U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

NDIA MES 2019 Threat Update
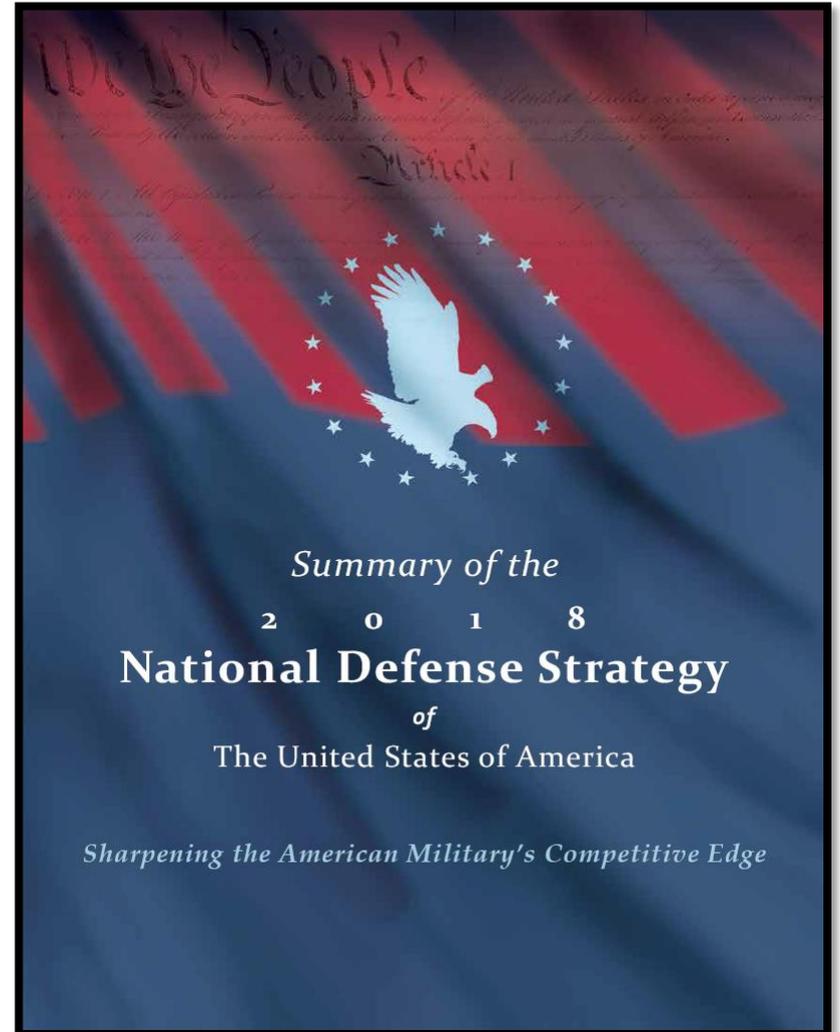
- The *National Defense Strategy* acknowledges an increasingly complex global security environment, characterized by overt challenges to the free and open international order and the re-emergence of long-term, strategic competition between nations.

Summary of the

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National Defense Strategy

of

The United States of America

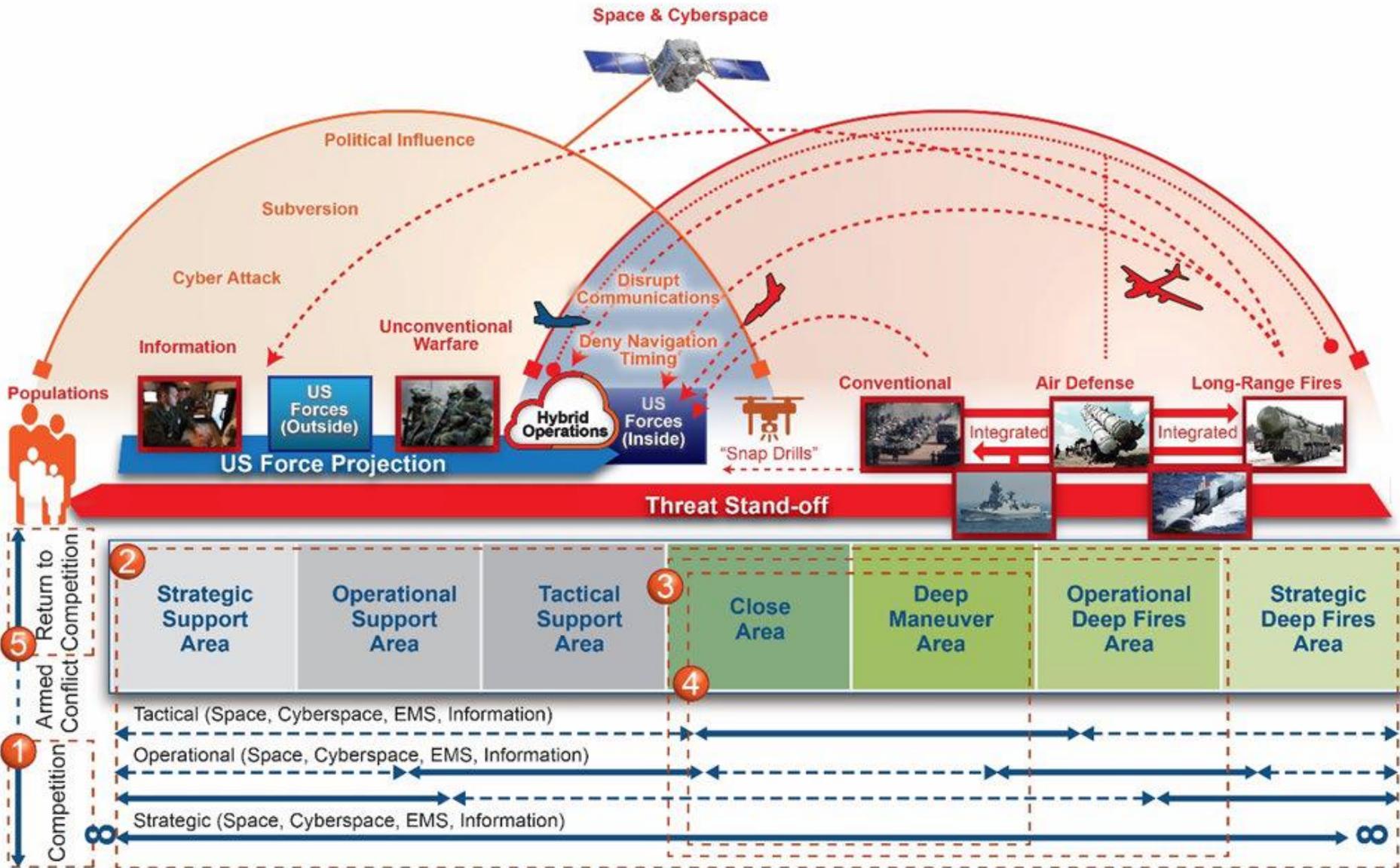*Sharpening the American Military's Competitive Edge*

The Reality of Fighting in AFVs

'The 75 (mm gun) is firing. The 37 (mm gun) is firing, but it is traversed round the wrong way. The Browning is jammed. I am saying 'Driver advance' on the A set and the driver, who can't hear me, is reversing. And as I look over the top of the turret and see twelve enemy tanks fifty yards away, someone hands me a cheese sandwich.'

British Tank Commander, Western Desert 1942

MULTI-DOMAIN OPERATIONS CHALLENGES

- Threats to US national security will expand and diversify in the coming year, driven in part by China and Russia as they respectively compete more intensely with the United States and its traditional allies and partners.

STATEMENT FOR THE RECORD

WORLDWIDE THREAT ASSESSMENT
OF THE US INTELLIGENCE COMMUNITY

Daniel R. Coats
Director of National Intelligence
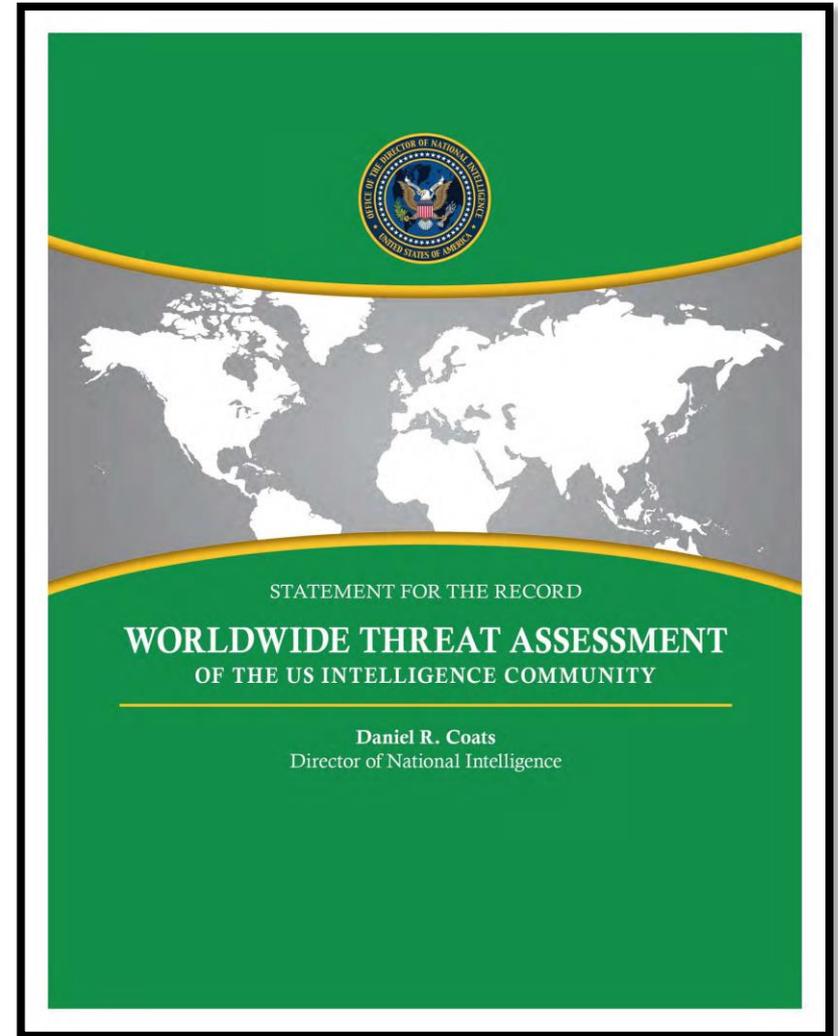
- Russia is the "pacing threat" and the most capable adversary now
- China is rapidly modernizing and will become the "pacing threat" by 2035
- North Korea and Iran are significant but less capable regional actors
- Violent Extremist Organizations and Transnational Criminal Organizations will remain viable
- The US may not necessarily fight Russia, China, North Korea, or Iran, but we will fight their equipment, concepts, and doctrine
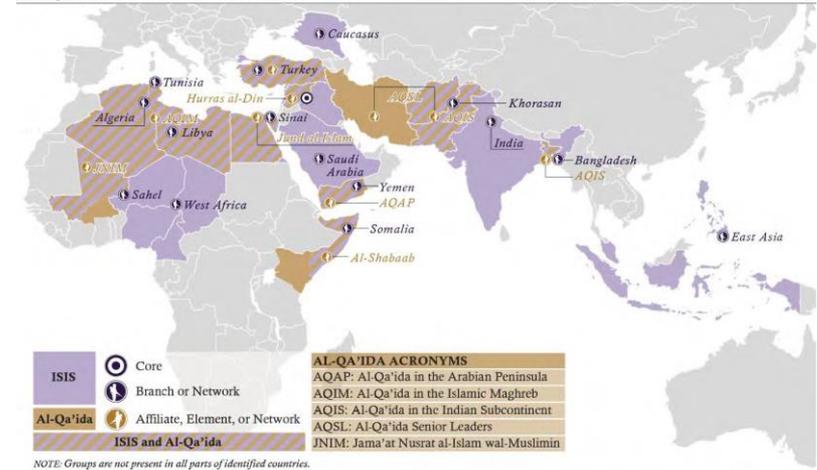
- The conflicts in Iraq and Syria have generated a large pool of battle-hardened fighters with the skills to conduct attacks and bolster terrorist groups' capabilities.
- ISIS still commands thousands of fighters in Iraq and Syria, and it maintains eight branches, more than a dozen networks, and thousands of dispersed supporters around the world, despite significant leadership and territorial losses.

Al-Qa'ida and ISIS as of 2018

ISIS	Core
	Branch or Network
Al-Qa'ida	Affiliate, Element, or Network
ISIS and Al-Qa'ida	

AL-QA'IDA ACRONYMS
AQAP: Al-Qa'ida in the Arabian Peninsula
AQIM: Al-Qa'ida in the Islamic Maghreb
AQIS: Al-Qa'ida in the Indian Subcontinent
AQSL: Al-Qa'ida Senior Leaders
JNIM: Jama'at Nusrat al-Islam wal-Muslimin

NOTE: Groups are not present in all parts of identified countries.

1810-00426-B-U

ENVIRONMENT AND CLIMATE CHANGE

- Global environmental and ecological degradation, as well as climate change, are likely to fuel competition for resources, economic distress, and social discontent through 2019 and beyond.

- Diminishing Arctic sea ice may increase competition—particularly with Russia and China—over access to sea routes and natural resources.

- The United States faces a complex global foreign intelligence threat environment in 2019. Russia and China will continue to be the leading state intelligence threats to US interests, based on their services' capabilities, intent, and broad operational scopes.
- We assess that China's intelligence services will exploit the openness of American society, especially academia and the scientific community, using a variety of means.

China's Technology Development Strategy

China takes a multifaceted, long-term, whole-of-government approach to foreign technology acquisition and indigenous technology development.

Legal and Regulatory Environment · Non-Traditional Collectors · Intelligence Services · Joint Ventures · Talent Recruitment Programs · Research Partnerships · Front Companies · Academic Collaborations · Mergers and Acquisitions · S&T Investments

CHINA'S STRATEGIC GOALS
Comprehensive National Power
Innovation-Driven Economic Growth Model
Military Modernization

1810-00427-B

RUSSIA

- Moscow will employ a variety of aggressive tactics to bolster its standing as a great power, secure a "sphere of influence" in the post-Soviet space, weaken the United States, and undermine Euro-Atlantic unity.
- In 2019, Russia will continue to modernize, develop, and field a wide range of advanced nuclear, conventional, and asymmetric capabilities to balance its perception of a strategic military inferiority vis-a-vis the United States.

GDP
GDP (purchasing power parity): **$3.471 trillion** (2015 est.)
 – country comparison to the world: **7**
GDP (official exchange rate**): $1.236 trillion** (2015 est.)
GDP - real growth rate: **-3.9%** (2015 est.)
 – country comparison to the world: **213**
GDP - per capita (PPP): **$23,700** (2015 est.)
 – country comparison to the world: **57**
Military Spending: **3.49% GDP** (2014)

Population: **142,470,272** (July 2014 est.)
 - country comparison to the world: **10**
Age structure:

Median age: **36.7 years**
Population growth rate: **0.44%** (2014 est.)
Russian Ground Forces Personnel (active): **230,000**

Geography
Area total: **17,098,242 sq km**
 – country comparison to the world: **1**
Approximately 1.8 times the size of the U.S.

		Total Number	Most Capable	Main Armament/Payload (kg)	Range (km)
Ground Forces	Tanks	2,562	T-90A	125mm gun	5 (AT-11 GLATGM)
	IFVs	3,229	BMP-3U	30mm cannon 100mm gun	5.5 (AT-10 GLATGM)
	APCs	2,876	BTR-82AM	30mm cannon	N/A
	Gun Arty (towed)	1,781	2A65	152mm gun	25 (Conventional) 29 (Extended)
	Gun Arty (self propelled)	2,606	2S19 series		
	Rocket Arty (MRL)	1,352	Tornado-G	122mm rocket	40
	Rocket Arty (CRBM)		Smerch	300mm rocket	120
	Missile Arty (SRBM)	328	SS-26	480-700kg	300+
	Missile Arty (GLCM)	88*	R-500	unknown	Less than 500
AD	Tactical SAM	1,531	PANTSIR-S1	Gun/Missile	3/20
	Strategic SAM	963	S-400	Missile	250
Strategic Missiles**	SS-18 Mod 5	About 50**	SS-27 Mod 2	10 RVs	10,000+
	SS-19 Mod 3	About 50**		6 RVs	9,000+
	SS-25	More than 150**		1 RV	11,000
	SS-27 Mod 1	About 80**		1 RV	11,000
	SS-27 Mod 2	About 20**		Multiple RVs	11,000
Rotary Wing	Medium Lift	Less than 608	Mi-8AMTSh	80mm rockets	2-4
	Heavy Lift		Mi-26	N/A	N/A
	Attack	Less than 490	Ka-52	30mm Cannon AT-9 ATGM	6 (AT-9)
				* R-500 is part of the Iskander Missile Complex and is fired from the same launcher as the SS-26 ballistic missile ** Strategic missile OB data is dated 2013	

Russian New Generation Warfare

Threat Considerations

- Electronic Warfare
- Integrated Air Defense
- Counter Space & PNT
- Cyber & Social Media
- Recon-Info-Strike Complex
- Extensive use of UAVs
- Massed Artillery & Forces
- Protection
- Proxies
- Deception & Ambiguity
- CBRNE/WMD

Potential for Conventional Overmatch

Electronic Warfare

Cyber & Space

Fighting Vehicles
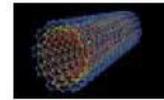
Air Defense

MRLS & Rockets

Artillery

OE Characteristics

Populations & complex terrain

Proliferation of WMD

Potential for overmatch

Speed of human interaction

Contested in all domains

Fundamental Changes

Laser Weapons

Synthetic Bio

RF Weapons

Internet of Things

Energetics

Power

EDKEW(Rail Guns)

- Since 2010, there have been significant improvements in the condition of Russian ground arms, including the modernization and upgrade of the main battle tank (MBT) inventory. The active inventory includes the T-72, T-80U, and T-90 MBTs.

CHINA

- China will continue to pursue an active foreign policy—especially in the Asia Pacific region—highlighted by a firm stance on its sovereignty claims in the East China Sea (ECS) and South China Sea (SCS), its relations with Taiwan, and its pursuit of economic engagement across the region.
- China will also pursue efforts aimed at fulfilling its ambitious Belt and Road Initiative to expand China's economic reach and political influence across Eurasia, Africa, and the Pacific through infrastructure projects.

GDP
GDP (purchasing power parity): **$19.39 trillion** (2015 est.)
 – country comparison to the world: **1**
GDP (official exchange rate): **$8.939 trillion**
GDP - real growth rate: **7.3%** (2014 est.)
 – country comparison to the world: **14**
GDP - per capita (PPP): **$14,107** (2015 est.)
 – country comparison to the world: **83**
Military Spending: **2.41% GDP/$215 billion** (est.)

Population: 1,355,692,576 (July 2014 est.)
 – country comparison to the world: **1**
Age structure:

Median age: **36.7 years**
Population growth rate: **0.44%** (2014 est.)
People's Liberation Army, Army (active): **850,000**

Geography
Area total: **9,597,000 sq km/3,705,000 sq mi**
 – country comparison to the world: **4**
Slightly smaller than the U.S.

		Total Number	Most Capable	Main Armament/Payload (kg)	Range (km)
Ground Forces	Tanks	6,950	Type 99A	125mm main gun	5 (GLATGM)
	IFVs	3,800	ZBD-04A	30mm cannon 100mm gun	5 (GLATGM)
	SP Arty	2,170	PLZ-05	155mm howitzer	32 (Conv) 58 (Extended)
	Towed Arty	3,800	Type 59-1	130mm gun	27.5 (Conv) 45 (Extended)
	MRLs / CRBMs	1,696	PHL-03	12x 300mm tubes	150
AD	Towed ADA	More than 2,000	Type 90 with 3D 902	35mm	4 max
	SP ADA	More than 250	PGZ-07	35mm	11.2 max
	Gun Missile Systems	Fewer than 100	LD 2000 with CSA-6B	30mm	18
	Tactical SAMS	More than 200	CSA-16	6 per launcher	42
	Strategic SAMS	More than 400	CSA- 9	4 per launcher	200
Missiles	**ICBMs** CSS-4 Mod 1	About 20	NA		12,000+
	CSS-2	5 to 10	CSS-2		3,000
	MRBMs CSS-5 Mod 1	Fewer than 50			1,750+
	CSS-5 Mod 2	Fewer than 50			1,750+
	CSS-6 Mod 2	More than 200	CSS-6 Mod 2		850+
	SRBMs CSS-11 Mod 1	Total			800+
	CSS-6 Mod 3	SRBMs			725+
	CSS-7 Mod 2				600+
Rotary Wing	Attack	236	Z-10	23mm cannon, ATGM, rockets, air-to-air missiles / 870	8
	Medium Lift	385	Mi-171, Z-8	Unguided rockets / 4,000	

- As China's global footprint and international interests have grown, its military modernization program has become more focused on investments and infrastructure to support a range of missions beyond China's periphery, including a growing emphasis on the maritime domains, offensive air operations, and long-distance mobility operations.

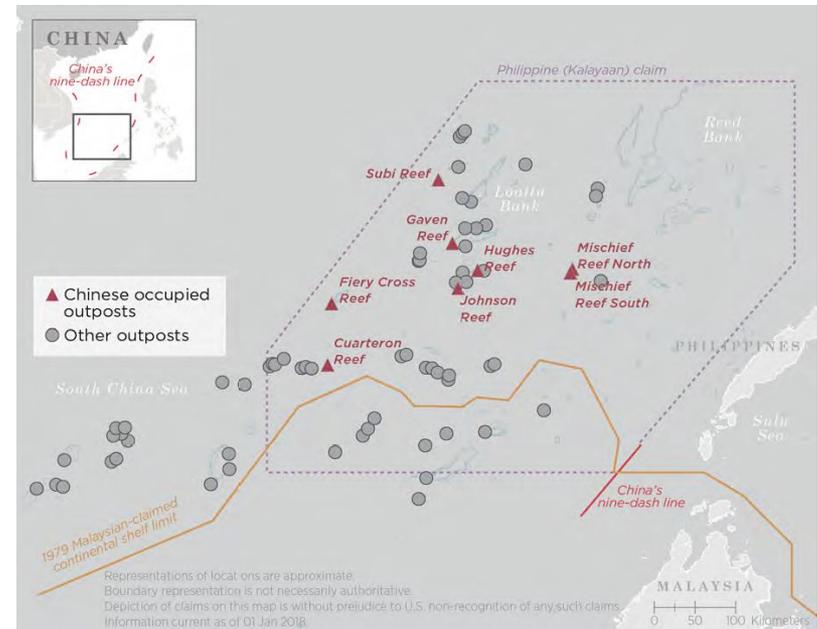- We assess that China will continue increasing its maritime presence in the South China Sea and building military and dual-use infrastructure in the Spratly Islands to improve its ability to control access, project power, and undermine US influence in the area.

- China and Russia are more aligned than at any point since the mid-1950s, and the relationship is likely to strengthen in the coming year as some of their interests and threat perceptions converge, particularly regarding perceived US unilateralism and interventionism and Western promotion of democratic values and human rights.

INFORMATION CONFRONTATION

- Adversaries and strategic competitors probably will attempt to use deep fakes or similar machine-learning technologies to create convincing—but false— image, audio, and video files to augment influence campaigns directed against the United States and our allies and partners.

- At present, China and Russia pose the greatest espionage and cyber attack threats, but we anticipate that all our adversaries and strategic competitors will increasingly build and integrate cyber espionage, attack, and influence capabilities into their efforts to influence US policies and advance their own national security interests.
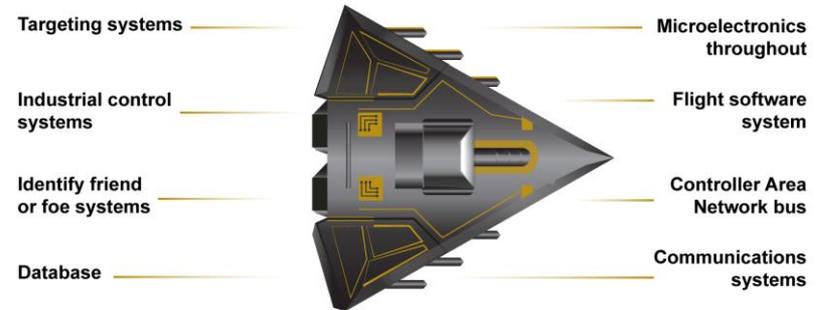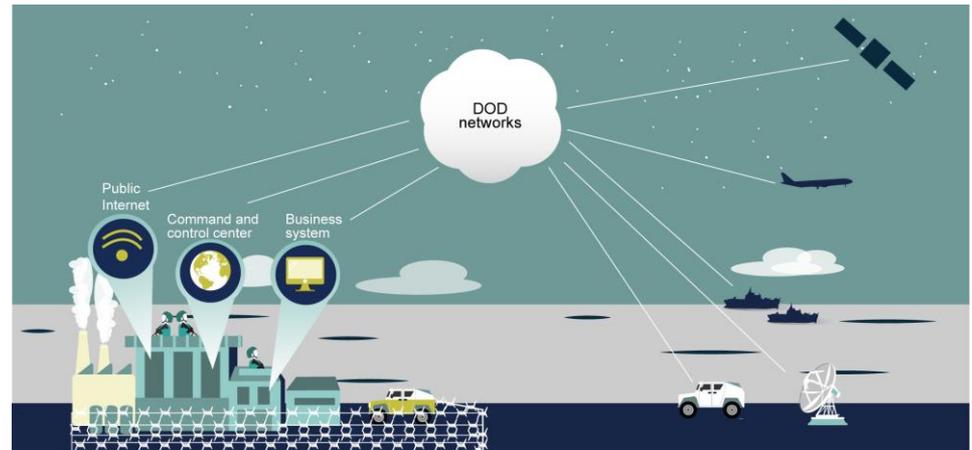
WEAPONS SYSTEM CYBERSECURITY

- In operational testing, DOD routinely found mission-critical cyber vulnerabilities in systems that were under development, yet program officials GAO met with believed their systems were secure and discounted some test results as unrealistic. Using relatively simple tools and techniques, testers were able to take control of systems and largely operate undetected, due in part to basic issues such as poor password management and unencrypted communications.

Targeting systems — Microelectronics throughout

Industrial control systems — Flight software system

Identify friend or foe systems — Controller Area Network bus

Database — Communications systems

Source: GAO analysis of Department of Defense information. | GAO-19-128

DOD networks

Public Internet

Command and control center

Business system

Source: GAO analysis of Department of Defense information. | GAO-19-128

- The global race to develop artificial intelligence (AI)— systems that imitate aspects of human cognition—is likely to accelerate the development of highly capable, application-specific AI systems with national security implications.

"Artificial intelligence is not only the future of Russia, it is the future of the entire mankind. . .The one who becomes the leader in this area, will be the ruler of the world."

- Currently, the Russian military is working on incorporating elements of AI in its various weapons systems such as electronic warfare, anti-aircraft defenses, fighter jets, missiles, and unmanned systems, though it's unclear what exactly "AI" is in these systems – the language of such announcements alludes to AI but probably implies "automated control systems" that have limited and pre-programmed autonomy.

- The Chinese People's Liberation Army (PLA) is exploring the use of AI technologies to enhance future command decision-making. In particular, the PLA seeks to overcome admitted deficiencies in its commanders' capabilities and to leverage these technologies to achieve decision superiority in future "intelligentized" (智能化) warfare.

- A global resurgence in materials science and manufacturing technology is likely to enable advanced states to create materials with novel properties and engineer structures not previously possible, while placing high-end manufacturing capabilities within reach of small groups and individuals.
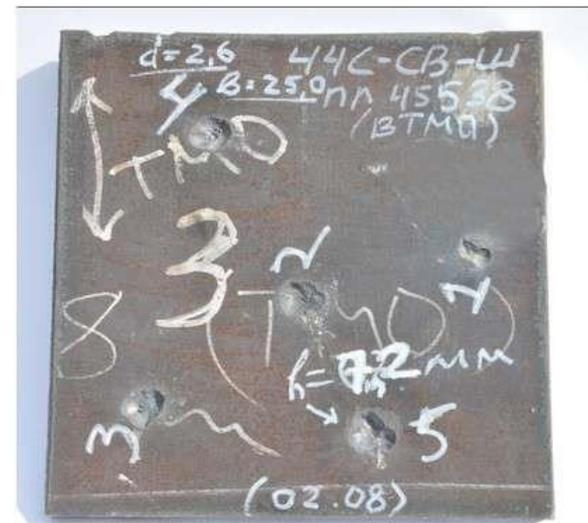
- Rapid advances in biotechnology, including gene editing, synthetic biology, and neuroscience, are likely to present new economic, military, ethical, and regulatory challenges worldwide as governments struggle to keep pace.

- We assess that China and Russia are training and equipping their military space forces and fielding new antisatellite (ASAT) weapons to hold US and allied space services at risk, even as they push for international agreements on the nonweaponization of space.

Satellites Launched and Countries Owning the Satellites (2013–18)
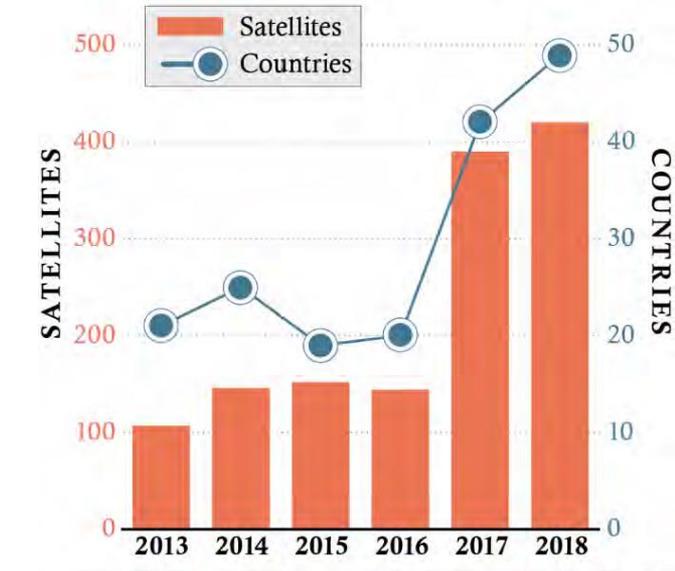
Counterspace Continuum

Denial and Deception · Directed Energy Weapons · Orbital Threats · Ground Site Attacks

REVERSIBLE — NONREVERSIBLE

Space Situational Awareness · Electronic Warfare · Cyberspace Threats · Kinetic Energy Threats · Nuclear Detonation in Space

Visualization: DIA, D3 Design · IBII-20003
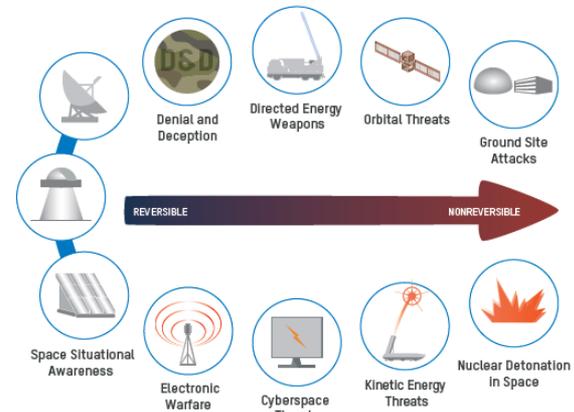
- Chinese and Russian military doctrines indicate that they view space as important to modern warfare and view counterspace capabilities as a means to reduce U.S. and allied military effectiveness.
- Both states are developing jamming and cyberspace capabilities, directed energy weapons, on-orbit capabilities, and ground-based antisatellite missiles that can achieve a range of reversible to nonreversible effects.

MAIN BATTLE TANKS

	CHINA	IRAN	N. KOREA	RUSSIA	U.S.
MOST CAPABLE MBT	Type 99A	T-72S	M-2009	T-90A	M1A2
Total MBT # Most Capable % Most Capable	6,950 383 6%	1,658 480 29%	3,800 100 2.6%	2,562 550 21%	
Combat weight Road Range	59 tonnes 550(+) km	46.5 tonnes 550 km	40+ tonnes 480-550 km	46.5 tonnes 550 km	69.5 tonnes 426 km
Fording	5.0 m (w/prep)	1.8 m (w/o prep) 5.0 m (w/prep)	1.4 m	1.8 m (w/o prep) 5.0 m (w/prep)	1.98m (w/prep)
Main armament	125mm	125mm	115mm	125mm	120mm
Main Armament Effective Range	≥ 2200	≤ 2200	~1500	≥ 2200	> 2200
Day/Night Capable	Yes (Thermal)	No (Image Intensifier)	No (Image Intensifier)	Yes (Thermal)	Yes (FLIR)
GLATGM – maximum range	5 km	4 km	N/A	5 km	N/A
Hunter/Killer	Yes	No	No	Limited	Yes
Appliqué	Yes	Yes (Kontakt-I ERA)	Passive	Yes (Kontakt-V ERA)	Yes (ARAT 1&2)
APS	Yes	No	No	Shtora-1 APS	No

- Armata?
- Upgrades
- Non-traditional roles
- Large numbers
- Increased protection
- Defensive Aid Suites
- Robotic enablers

T-14 Armata MBT

1. Fuel tanks
2. Bar armour
3. Radio antenna
4. Fixed APS launchers
5. APS radars
6. Met sensor
7. EO/IR APS receivers
8. Gunner's sight
9. Driver's periscopes
10. Driver
11. Applique armour
12. Driver's FLIR
13. Commander
14. Exhausts
15. Fixed large APS launchers
16. Entrenching tool
17. Remote weapon station and integrated commander's sight
18. Datalink
19. Trainable APS launchers
20. Powerpack
21. 125mm cannon

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- Unmanned Aerial Vehicles
  - ISR
  - Fire direction
  - Attack
- Unmanned Ground Vehicles
  - Scout platforms
  - Fire support

Russian Fixed Wing UAS used over Ukraine

Name	Maximum Altitude (m)	Range (km)	Wingspan/ Fuselage Length (m)	Payload (kg)	Propulsion	Speed (km/hr) Maximum/ Cruising	Altitude Maximum/Max Working/Minimum Working (km)	Maximum Flight Duration (hrs.)	Equipment	Flight Regimes	Other
1. Tahcon	4000	400	2/0.61	1		120/	4/	2			
2. Forpost	5800	250	8.55/5/85		Internal Combustion Engine Type "Winkel" JABIRU 2200, 80HP	204/130	5.8/3/0.05	17.5	Modular combined, heat sensing video camera, gyro stabilized suspension	Manual with operator, automatic with software, with possible transition to direct manual	
3. Orlan-30	4500	200	2.7/1.5	7		170/	/4.5/	10			
4. Dozor-100	5000	120	5.4/3	15-32	DVZ,3W210,21	150/120	5/1.5-4/0.9	10	Color video camera, photo camera, laser sensor, airborne radar	Automatic to manual	Autonomous take-off and landing
5. BLA-0.8 Tipchak	4000	120	4.1/2.7	25-30		125/	/4/	8			
6. Orlan-10	5000	100	2.4/1.1	5		150/	5/	4			
7. Irkut-10	3000	100	2/0.7	1.5		120/	/3/	2.5			
8. Granat-4	2000	100		3		140/	2/	6			
9. Lastochka (Swallow)	3600	50	1.6/0.62	1		120/	3.6/	2			
10. Aleron-10	5000	50	2.2/0.83	4		180	5/	6			
11. Granat-3	2000	25		1		120/	2./	2			
12. Aleron-35V	5000	25	1.47/0.63		Electric Motor	130/70	5/3/0.05	2	Hi-def camera, heat sensor, gyro-stabilized suspension	Automatic to manual	Catapult launch, parachute landing
13. Granat-2	600	15		0.7		120/	0.6/	1			
14. Zastava	500	10	2.2/0.8	0.6-1.2		100/	0.5/	1			
15. Grusha (Pear)	500	10	0.48/0.2	0.5		120/	0.5/	1.25			
16. Granat-1	1500	10		0.5		60/	1.5/	1.25			

- Growing market
- Extended ranges
- Increased penetration
- 130+ state and non-state users
- Multiple guidance schemes
- GLATGM

- Few new systems
- Upgrades to old systems
- Increased range
- Greater lethality
- Higher precision
- Better terminal effects
- Higher cost
- Wheeled systems

Range	Rate of Fire	Stowage
70km	16-20rds/min	50-70rds

- Base Bleed and RAP
- Interest in Ramjet
- Course correction
- Sensor Fuzed Munitions and DPICM still produced

Types of Ammunition for 2A88 152mm Howitzer (above) to Include a New Precision-Guided Munition Round (below)

- China and US lead
- Current status: TRL 5-6
- Pulsed power is critical for ground systems
- Expected IOC in 2025

SHORAD

V-SHORAD	Range		Counter PGM	Multi-Target Engagement	All Weather	Ready Load
Avenger (U.S.)	Stinger Range	5 km	No	No	No	8 Stinger Missiles
PANTSIR-S1 (Russia)	20 km Range/15 km Alt		Yes	Yes	Yes	12 Goblin Missiles
CSA-6b (China)	18 km		Yes	No	Yes	6 HQ-6 Missiles
SA-15 (Iran)	12 km		Yes	Yes	Yes	8 SA-15 Missiles
SA-13 (N. Korea)	5 km		Yes	No	Yes	4 SA-13 Missiles

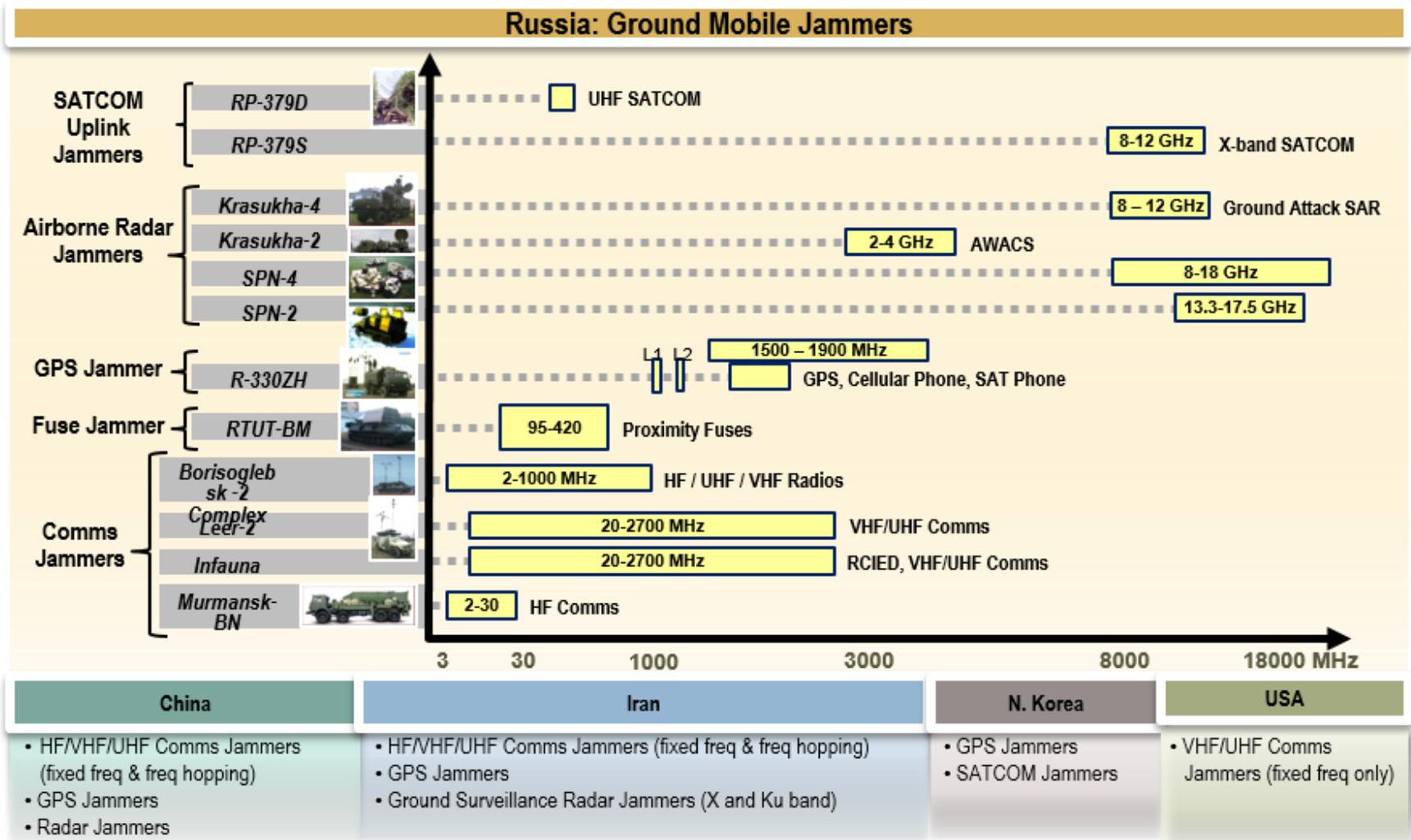■ U.S. to Foreign

■ U.S. overmatch

■ Foreign overmatch

- US reliance on GPS is known
- Jamming is inexpensive compared to anti-jamming
- Wide frequency coverage
- Higher power
- Multitasking

Russia: Ground Mobile Jammers

SATCOM Uplink Jammers
- RP-379D — UHF SATCOM
- RP-379S — 8-12 GHz — X-band SATCOM

Airborne Radar Jammers
- Krasukha-4 — 8 – 12 GHz — Ground Attack SAR
- Krasukha-2 — 2-4 GHz — AWACS
- SPN-4 — 8-18 GHz
- SPN-2 — 13.3-17.5 GHz

GPS Jammer
- R-330ZH — L1 L2 — 1500 – 1900 MHz — GPS, Cellular Phone, SAT Phone

Fuse Jammer
- RTUT-BM — 95-420 — Proximity Fuses

Comms Jammers
- Borisoglebsk -2 — 2-1000 MHz — HF / UHF / VHF Radios
- Complex Leer-2 — 20-2700 MHz — VHF/UHF Comms
- Infauna — 20-2700 MHz — RCIED, VHF/UHF Comms
- Murmansk-BN — 2-30 — HF Comms

Frequency scale: 3 — 30 — 1000 — 3000 — 8000 — 18000 MHz

China	Iran	N. Korea	USA
• HF/VHF/UHF Comms Jammers (fixed freq & freq hopping) • GPS Jammers • Radar Jammers	• HF/VHF/UHF Comms Jammers (fixed freq & freq hopping) • GPS Jammers • Ground Surveillance Radar Jammers (X and Ku band)	• GPS Jammers • SATCOM Jammers	• VHF/UHF Comms Jammers (fixed freq only)

Figure 1: GAO's Four Broad Categories for 26 Long-Range Emerging Threats Identified by DOD, State, DHS, and ODNI

Adversaries' Political and Military Advancements

- Chinese Global Expansion
- Russian Global Expansion
- Iranian Political and Military Developments
- North Korean Military Developments
- Foreign Government Capacity and Stability
- Terrorism
- New Alliances and Adversaries
- Information Operations

Dual-Use Technologies

- Artificial Intelligence
- Quantum Information Science
- Internet of Things
- Autonomous and Unmanned Systems
- Biotechnology
- Other Emerging Technologies

Weapons

- Weapons of Mass Destruction
- Electronic Warfare
- Hypersonic Weapons
- Counterspace Weapons
- Missiles
- Intelligence, Surveillance, and Reconnaissance Platforms
- Aircraft
- Undersea Weapons
- Cyber Weapons

Events and Demographic Changes

- Infectious Diseases
- Climate Change
- Internal and International Migration

Source: GAO analysis of DOD, State, DHS, and ODNI questionnaire responses, agency documents, and national security strategies. | GAO-19-204SP

Potential Game Changers Through 2035 (The Era of Accelerated Human Progress)

Robotics
40+ countries develop military robots with some level of autonomy. Impact on society, employment.
Vulnerable: Cyber/EM disruption, power systems, ethics without man in the loop.
Formats: Unmanned/Autonomous; ground/air vehicles/subsurface/sea systems. Nano-weapons.
Examples: (Air) Hunter/killer UAV swarms; (Ground) Russian Uran: Recon, ATGMs, SAMs.

Swarms/Semi Autonomous
Massed, coordinated, fast, collaborative, small, stand-off. Overwhelm target systems. Mass or disaggregate.

Computing
Human computer interaction transformed, processing power increases exponentially.
Interface: From mouse/keyboard/wearables to digital telepathy, centaur systems.
Quantum Computing: From 1&0 binary to quantum superpositions & entanglement (e.g., 0 and 1 at same time).
Big Data: Quantum computing using advanced predictive algorithms/sensing, Internet of Things (IoT) enabled. Must protect against deception.
Sentient Data: Pinpoints who can/cannot access and interact with, without human intervention.

Cyber
Self-configuring, self-protecting computer systems and networks.

Logistics/Additive Manufacturing
Ability to print materiel, in theater, on an as-needed basis.
Example: Print a small drone with specific capabilities for a mission in 24 hours.

Electronic Warfare
Radar Jammers: Sophisticated noise or repeaters.
Convergence of RF+Cyber through software defined radios. Controlled modulation can make signals look like noise to interceptors.

Advanced ATGM & MANPADS
Extended range. Proliferate more rapidly than Active Protection systems develop, putting armored vehicles and helicopters at risk.

Chemical Weapons
Non-traditional agents developed to defeat detection and protection capabilities.

Artificial Intelligence
Human-Agent Teaming, i.e., where humans and intelligent systems work together to achieve a physical or mental task. Human and the intelligent system will trade off cognitive and physical loads in a collaborative way.
Weaponized Information enabled by AI that deliberately misrepresents voice and video to influence the political, financial, and military areas.

Internet of Things (IoT)
Trillions of internet linked items create opportunities and vulnerabilities.
Explosive growth in low Size Weight and Power (SWaP) connected devices (Internet of Battlefield Things), especially for sensor applications (situational awareness). Greater than 100 devices per human. Significant end-device processing (sensor analytics, sensor to shooter, supply chain management).
Vulnerable: Cyber/EM/Power disruption. Privacy concerns regarding location and tracking.
Sensor to shooter: Accelerate kill chain, data processing and decision making.

Camouflage, Cover, Concealment, Denial and Deception
Low tech to high tech means to create uncertainty for adversaries, proliferating widely. **Obscurants/Thermal Paint** Confuse sensors. **Redirected Energy**: Hyper stealth invisibility, Electromagnetic illusion. (Revolutionary) **Decoys**: Must deceive multi-disciplined intelligence.

Space
Over 50 nations operate in space, increasingly congested and difficult to monitor, endanger PNT; **GPS Jamming/Spoofing**: Increasingly sophisticated, used successfully in Ukraine; **Anti Satellite**: China has tested two direct ascent anti-satellite missiles.

Cannon/Rocket Artillery
Long range artillery, hardened GPS munitions, Point air defense systems defend against PGM.

Missiles
Developed for greater range and improved accuracy using inertial guidance.

Potential Game Changers through 2050 (The Era of Contested Equality)

Convergence – The intersection or merging of many new and potentially revolutionary technologies will create exponential change in the operational environment.

Hyper Velocity Weapons
Rail Guns (Electrodynamic Kinetic Energy Weapons)
Electromagnetic projectile launchers: High velocity/energy and space (**Mach 5** or higher). Not powered by explosive.
No Propellant: Easier to store and handle.
Lower Cost Projectiles: Potentially. Extreme G-force requires sturdy payloads.
Limiting factors: Power. Significant IR signature. Materials science.
Hyper Glide Vehicles: Less susceptible to anti ballistic missile countermeasures.

Directed Energy Weapons
Signature not visible without technology. Power requirements currently problematic.
Potential: Tunable, lethal, and non-lethal.
Laser: Directed energy damages intended target. Targets: Counter Aircraft, UAS, Missiles, Projectiles, Sensors, Swarms. Must dwell on target.
RF: Attack targets across the frequency spectrum.
Targets: Not just RF: Microwave weapons "cook targets," people, electronics.

Energetics
Defines the relationships of the flow and storage of energy.
LENR: Low Energy Nuclear Reactions
Insensitive Munitions: Chemically stable munitions withstand shock, fire, projectiles; yet explode as intended.
Nano Materials: Miniaturized power sources; reduce bulk, increase yield.

Power
Critical driver of future capabilities. Storage/production increases despite getting smaller/lighter.
Strategies: Renewables, reduce consumption, increased storage and generation.
Thin / Super Capacitors: Store exponentially more energy and recharge faster.
Hybrid Renewable Energy: Combining two or more renewable energy sources.
Wireless: Power and charging over the air (long distances).
Nuclear: Very small reactors for the electrified force: small modular advanced nuclear power via DE and electric transportation.

Synthetic Biology
Engineering / modification of biological entities.
Increased Crop Yield: Potential to reduce food scarcity.
Weaponization: Potential for micro-targeting, seek & destroy microbes that can target DNA. Potentially accessible to super-empowered individuals.
Medical Advances: Enhance Soldier survivability.
Genetic Modification: Disease resistant, potentially designer babies and super athletes/Soldiers. Synthetic DNA stores digital data. Data can be used for micro-targeting.
CRISPR: Genome editing.

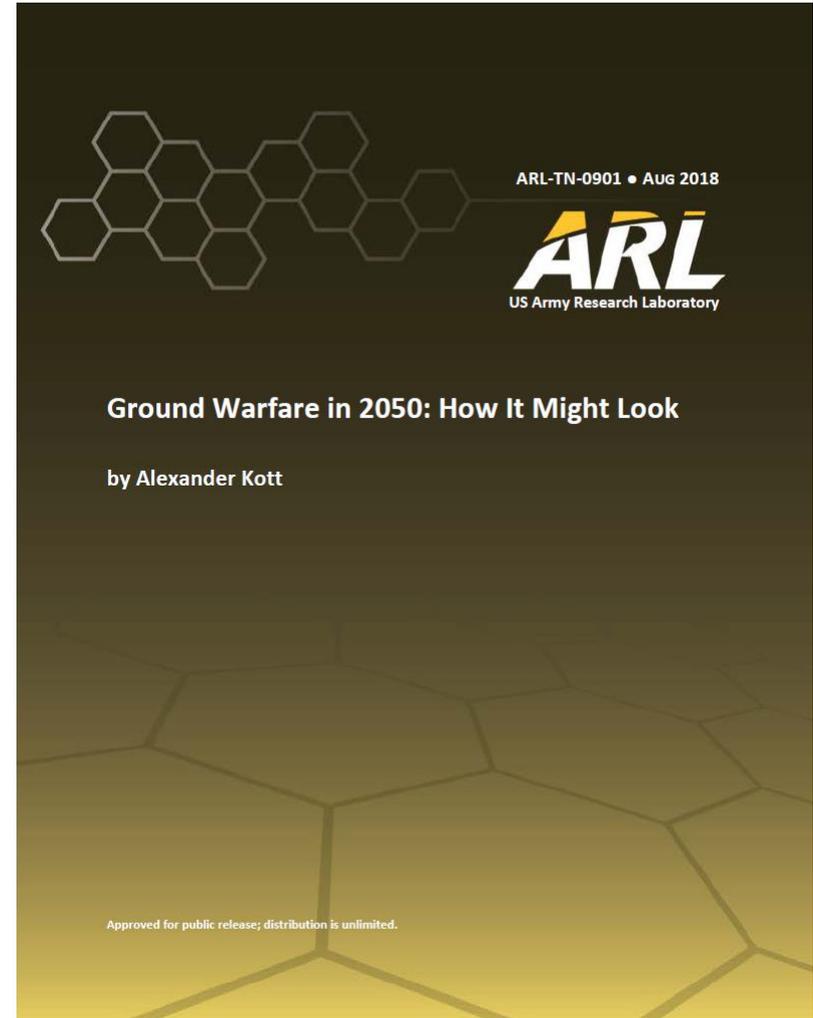**Information Environment**
Use IoT and sensors to harness the flow of information for situational understanding and decision-making advantage.

GROUND WARFARE IN 2050

- **Electrically powered** legged locomotion
- **AI** pilots flying Nap-of-the-earth in swarms
- **Robotically enhanced** soldiers
- A continuous spectrum of **autonomous munitions** in all velocity regimes with 3-10x explosive energy density
- Prepositioned, remotely operated, **coordinated ISR/DE/CEMA/kinetic effects**
- Active **deception** platforms
- Persistent, hovering **"antimissiles"**
- High-volume **robotic ISR** with C2 guided sharing schemes
- Autonomous intelligent **cyber defense** agents

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US Army Research Laboratory

Ground Warfare in 2050: How It Might Look

by Alexander Kott

Approved for public release; distribution is unlimited.

Fundamental Questions Affecting Army Modernization

Does this capability anticipate the convergence of quantum, nano, bio, info, & neuro?
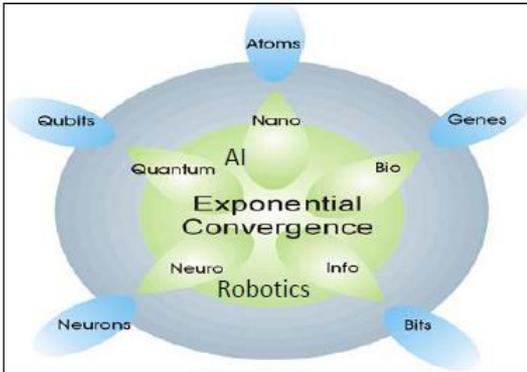
How will this system operate when degraded or disconnected from the network?
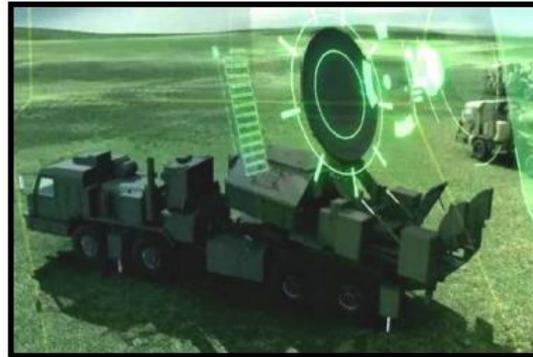
How does this capability help us win in competition short of conflict?

What signature does this system present to an adversary?

How does this system operate in dense urban environments?

How does this system take advantage of open and modular architectures?

Future Readiness dependent on OE-informed Modernization Decisions

Victory Starts Here!