

A New Munitions Taxonomy

Categorizing Advanced Weapons for Robust Analysis and Artificial Intelligence Assisted Applications



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- Project background
- Why it matters to NATO
- Scoping a new munitions taxonomy
- Developing a new munitions taxonomy
- An example taxonomy
- Conclusions, future applications, and further research

Project Background

- **Center for Strategic and Budgetary Assessments (CSBA) has a long history studying munitions and their impacts**
 - Watts, *Long Range Strike: Imperatives, Urgency and Options* (2005)
 - Watts, *Six Decades of Guided Munitions and Battle Networks: Progress and Prospects* (2007)
 - Watts, *The Evolution of Precision Strike* (2013)
 - Gunzinger and Clark, *Sustaining America's Precision Strike Advantage* (2015)
 - Cohn, Walton, Lemon, and Yoshihara, *Leveling the Playing Field: Reintroducing Theater-Range Missiles in a Post-INF World* (2019)
- **Originated in two CSBA studies:**
 - *Rings of Fire: A Conventional Missile Strategy for a Post-INF World* (2022)
 - *Munitions Mixes for Great Power Conflict* (study in progress)

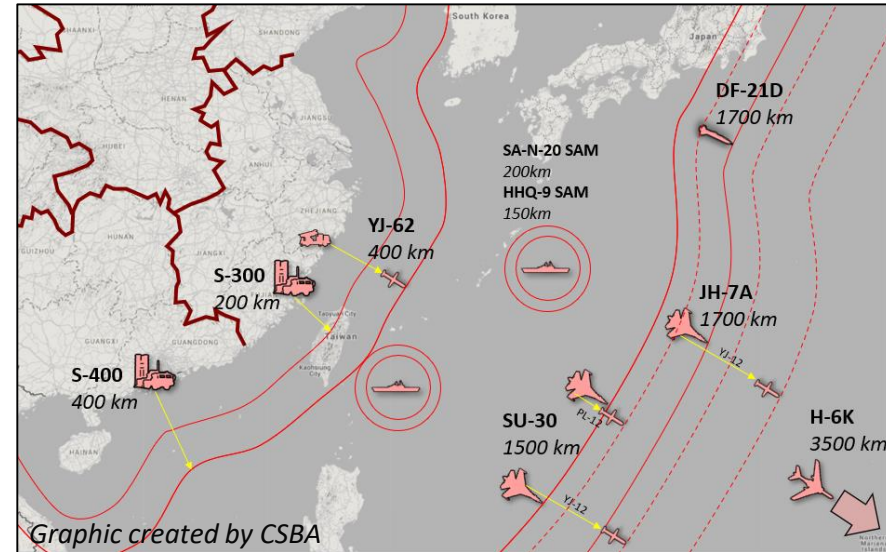


Project Background

- **What is a long-range munition?**
 - Traditional ballistic missile classifications
 - Short-range (0 – 1000 km)
 - Medium-range (1000 – 3000 km)
 - Intermediate-range (3000 – 5500 km)
 - Intercontinental (5500+ km)
 - Ranges vary by theater, munition type

- **What is a standoff munition?**
 - AGM-154 Joint *Standoff* Weapon: ~117 km
 - AGM-158B Joint Air-to-Surface *Standoff* Missile: 1000+ km
 - Standoff, stand-in, and direct attack vary by threat

- **Where is the line between loitering munitions and small UAS? Between advanced submunitions and swarms?**



Why it Matters to NATO

- **Determining munitions requirements is an enduring military problem with stakeholders at multiple levels**
 - Tactical level: weaponeering, mission planning, logistics planning
 - Operational level: campaign analysis, theater requirements
 - Strategic/political level: procurement, budgeting, strategy
- **Terms and classifications, or taxonomies, matter when addressing the munitions problem**
 - They feed targeting decisions
 - They feed analytical modeling
 - They feed budgeting and resourcing
 - They frame discussions and debate
- **Advancements in munitions technologies are making classifying munitions more complex**
- **How should we categorize and group current and future munitions to fully leverage sophisticated weapon systems and frame future munitions discussion and analysis?**



Scoping a New Munitions Taxonomy

- Ideally, a new taxonomy would be **comprehensive**, inclusive of systems on the **cutting edge** of weapon development, and **useful to a broad set of stakeholders**
- More realistic: a new taxonomy as a **flexible framework** that organizes current munitions and remains **open to adaptation**
 - Broad construct able to fit more detailed models
 - Ensure utility to a wide range of stakeholders
- **Start with “surface strike” munitions**
 - Focus of previous studies
 - Widest variety of features—a difficult case
 - Exclude surface-to-air, waterborne, nuclear weapons

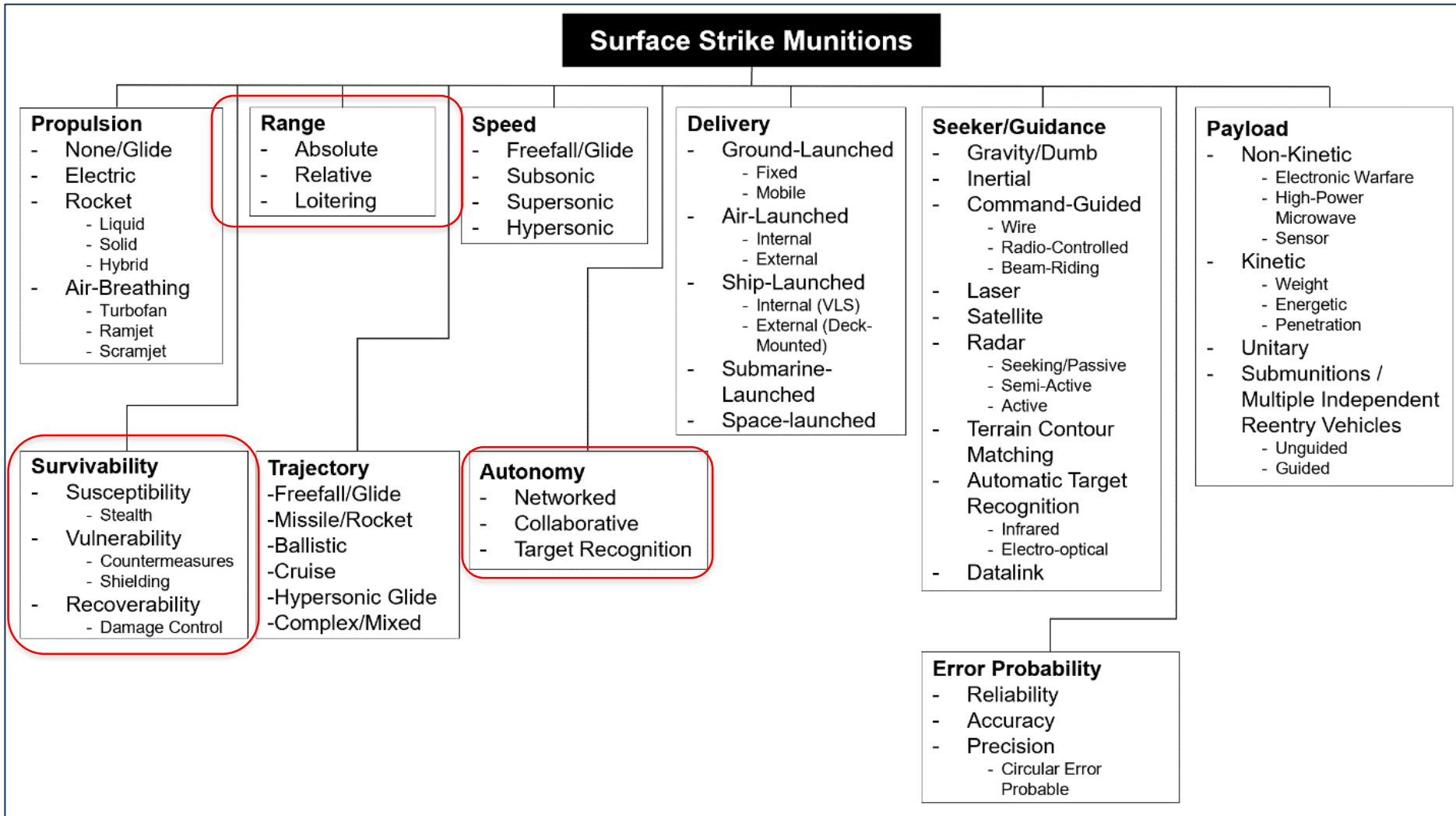


Developing a New Munitions Taxonomy: Starting with Surface Strike

- Conducted a comprehensive survey of 125+ past, current, and developmental surface strike munitions
 - Munitions from the **United States, NATO, Russia, and China**
 - Include characteristics such as speed, range, flight profile, launch weight, guidance system (initial, mid-course, terminal), circular area probable, payload type and weight, cost, launch platform, and manufacturer
 - Used only information verifiable by **open sources**
 - Devised **categories and subcategories** from munitions' attributes

Name	Categ	ang	Speed	Speed	Wgt (lb)	Traj	Guidance	C	L	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	
AIM-9X Sidewinder	Air-to-Air	66	Mach 2+		2,188	Missile	Passive IR																						
AIM-7M Sparrow	Air-to-Air	85	Mach 4		4,510	Missile	Semi-Active Rad	X																					
AIM-120D AMRAAM	Air-to-Air	161	Mach 4		4,335	Missile	Active Radar, GF	X																					
CBU-107 Passive Attack Weapon (PAW)	Direct Attac	0	Aircraft Launch/Drop			Bomb	GPS	X																					
CBU-105 Sensor Fuzed Weapon (SFW)	Direct Attac	0	Aircraft Launch/Drop			Bomb	GPS	X		X																			
GBU-43 Massive Ordnance Air Blast (MOAB)	Direct Attac	0	Aircraft Launch/Drop			Bomb	GPS/INS	X																					
GBU-57B Massive Ordnance Penetrator (MOP)	Direct Attac	0	Aircraft Launch/Drop			Bomb	GPS	X																					
GBU-101/121/143 Paveway II	Direct Attac	15	Aircraft Launch/Drop			Bomb	Laser-seeking	BU-10V	X																				
GBU-24/28B/28C Paveway III	Direct Attac	15	Aircraft Launch/Drop			Bomb	Laser/GPS	BU-24	X																				
GBU-31/32/38 Joint Direct Attack Munition (JDAM)	Direct Attac	24	Aircraft Launch/Drop			Bomb	GPS/INS	X																					
GBU-54 Laser JDAM (LJDAM)	Direct Attac	24	Aircraft Launch/Drop			Bomb	GPS/Laser	X	X																				
M30A1 GMLRS Altitude Warhead	Stand-in	70	Mach 2.5		2.5, 665	Ballistic	GPS/INS	X																					
M31 GMLRS Unitary	Stand-in	70	Mach 2.5		2.5, 665	Ballistic	GPS/INS	X																					
GBU-53/B (Small Diameter Bomb II)	Stand-in	70	Subsonic Glide		0.4, 200	Glide	GPS/INS	X	X	X																			
AGM-154C-1 Joint Stand Off Weapon (JSOW)	Stand-in	70	Subsonic Glide		0.4, 1000	Glide	GPS/INS	X	X																				
GBU-39/B (Small Diameter Bomb)	Stand-in	70	Subsonic Glide		0.4, 250	Glide	GPS/INS	X																					
AGM-89E AARGM (USM)	Stand-in	77	Mach 2+		2,796	Missile	GPS/INS	X																					
Naval Strike Missile (NSM)	Stand-in	65	<Mach 1		0.8, 897	Cruise	GPS/INS	X	X	X																			
RGM/UGM/AGM-84N Harpoon Block II	Stand-in	240	Mach 0.8 (High Subsoni		0.8, 1523	Cruise	INS/GPS-aided	X																					
SM-6 Block IA	Stand-in	240	<Mach 3.5		3.5, 1300	Ballistic	INS			X	X																		
AGM-84HK SLAM-ER	Stand-in	280	Mach 0.8 (High Subsoni		0.8, 1488	Cruise	INS/GPS-aided	X	X																				
ATACMS Block IA	Stand-in	300	>Mach 3		3, 212	Ballistic	GPS/INS	X																					
AGM-158A JASSM	Stand-in	370	<Mach 1		0.8, 2250	Cruise	GPS/INS	X	X																				
AGM-158B Long-Range Anti-Ship Missile (LRASM)	Stand-off	326	<Mach 1		0.8, 2500	Cruise	GPS/INS	X	X																				
ADM-160C Miniature Air Launched Decoy (MALD)	Stand-off	326	Mach 0.3+		0.3, 300	Cruise	GPS/INS	X																					
AGM-158B JASSM-ER	Stand-off	1000	<Mach 1		0.8, 2250	Cruise	GPS/INS	X	X																				
Tomahawk Land Attack Missile (TACTOM) Block I	LR	1700	<Mach 1		0.74, 3,330	Cruise	GPS/INS/TERC	X																					
RIM-16C Rolling Airframe Missile (RAM) Block II	Surface to A	9.6	Mach 2+		2, 162	Missile	RF Homing/IR Homing																						
MIM-104F Patriot (PAC-3 MSE)	Surface to A	35	Mach 4.1		4.1, 688	Missile	Active-radar seeker																						
RIM-162 Evolved SeaSparrow Missile (ESSM) Block II	Surface to A	55	Mach 4+		4, 654	Missile	Semi-active radar homing, INS																						
SM-2ER Block IV (RIM-156A)	Surface to A	370	Mach 3		3, 3231	Missile	INS, Semi-active radar																						
SM-3 Block IIA	Surface to A	1200	Mach 3		3, 3300	Missile	GPS/INS, IIR	X	X																				

An Example Taxonomy for Surface Strike Munitions



Conclusion, Future Applications, Further Research

- **Taxonomy is an illustrative example—limited in scope and detail**
 - Demonstrate inadequacy of current taxonomies
 - Foundation for further research
- **Useful to stakeholders at the tactical, operational, and strategic levels**
 - Apply to reconstitution of NATO Alliance munitions inventories
- **Necessary step for analysis applications with both munitions and artificial intelligence**
 - Build ontologies for semantic reasoning engines
 - Natural language processing
- **Future work must expand and refine the taxonomy**
 - Other types of munitions
 - Future technologies and features
 - Evaluate through case studies
- **What is missing?**



Questions