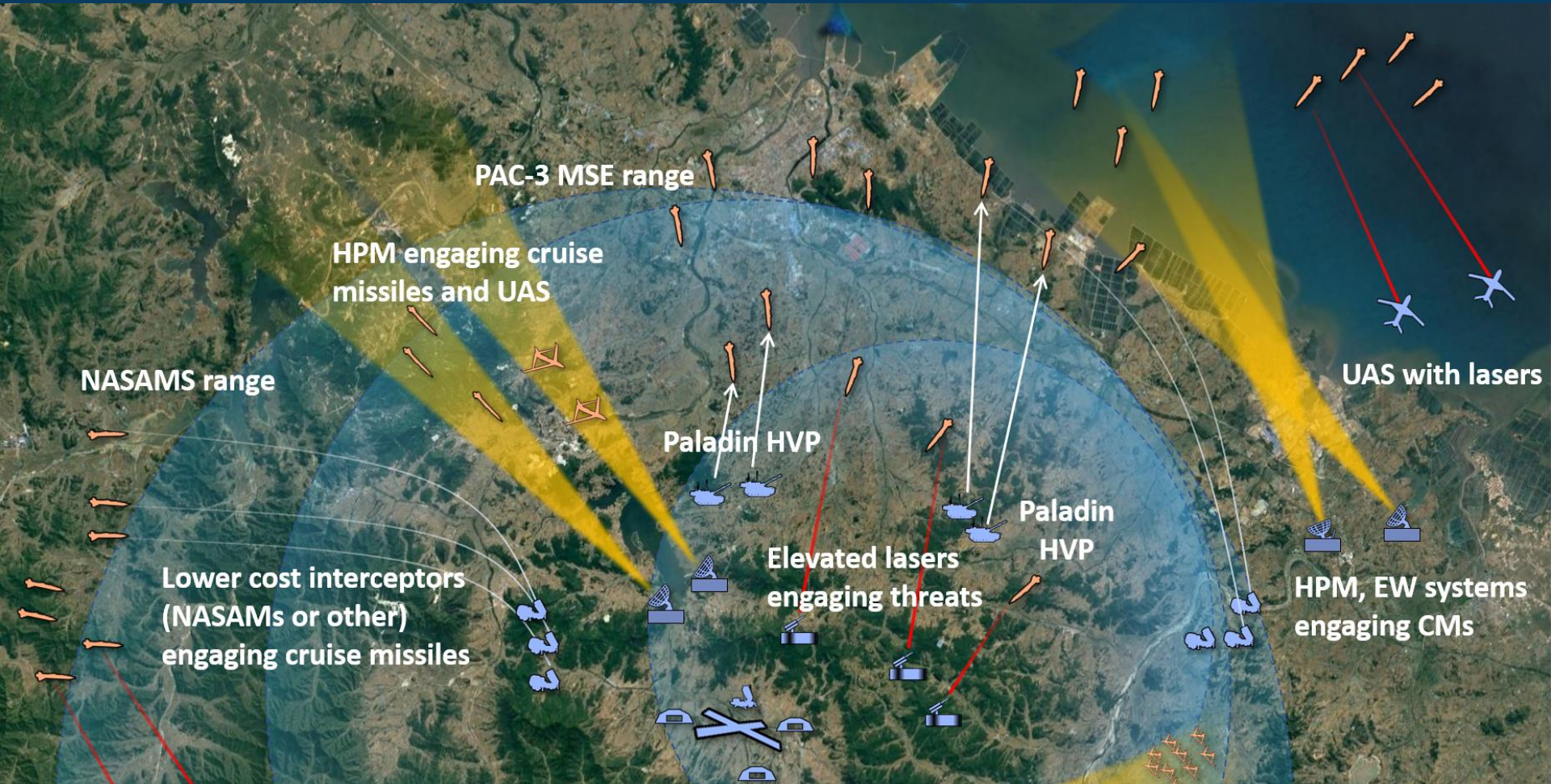


- **Sensor network detects salvos and cues intercepts**
- **Begin to reduce salvos from the outside-in using airborne HELs and aircraft launching long-range interceptors**
- **Kinetic + non-kinetic systems are complementary**

Concept: An "outer ring" layered defense to counter enemy salvos

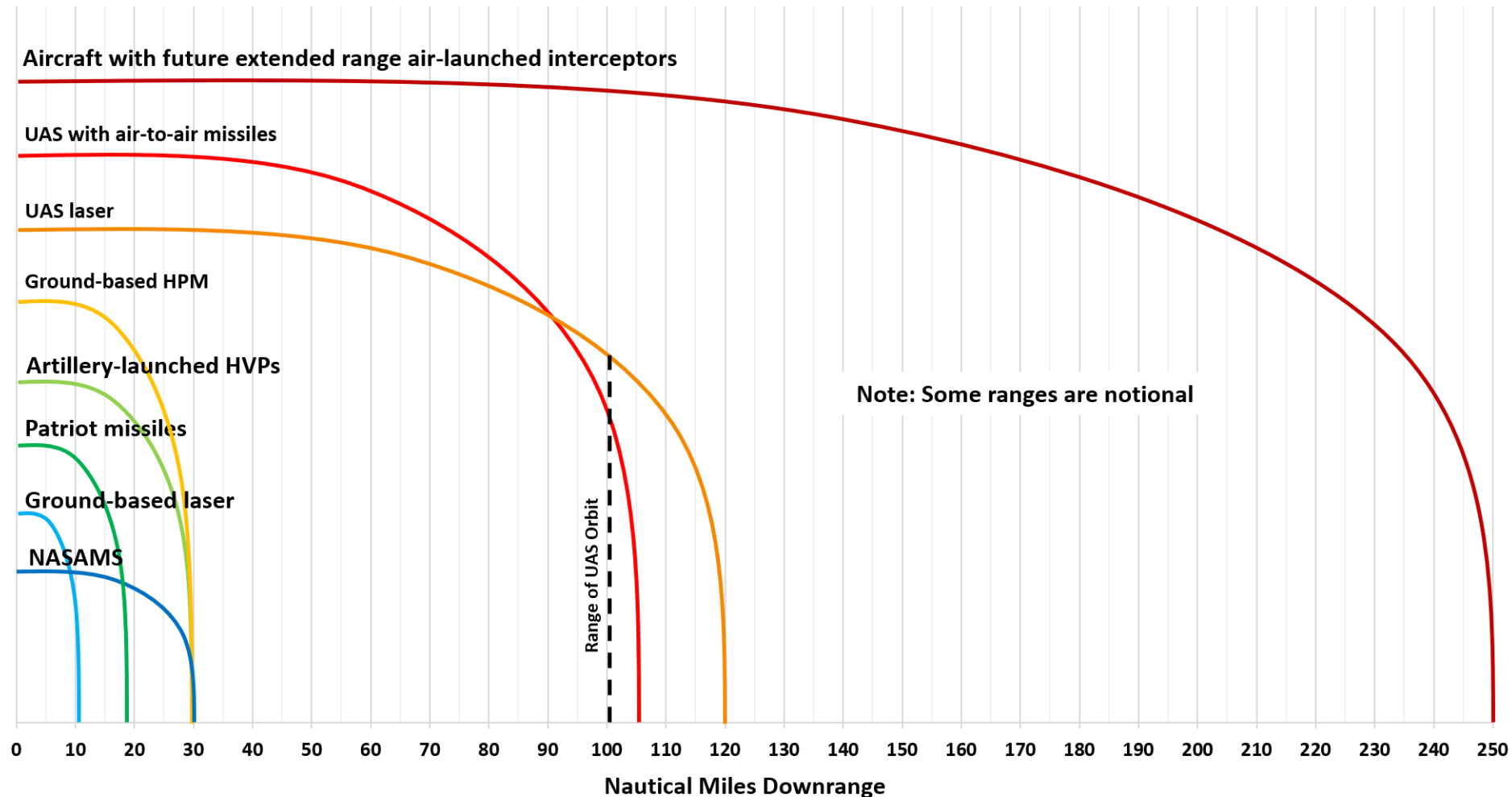


Concept: An "inner ring" of kinetic and non-kinetic defenses



- UAS with HELs and mobile /relocatable ground-based HELs
UAS with lasers engaging HPM engaging UAS swarm
- HPM to counter cruise missile salvos and UAV swarms
- Kinetic SHORADs: low-cost interceptors, 155mm guns with HVPs...¹⁷

Combining short-range, medium-range, and long-range systems

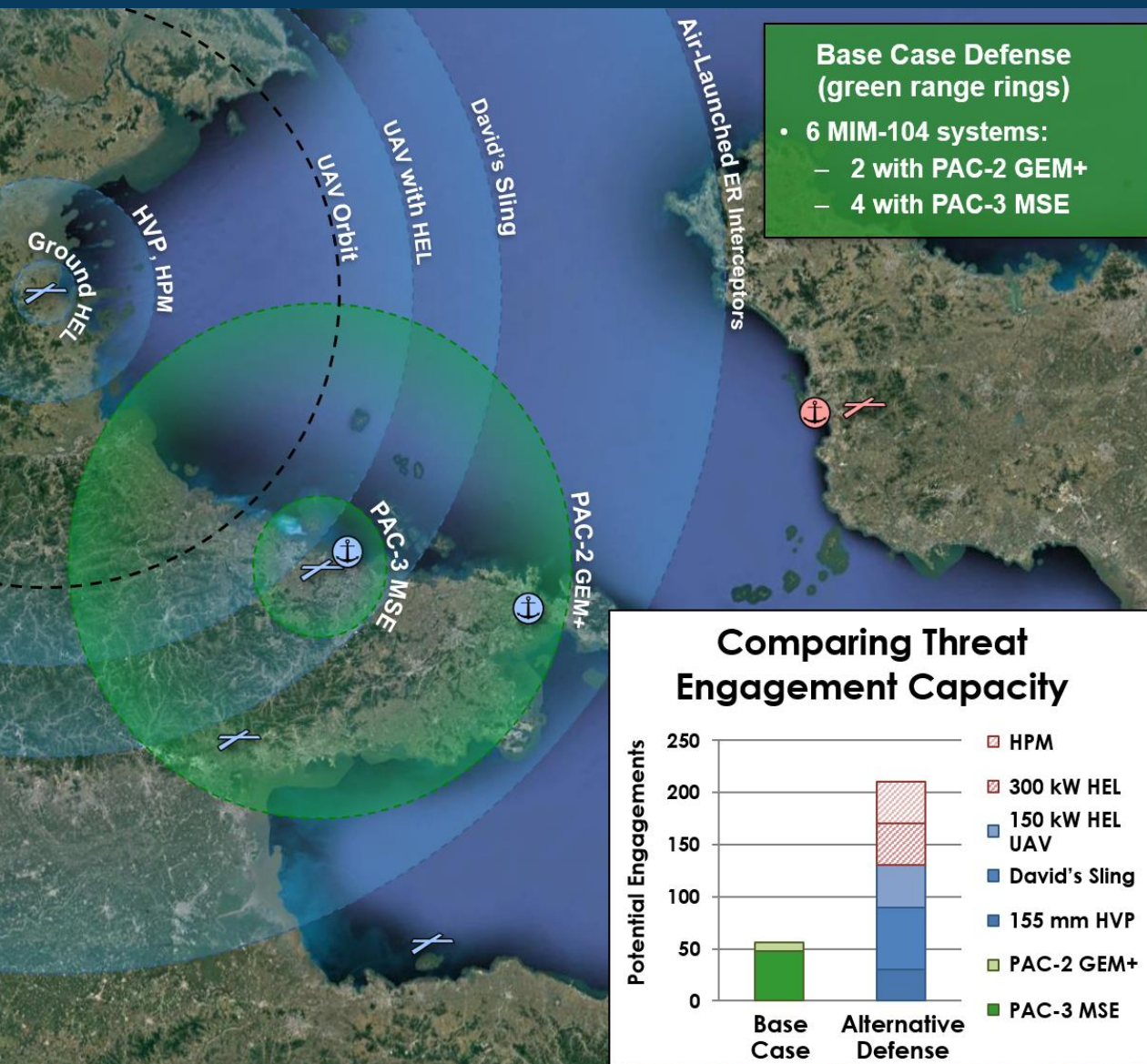


- In combination, potential to create higher capacity and more cost effective salvo defenses compared to today's limited defenses



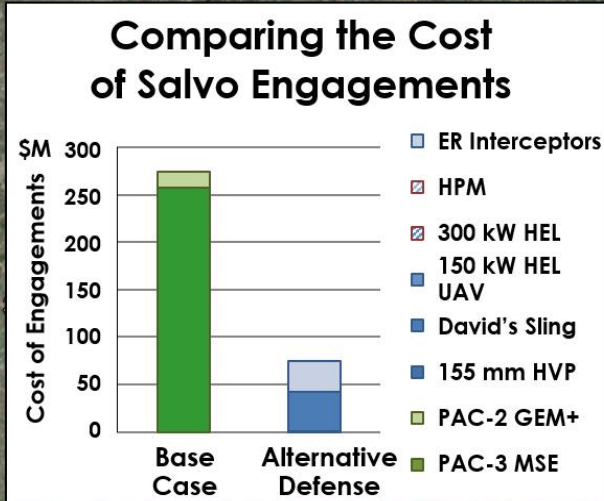
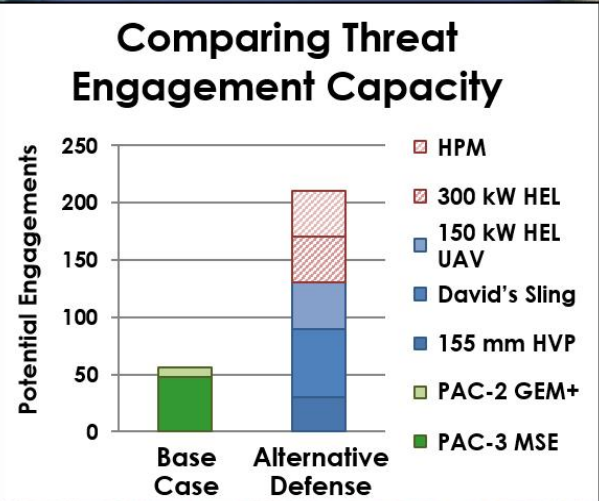
***Illustrating the capacity and cost
of an alternative base defense***

New technologies could greatly increase airbase threat engagement capacity



- Base Case Defense (green range rings)**
- 6 MIM-104 systems:
 - 2 with PAC-2 GEM+
 - 4 with PAC-3 MSE

- Alternative Airbase Defense (blue range rings)**
- 4 fighters or UAS with ER Interceptors
 - Low-cost interceptor (David's Sling)
 - 4 150 kW-class UAS HEL
 - 4 300 kW-class ground HEL
 - 4 HPM ground mobile systems
 - 6 155 mm guns with HVP



Patriot Missiles Only

Patriot System	Estimated Cost per Engagement	Total Cost of Engagements
2 PAC-2 GEM+ launchers	\$2 million	\$16 million
4 PAC-3 MSE launchers	\$5.38 million	\$258 million
56 threat engagements for \$274 million		

Alternative

Defensive System	Rate of Fire per Minute	Estimated Cost per Engagement	Total Cost of Engagements
6 155 mm HVP launchers	5 HVPs per launcher	\$25 thousand	\$750 thousand
4 David's Sling-like launchers	16 interceptors per launcher	\$700 thousand	\$44.8 million
4 ground-based 300 kW-class lasers	10 shots per laser (assume 6 seconds for each threat engaged)	\$100	\$4 thousand
4 ground-based mobile HPM weapons	10 shots per system (assume 6 seconds for each threat engaged)	\$100	\$4 thousand
4 UAVs with 150 kW-class lasers	10 per laser (assume 6 seconds for each threat engaged)	\$500	\$20 thousand
4 fighters with multi-stage, extended-range interceptors	4 interceptors per fighter or UAV	\$2 million	\$32 million

214 to 230 threat engagements for \$77.6 million

- **The ability to defend and operate from bases that are located inside contested areas would enhance regional deterrence**
- **Existing base capacity to engage weapon salvos is lacking, especially to counter non-ballistic threats**
- **Mature and maturing technologies could support the fielding of base defenses with greatly increased threat engagement capacity relative to existing systems**
 - Defenses that are mobile / rapidly relocatable would also reduce the effectiveness of an enemy's counterfires
 - Non-kinetic systems could reduce strains on U.S. logistics systems

- **Develop and field UAS with sensors to detect and provide early warning of salvo attacks**
 - Integrate with other space, ground and sea-based sensors
 - Could help fill DoD's existing gap in capabilities to detect cruise missiles, unmanned aircraft, and other threats
- **Acquire UAS with HELs**
 - Integrate 150 kW-class lasers into current generation UAS
- **Acquire ground-based mobile HELs**
 - Develop, test and field 300KW-class lasers by combining two or more SSL modules

- **Acquire several types of HPM systems to counter cruise missile attacks and unmanned aircraft swarms**
 - HPM systems to counter small (Class 1 & 2) unmanned aircraft
 - Longer range HPM systems for cruise missiles and other threats
- **Develop and procure multi-stage, extended-range air-launched interceptors**
- **Field lower-cost, short- to medium-range kinetic ground-based defenses**
 - Hyper-velocity projectiles (HVPs) launched by Paladins
 - Lower cost surface-to-air interceptors

- **Consider adapting Naval Integrated Fire Control Counter Air (NIFC-CA) for base defense battle management and C2**
 - Creating an entirely new BMC2 architecture from scratch would be costly and take years
 - Could tie into existing sensor networks (e.g., Cooperative Engagement Capability)
- **Clarify responsibilities for base defense inside DoD**
 - Lack of clarity has been a barrier to the development of needed concepts and capabilities for base defense
 - Determine the right division of responsibilities to defend bases against salvos of guided weapons—not just ballistic missiles—between the Services and MDA



<https://csbaonline.org/research/publications/winning-the-salvo-competition-rebalancing-americas-air-and-missile-defenses>



<https://csbaonline.org/research/publications/air-and-missile-defense-at-a-crossroads-new-concepts-and-technologies-to-de>