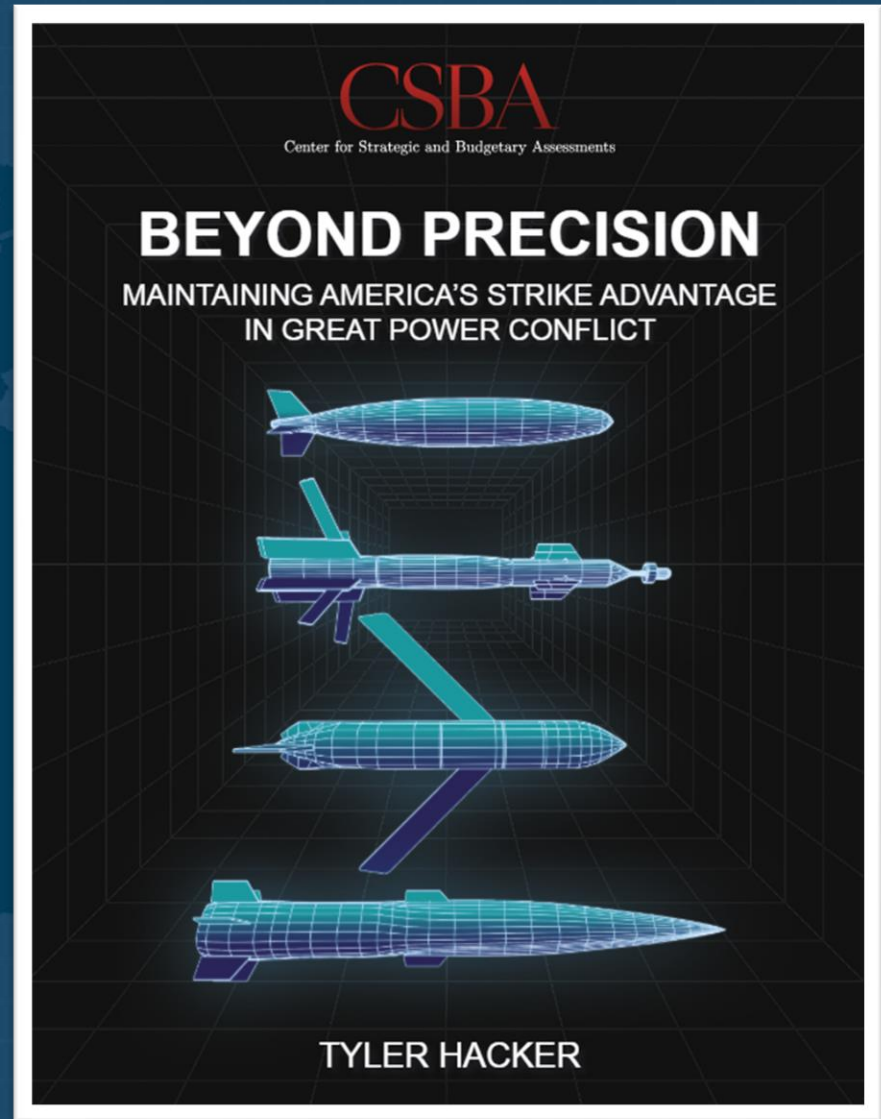


# *Beyond Precision*

## *Maintaining America's Strike Advantage in Great Power Conflict*

11 July 2023



CSBA

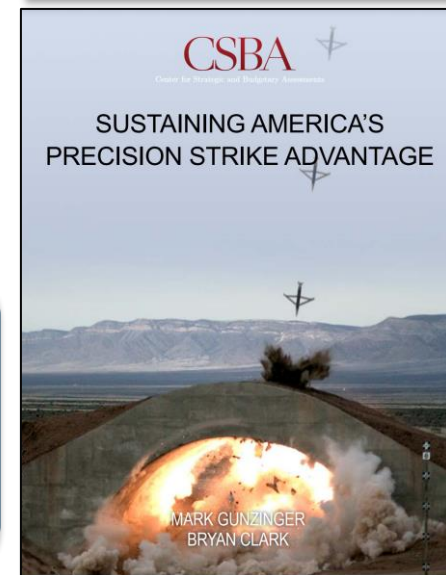
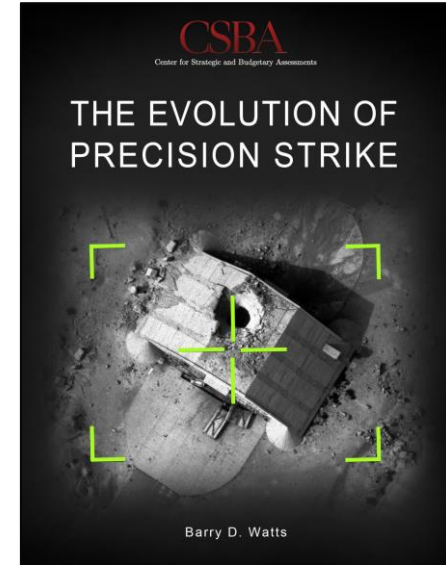
Center for Strategic and Budgetary Assessments

# Background and Introduction

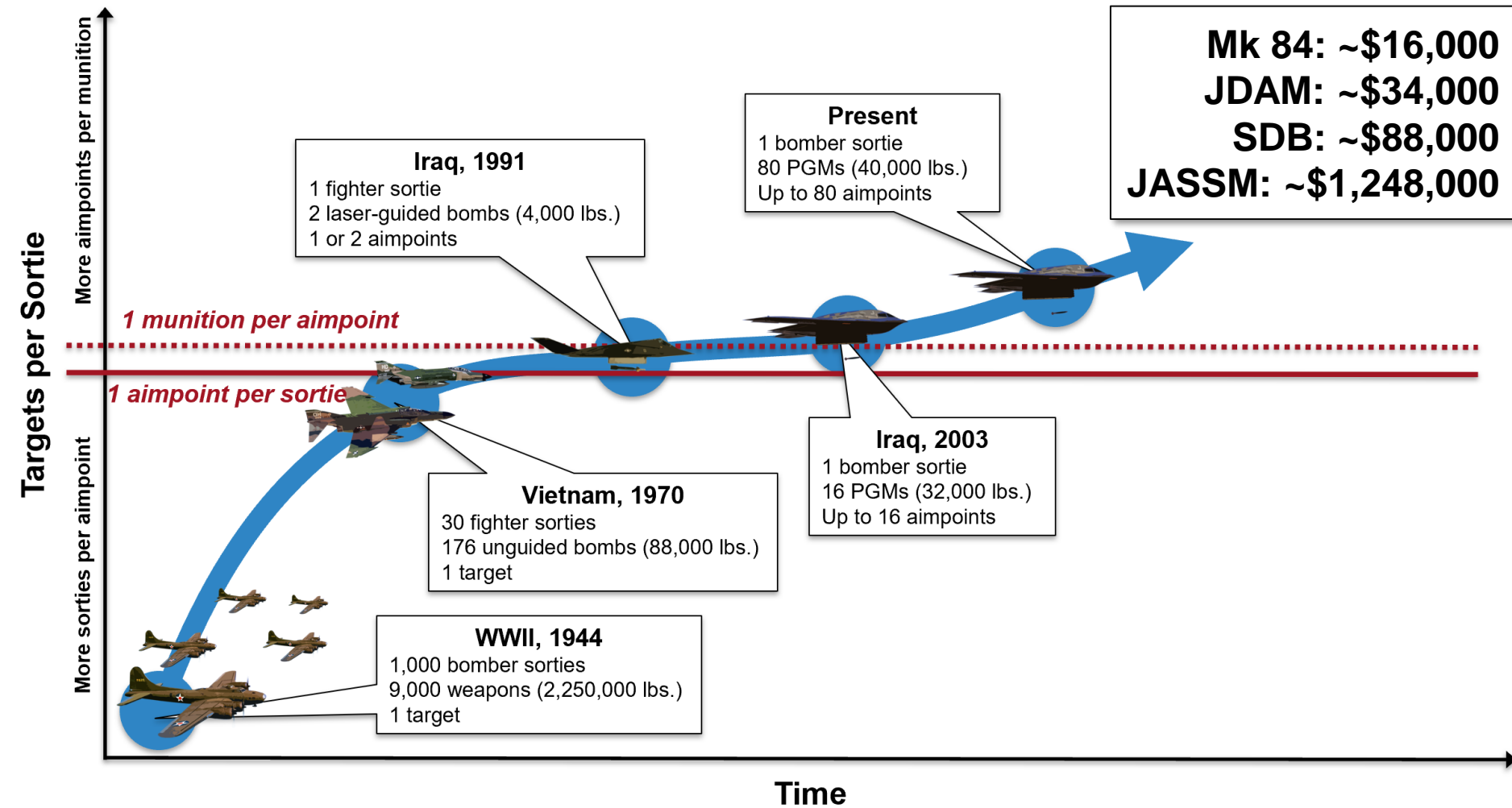
- **Russia-Ukraine conflict brings munitions and their industrial base to the forefront of discussion**
- **Inadequate quantities of PGMs in Iraq, Kosovo, Libya, and Syria**
- **Even so, munitions requirements remain an understudied topic**
  - Platforms vs. munitions
  - Assumptions about surge production
  - Classification issues
- **After the initial salvo: what about prolonged great power conflict?**

Analysts and policymakers have called for *more* munitions, but the key question remains: *more of what?*

**Will more PGMs be sufficient to maintain the United States' strike advantage in great power conflict?**



# The Evolution of Precision Strike



**Guided munitions nearly eliminate the tradeoff between range and accuracy, but increase the cost per munition.**

# Munitions Trends in Modern Strike Campaigns

**TABLE 1: COMPARISON OF POST-COLD WAR U.S. STRIKE CAMPAIGNS**

	<b>Desert Storm 1990 - 1991</b>	<b>Allied Force 1999</b>	<b>Enduring Freedom 2001</b>	<b>Iraqi Freedom 2003</b>	<b>Odyssey Dawn Unified Protector (NATO combined) 2011</b>	<b>Inherent Resolve 2014 - 2019</b>
<b>Length (days)</b>	43	78	176	30	234	~1,700
<b>Total Sorties</b>	116,000	38,004	~25,000	47,600	26,500+	234,000
<b>Average Sorties/Day</b>	2,500	200 - 1,000	~100	~1,600	~113	~143
<b>Aimpoints</b>	~40,000	7,600 fixed 3,400 mobile 11,000 total	120 fixed 400+ mobile 520+ total	30,542 19,898 struck	-	-
<b>Total Munitions</b>	277,165	23,614	17,472	29,199	7,642	115,983
<b>Guided Munitions</b>	17,161 (7.6%)	6,728 (29%)	12,001 (69%)	19,948 (68%)	7,642 (100%)	Largely PGMs
<b>Average Guided Munitions/Day</b>	399	86	68	665	33	~68
<b>TLAMs/ CALCMSExpended</b>	332	270	74	955	110	172
<b>SEAD Sorties</b>	4,326	4,538	-	-	1,500+	-
<b>HARMs Expended</b>	1,961	1,000+	-	408	-	-
<b>Radars Destroyed</b>	~250 / 500	10 / 41	-	-	-	-
<b>SAMs Destroyed</b>	35 / 120 fixed batteries	3 / 25 SA-6 batteries	-	-	Presumed by DoD: 11 SA-5 batteries 4 SA-2 batteries 16 SA-3 batteries Mobile unknown	-
<b>Combat Losses (# of aircraft)</b>	38 total coalition	2	0	1	1 mechanical	2 mechanical 5 UAS

- 1. Increasing prevalence of PGMs**
- 2. Increasing quantities of long-range and stand-off munitions**
- 3. Large quantities of munitions expended on mobile and elusive targets, often without achieving the desired effects**

# U.S. Adversaries Adapt to These Trends

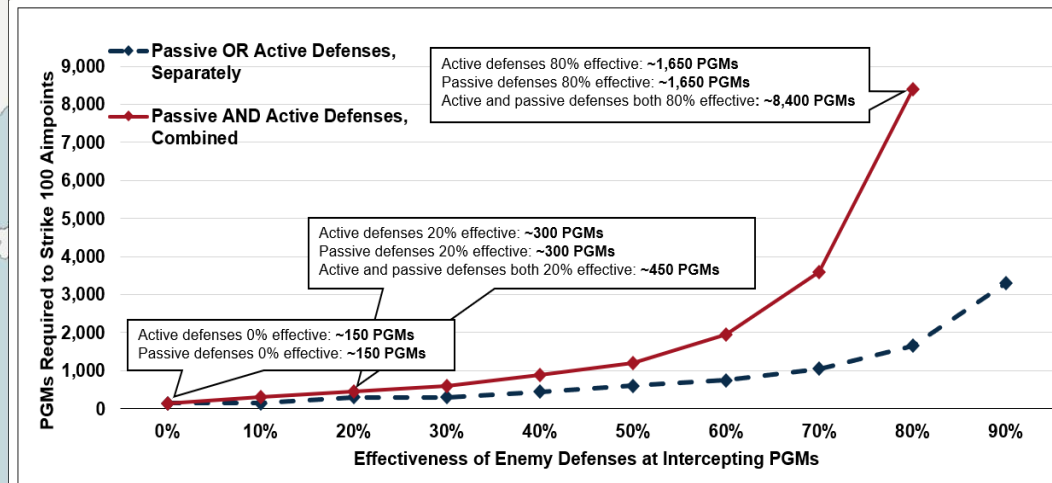
- **Deny delivery platforms ability to operate within weapons range**
  - Anti-access / area denial
- **Increase quantity of aimpoints**
  - Dispersion
  - Camouflage, concealment, and deception
- **Decrease munition probability of arrival**
  - Interceptors, SAMs
  - Point defenses
- **Reducing munition effects on target**
  - Countermeasures
  - Hardening



**These measures combine to exponentially increase U.S. munitions requirements for any strike campaign against the Chinese military.**

# Historic Lessons for Great Power Conflict

1. PGMs will continue to be the preferred munitions for many types of targets so long as inventories last.
2. The potential quantity of complex targets and their geographic spread is staggering.
3. The defenses of great power adversaries will further increase munitions requirements.
4. The intelligence and targeting requirements for great power conflict will be unprecedented in both volume and depth.



Given these trends, it is possible that the United States will never have enough munitions, sorties, or intelligence to conduct an all-encompassing precision-strike campaign against a great power adversary such as China.

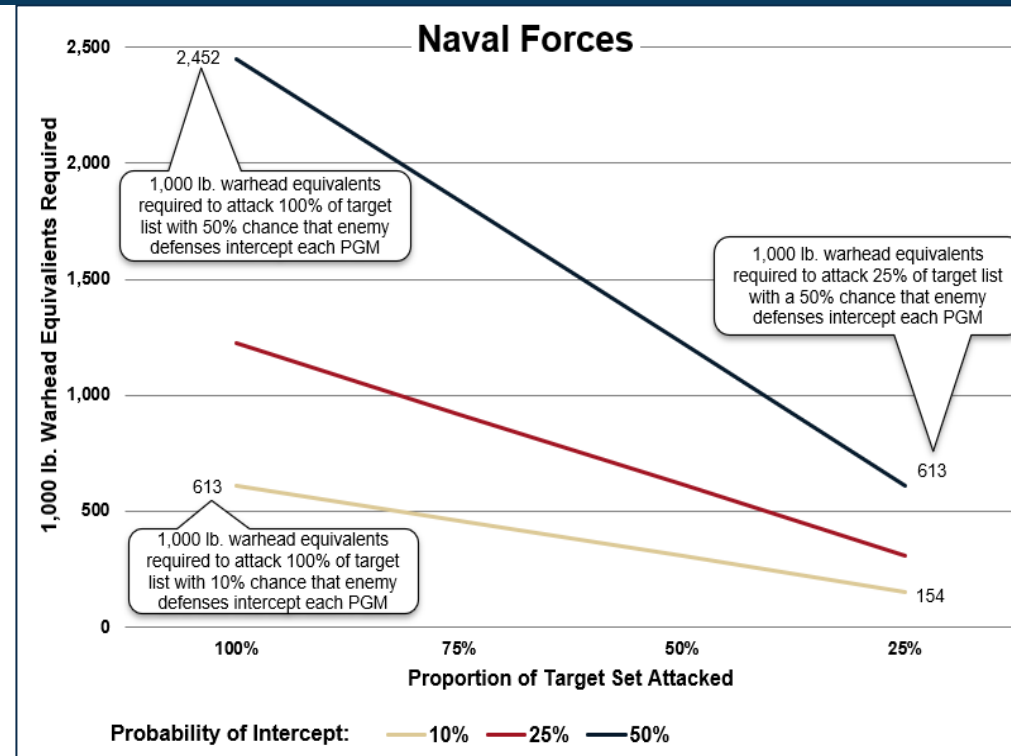
# Munitions in Five Conflict Scenarios: Assumptions and Methodology

## Key Assumptions:

- 2023 to 2025 time frame
- All scenarios involve China in the Indo-Pacific theater
- Excluded allies and partners
- Operational vignettes rather than complete scenarios
- Chosen for plausibility and analytical value
- Rapid versus protracted
- Could be combined or layered

## Methodology:

- Assembled hypothetical target lists for each scenario
- Estimated total number of aimpoints (1,000 lb. warhead equivalents) for different target types
- Calculated the quantity of munitions required to attack these aimpoints with a 90% or higher probability of kill, given varying probabilities that the munition is intercepted (10%, 25%, and 50%)
- Charted quantities at 100%, 75%, 50%, and 25% to show the range in quantity of munitions required to attack varying portions of the total target set, at varying probabilities of intercept



# Munitions in Five Conflict Scenarios: Scenario Objectives and Target Sets

## 1. Neutralize Invasion Force in Taiwan Strait

- **Objective:** Rapidly neutralize PLA invasion force in the Taiwan Strait to prevent large-scale amphibious landings on Taiwan.
- **Target Set:** 247 surface combatants and attack submarines, 63 commercial transport ships and ferries, up to 750 fighter aircraft, 250 bombers/attack aircraft, and 100+ other aircraft

## 2. Neutralize South China Sea Outposts

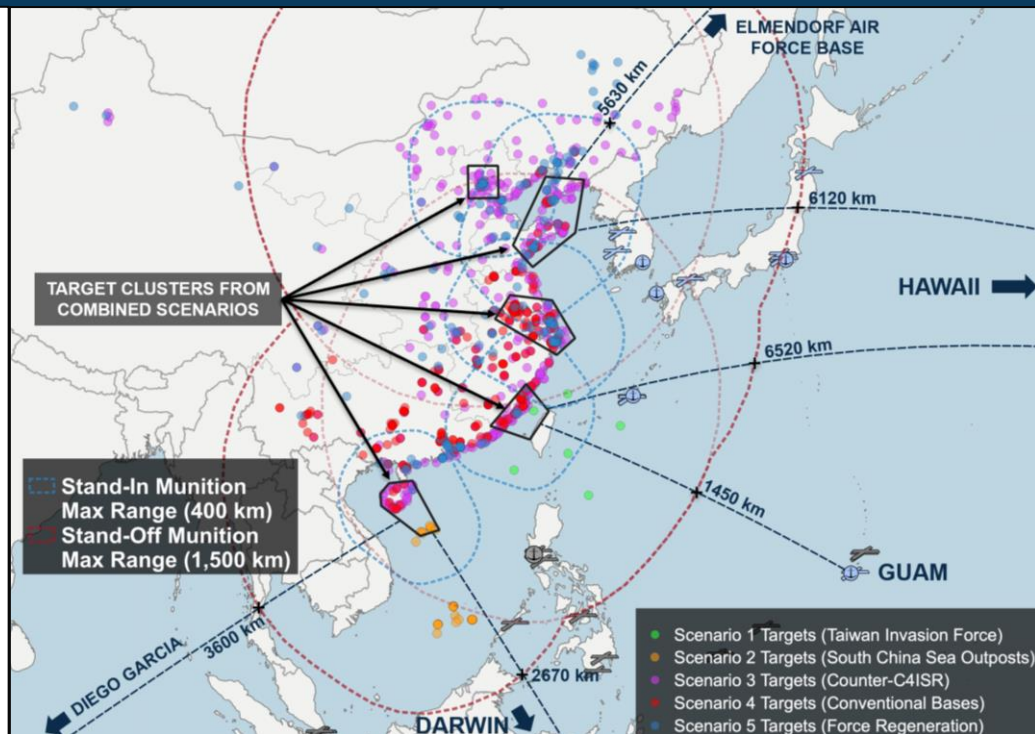
- **Objective:** Rapidly neutralize PLA outposts in the Paracel and Spratly islands to deny the PLA the ability to use these bases and features to project power or challenge freedom of navigation.
- **Target Set:** Four major outposts with airfields and harbors, 11 smaller outposts

## 3. Counter-C4ISR Campaign

- **Objective:** Rapidly degrade PLA sensing, communications, and C2 capabilities to cause “force paralysis” among units in the Eastern and Southern Theater Commands.
- **Target Set:** Select PLA HQs, C2 and sensing facilities, C2 infrastructure on selected airfields and naval bases

## 4. Strike Campaign Against Conventional Bases

- **Objective:** Neutralize PLA air and maritime bases and A2/AD forces in eastern and southern China to enable follow on operations in vicinity of the Taiwan Strait.



- **Target Set:** Major theater command HQs, airfields, naval bases, rocket brigade bases, long-range air defense sites, key logistics nodes

## 5. Force Regeneration Campaign

- **Objective:** Degrade the PLA's ability to sustain and regenerate the forces required for a protracted conflict with the United States.
- **Target Set:** Defense research and production facilities, POL infrastructure



# Munitions in Five Conflict Scenarios: Scenario Results

## 1. Neutralize Invasion Force in Taiwan Strait

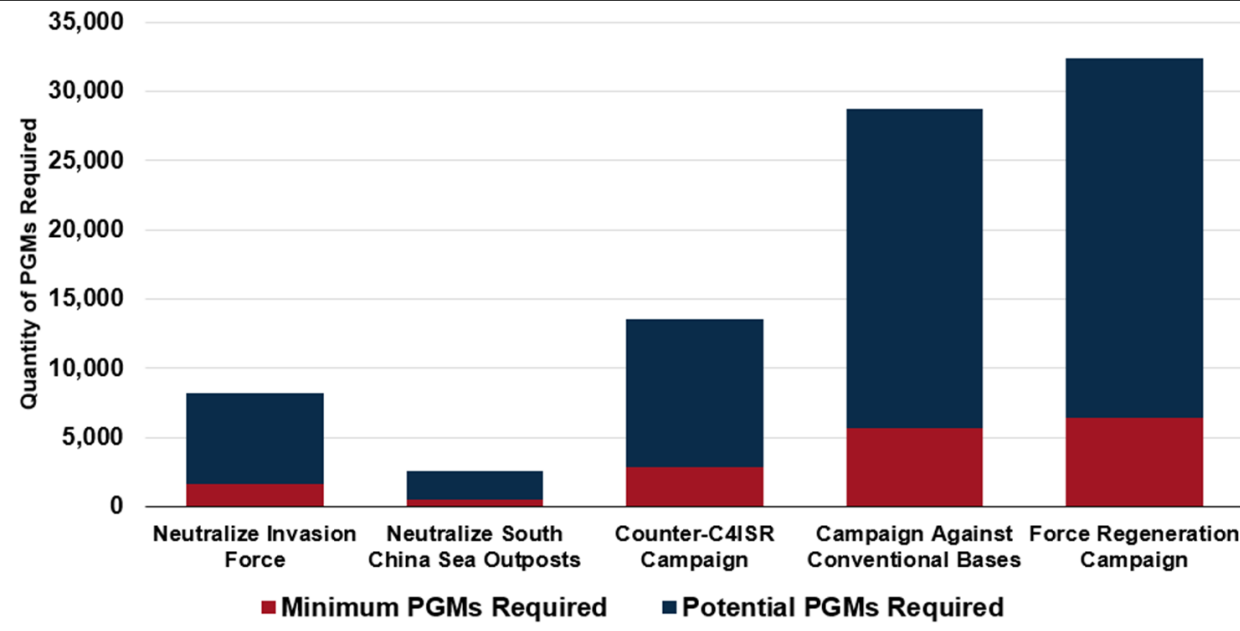
- 600 – 2,400+ anti-ship munitions, 1,000 – 4,200+ anti-air or air-to-air munitions required to attack complete target set
- **Munitions Focus:** Long-range ASCMs and anti-air missiles

## 2. Neutralize South China Sea Outposts

- 500 – 2,100+ munitions required to attack complete target set
- **Munitions Focus:** Short-range munitions with area effects

## 3. Counter-C4ISR Campaign

- 2,800 – 10,700+ munitions required for initial strikes against complete target set
- **Munitions Focus:** “Silver bullets,” specialized, and non-kinetic munitions



## 4. Strike Campaign Against Conventional Bases

- 5,700 – 23,000+ munitions required for initial strikes against complete target set
- **Munitions Focus:** Large volumes of varied munitions for fixed/mobile targets

## 5. Force Regeneration Campaign

- 6,400 – 26,000+ munitions required to attack complete target set
- **Munitions Focus:** Munitions for large, complex targets

# Munitions in Five Conflict Scenarios: Key Tradeoffs and Common Requirements

## Key Tradeoffs:

1. Range and survivability requirements for munitions and platforms are determined by the geographic location and dispersion of the targets.
2. Fixed versus mobile targets.
3. Recurring targets versus targets requiring a single attack.
4. Exquisite munitions versus large volumes of simpler weapons.

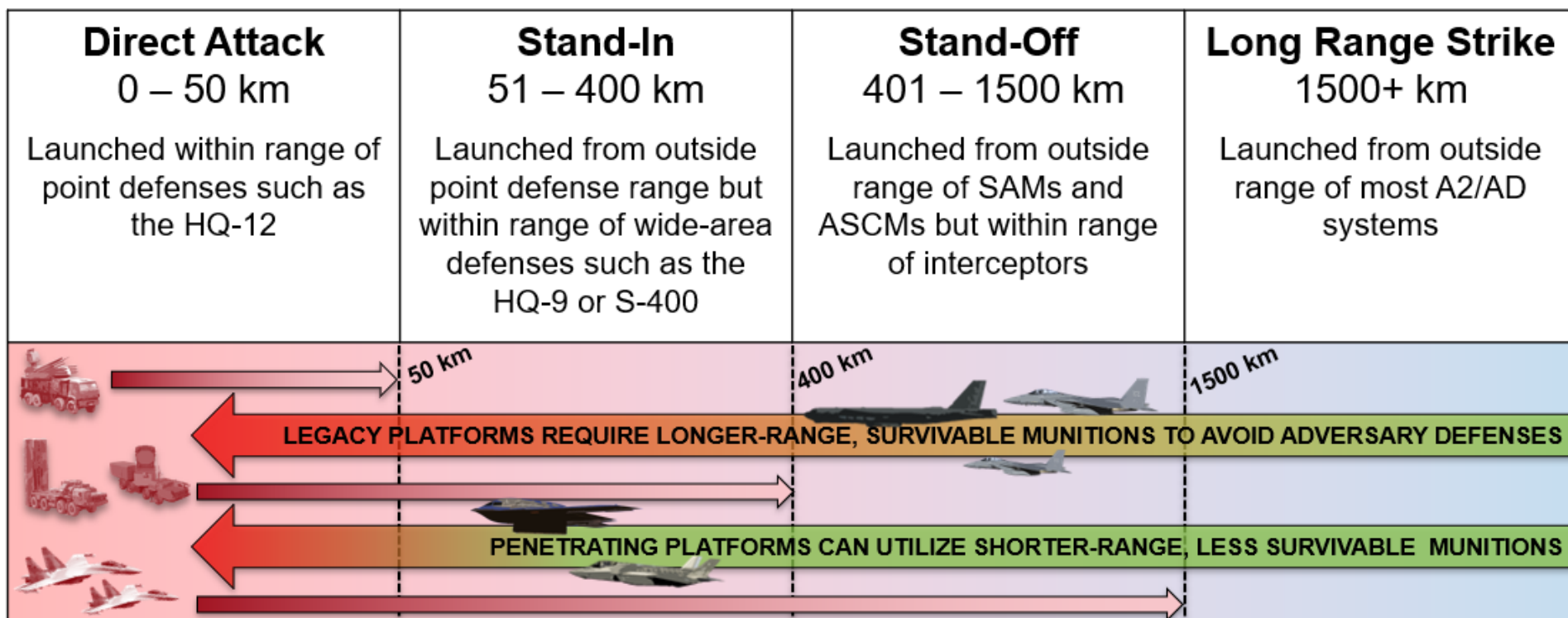
## Common Requirements:

1. Significant quantities of munitions with some degree of stand-off range to avoid putting delivery platforms at high risk from A2/AD threats.
2. PGMs capable of penetrating PLA air and missile defenses.
3. Capability to attack significant quantities of mobile targets (from PLA air and maritime forces to mobile air defense and rocket TELs).
4. Munitions to attack complex area targets such as airfields, naval bases, production facilities, and refineries.

# Current Gaps and Constraints

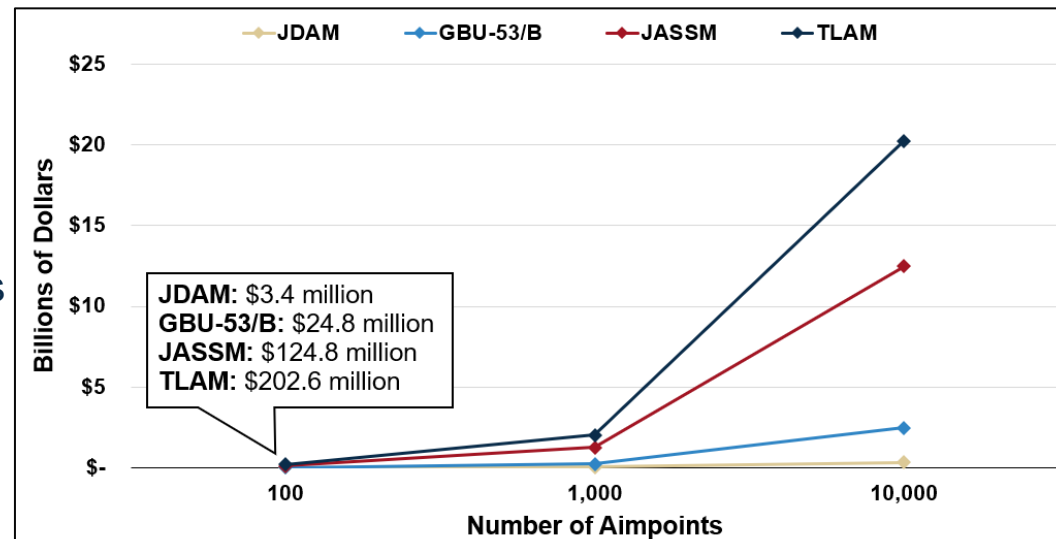
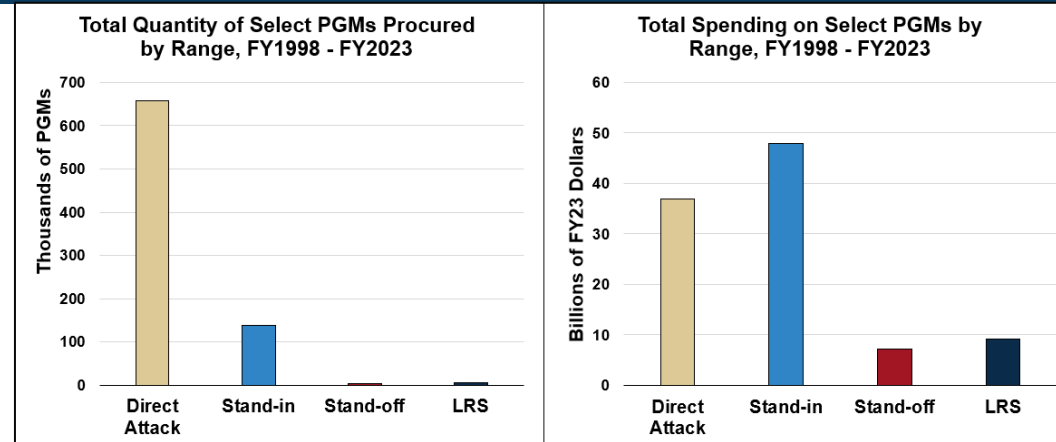
## Given these requirements, how does the current U.S. precision arsenal stack up?

- Examined 36 current and developmental U.S. PGMs (up to FY2023 budget request)
- Categorized PGMs by range (key to weapon-platform pairing and cost)
- Assessed munition capacity and capability gaps based upon range, speed, survivability, guidance system, payload, and other advanced features such as networking, datalinks, and autonomous capabilities



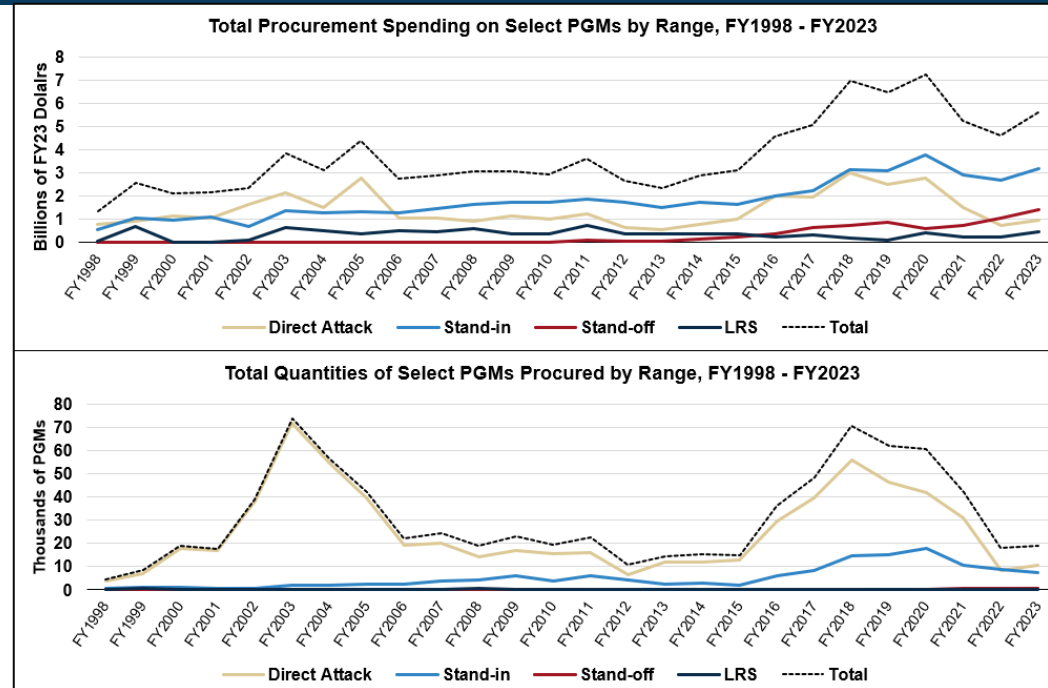
# Current Gaps in the U.S. PGM Portfolio

- **Overall capacity**
  - On-hand capacity
  - Production capacity
- **Range**
  - Dependent on force structure
- **Survivability**
- **Guidance without external support**
- **Weapons for time sensitive and mobile A2/AD targets**
- **Affordable mass**
- **Low versatility**
- **Munitions for specialized targets**
  - Hardened and deeply buried targets
  - Wide area targets
  - Airfield attack
  - Non-kinetic payloads



# Constraints on PGM Development and Employment

- **Budget**
  - \$5.6 billion in PGM procurement for FY2023 (>4% requested procurement)
  - Cyclic spending tied to operational use rather than strategic requirements
- **Industrial base**
  - Lack of surge capacity
- **Technology**
- **Policy and ethics**
  - Cluster munitions
  - Autonomy
  - Rules of engagement
- **Organizational and bureaucratic interests**
  - Lack of dedicated community
  - Interservice competition



# Future Weapon Technologies and Concepts

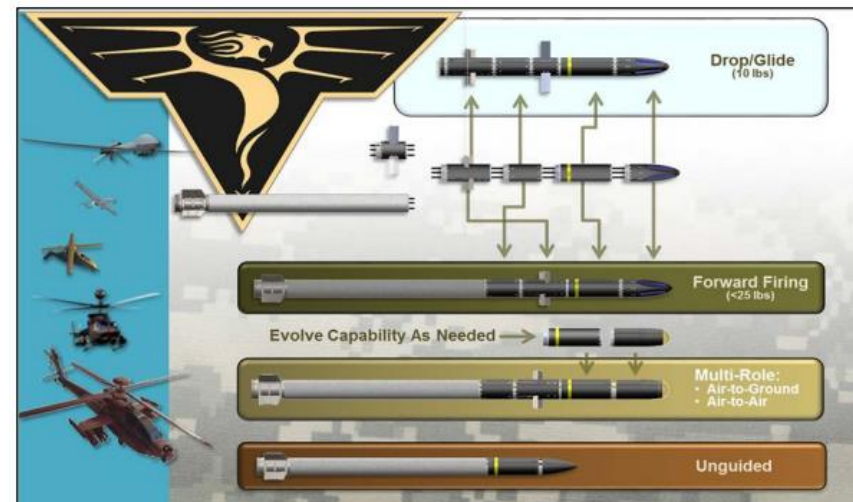
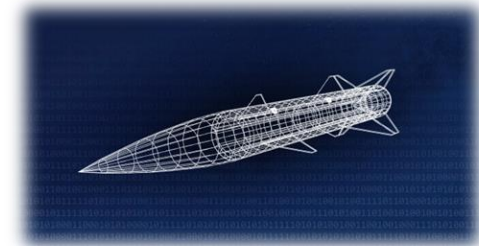
**Given these constraints, how can the United States maintain its precision-strike advantage?**

**Military planners have several “levers” to affect munitions requirements and ease munitions demands:**

- 1. Reduce the total number of targets or aimpoints;**
- 2. Increase the chance that weapons reach their targets and have effects;**
- 3. Increase the number of targets and aimpoints each munition can affect.**

# Future Weapon Technologies: Design and Producibility

- **Digital engineering and open architectures**
  - Leverage commercial sector
  - Expand industrial base
- **Advanced manufacturing techniques**
- **Multi-role munitions**
- **Modular munitions designs with interchangeable components**
  - Easily updateable
  - Expand industrial base
  - Weapons assembled for specific mission
  - Balance versatility with specialization
  - Modularity for export



# Future Weapon Technologies: Launchers, Propulsion

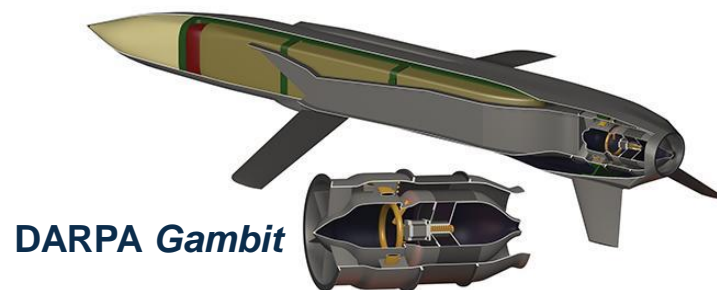
## Delivery platform versatility and standardized launchers/interfaces

- Software: Universal Armaments Interface (UAI)
- Hardware: Common Launch Tube, JAGM Quad Launcher



## Advanced propulsion technologies

- Modern engine designs
- Modern energetics



DARPA *Gambit*

## Delivery platform versatility and modular propulsion kits

**FREEFALL**



MAX RANGE: ~25 km

**GLIDE**



MAX RANGE: ~65 km

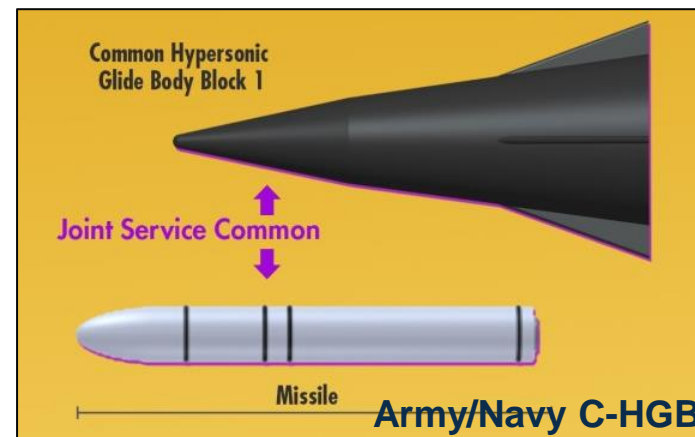
**POWERED**



MAX RANGE: ~550+ km

## Reduced cost hypersonics

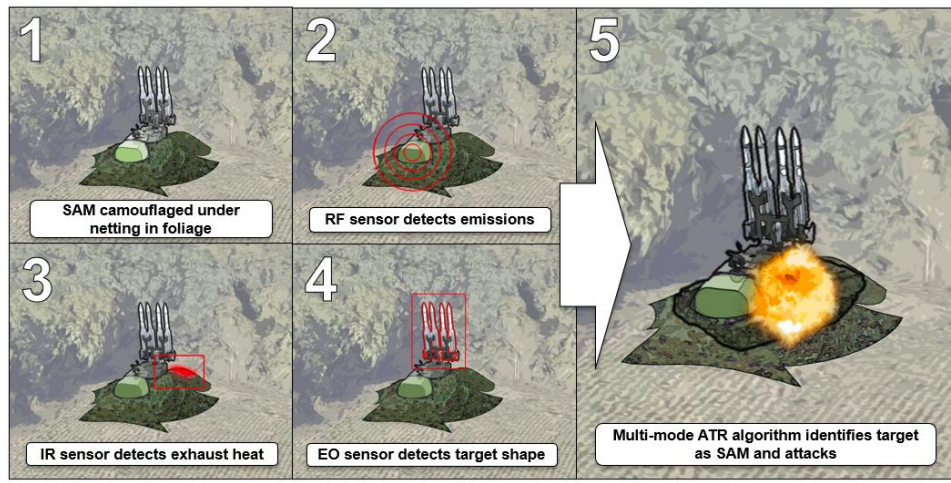
- Supersonic weapons?



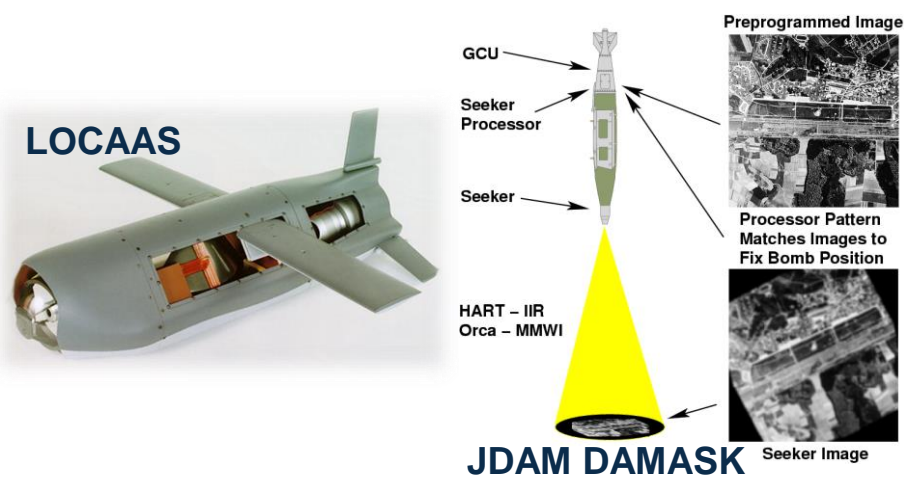


# Future Weapon Technologies: Sensors, Networking, Autonomy

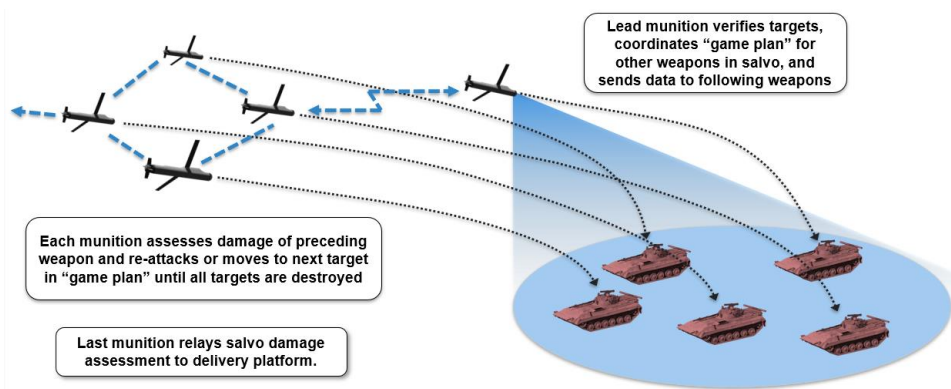
## Multi-mode sensors



## Ubiquitous affordable sensors



## Collaborative capabilities



## Improved data collection and processing

- Battle damage assessments
- Network-enabled, not network-dependent



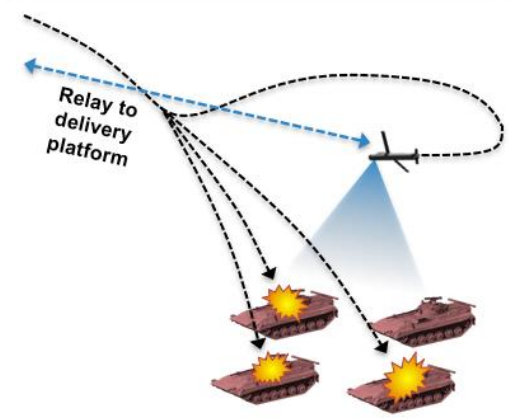
# Future Weapon Technologies: Payloads and Effects

## Advanced energetics and modern area effects



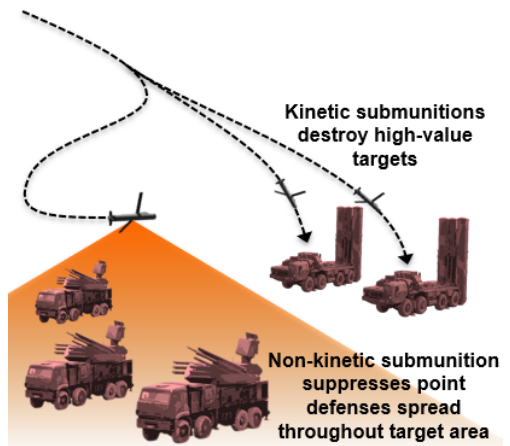
## Loitering and persistent payloads

Loitering element assesses payload effects, relays real-time damage assessment



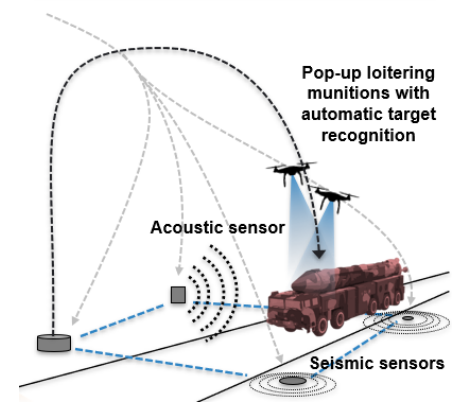
## Non-kinetic payloads

Non-kinetic effectors to increase survivability of kinetic effectors





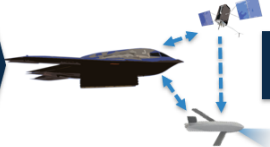
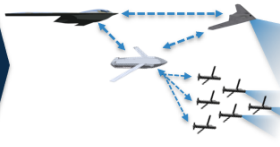
## Heterogenous payloads with complementary capabilities

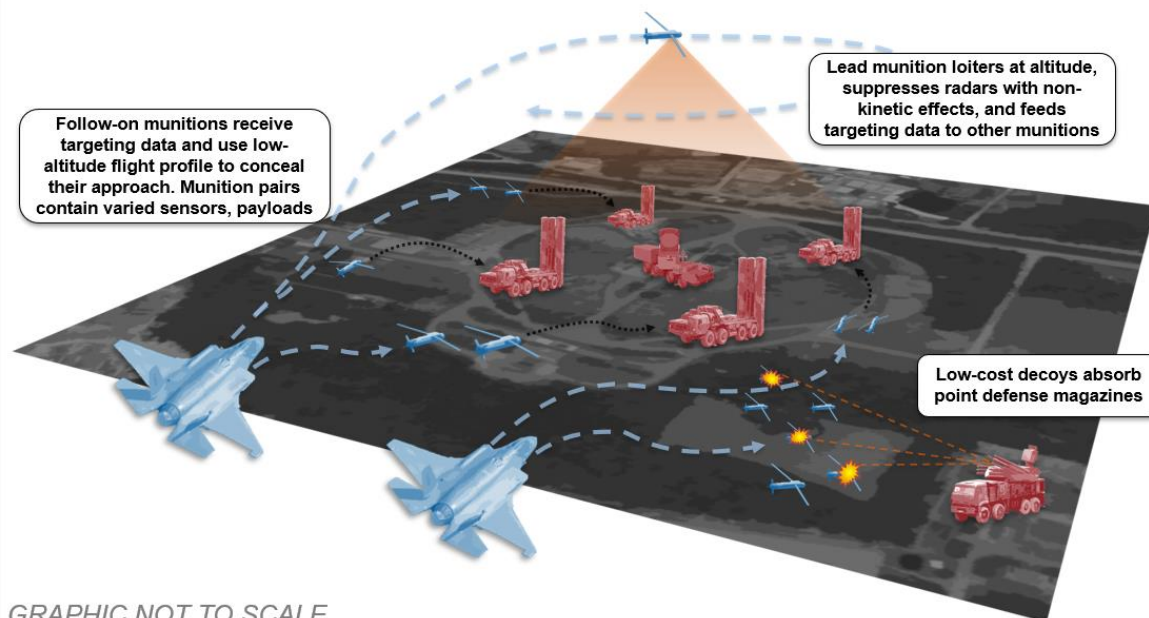
Persistent sensors that activate "pop-up" effectors for mobile targets



# Future Weapon Concepts

- Munitions as more than effectors
- Reducing the total quantity of aimpoints
  - Targeting essential nodes
  - Virtual attrition concepts
  - Attack fixed elements of mobile target kill chains
- Increasing munition survivability and effectiveness
  - Heterogenous salvos
  - Complex coordinated attacks

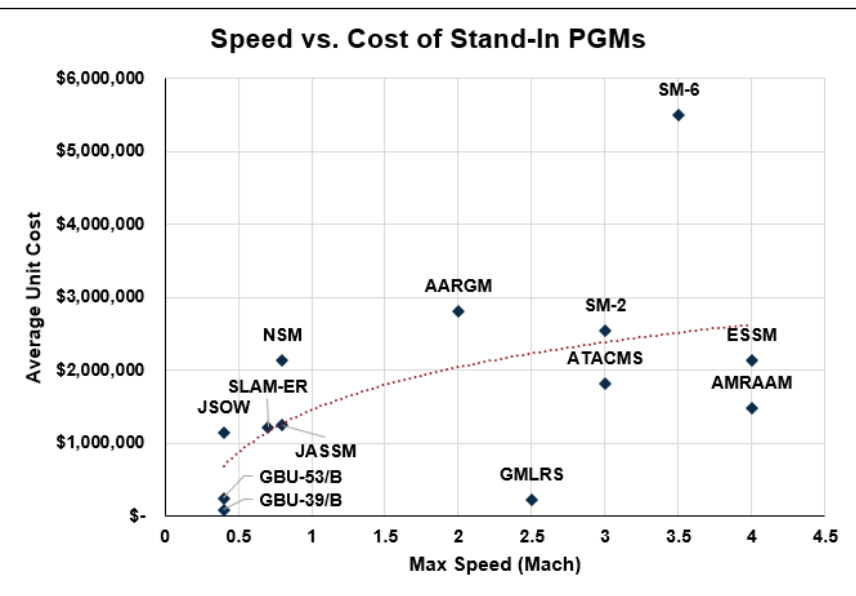
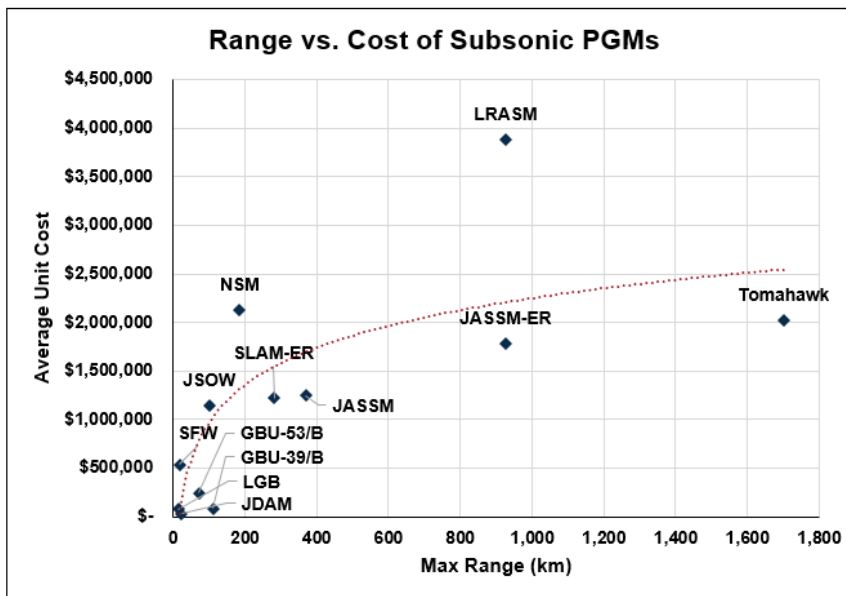
Before PGMs		Early PGMs		Modern PGMs		Future Mission-Specific PGM "Package"	
							
<b>Platform</b> <ul style="list-style-type: none"> <li>• Propulsion</li> <li>• Sensors</li> <li>• Comms</li> <li>• Guidance</li> <li>• Decision-maker</li> </ul>	<b>Munition</b> <ul style="list-style-type: none"> <li>• Effector</li> </ul>	<b>Platform</b> <ul style="list-style-type: none"> <li>• Propulsion</li> <li>• Sensors</li> <li>• Comms</li> <li>• Guidance</li> <li>• Decision-maker</li> <li>• Stealthy</li> </ul>	<b>Munition</b> <ul style="list-style-type: none"> <li>• Guidance</li> <li>• Effector</li> </ul>	<b>Platform</b> <ul style="list-style-type: none"> <li>• Propulsion</li> <li>• Sensors</li> <li>• Comms</li> <li>• Guidance</li> <li>• Decision-maker</li> <li>• Stealthy</li> </ul>	<b>Munition</b> <ul style="list-style-type: none"> <li>• Propulsion</li> <li>• Sensors</li> <li>• Comms</li> <li>• Guidance</li> <li>• Effector</li> <li>• Stealthy</li> </ul>	<b>Platform</b> <ul style="list-style-type: none"> <li>• Propulsion</li> <li>• Sensors</li> <li>• Comms</li> <li>• Guidance</li> <li>• Decision-maker</li> <li>• Stealthy</li> </ul>	<b>Munition</b> <ul style="list-style-type: none"> <li>• Sensors</li> <li>• Comms</li> <li>• Guidance</li> <li>• Effector</li> </ul>
<b>Unmanned Munition Carrier</b> <ul style="list-style-type: none"> <li>• Propulsion</li> <li>• Comms</li> <li>• Guidance</li> <li>• Stealthy</li> </ul>							



GRAPHIC NOT TO SCALE

# Future Weapon Concepts (continued)

- **Generating precision effects in volume**
  - Procurement of range and cost-balanced PGMs
  - Revised requirements for “second-tier” PGMs
  - Unmanned munitions carriers
    - “Loyal Wingman”
    - XLUUV
    - NMESIS



# Key Findings

- 1. Previous assumptions about munitions production and consumption do not apply to contemporary great power conflict.**
  - Rapid conflict scenarios
  - PGM surge production
  - Reliance on precision-strike advantage
- 2. The United States has significant capacity and capability gaps in its current PGM portfolio.**
- 3. Even with increased spending on and production of PGMs, the United States will likely struggle to maintain adequate quantities of PGMs to execute a comprehensive precision-strike campaign against a great power adversary.**
- 4. Precision alone is necessary but insufficient for future munitions.**
  - Semi-autonomous and collaborative capabilities, integrated sensors, automatic target recognition, loitering capabilities, heterogenous payloads
- 5. Several variables have outsized effects on munitions requirements, including: operational objectives, the proportion of targets that must be attacked to achieve these objectives, and the effectiveness of enemy defenses.**
  - Planning assumptions are key, and reveal the value of strategic and operational wargaming
- 6. Conflict duration is a major determinant of munitions requirement and, as such, could influence campaign objectives.**
- 7. Maintaining the United States' strike advantage requires more than munitions; it requires improvements along the entire kill chain.**
  - ISR assets, targeting processes, networking infrastructure, delivery platforms

# Near-Term Recommendations (2023 – 2027)

- **Immediately increase munitions funding and procurement to maximize the production of critical precision munitions.**
- **Align PGM procurement spending with the requirements of long-term strategy and analysis rather than simply replacing weapons expended in recent operations.**
- **Incentivize expansion of the weapons industrial base by committing to consistent munitions purchases through multi-year procurement, direct investments, and other policies that foster a steady demand signal for precision weapons.**
- **Bolster the current PGM arsenal with rapidly producible modular kits and modifications to operational weapons.**
- **Consider campaigns, operational concepts, and target sets that enable the current portfolio of precision weapons to be most effective, particularly in protracted conflict.**

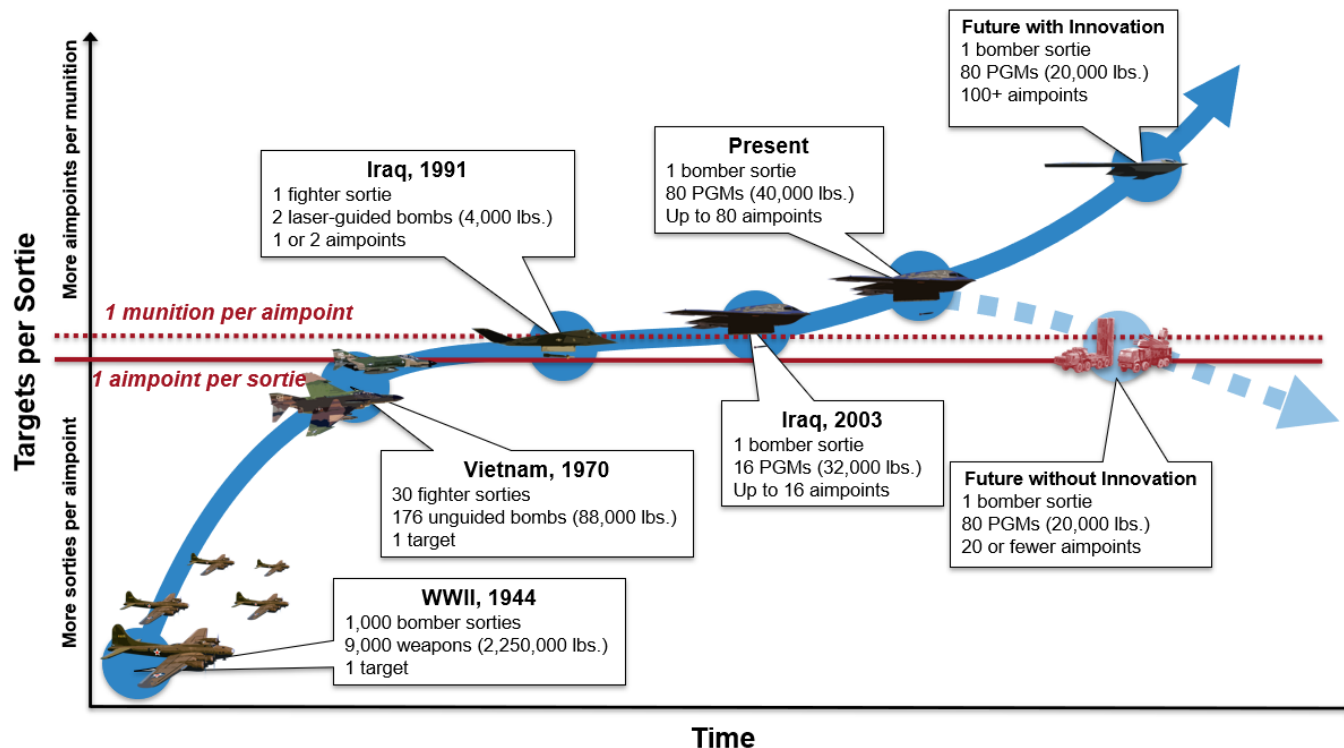
# Medium-Term Recommendations (2028 – 2032)

- **Continue expanding the active and surge capacity of the munitions industrial base with a focus on resilient and redundant rather than lean supply chains.**
- **Implement open architectures and digital engineering into new munitions designs to take advantage of modularity and advanced manufacturing methods.**
- **Continue experimenting with and fielding advanced munitions technologies to fill current capability gaps.**
- **Pursue an affordable mix of exquisite and cheap PGMs to enable “affordable precision in mass.”**
- **Develop new employment techniques and operational concepts that leverage the advanced features of next-generation PGMs.**



# Long-Term Recommendations (Beyond 2033)

- Procure a mix of PGMs that complement next-generation platforms as they are fielded in the 2030s.
- Develop and field munitions that utilize advanced technologies to fill long-running capability gaps, reduce planning tradeoffs, and outpace adversary countermeasures.
- Refine employment techniques and operational concepts to utilize advanced munitions and future force packages to create the greatest advantage.





A dark blue world map is centered in the background of the slide. The map shows the continents in a slightly lighter shade of blue. Overlaid on the map is the title text.

# Question and Answer

**CSBA**

Center for Strategic and Budgetary Assessments