CRITICAL AND EMERGING TECHNOLOGIES LIST UPDATE

A Report by the

FAST TRACK ACTION SUBCOMMITTEE ON CRITICAL AND EMERGING TECHNOLOGIES

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

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About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure that science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at http://www.whitehouse.gov/ostp/nstc.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government. More information is available at http://www.whitehouse.gov/ostp.

About the Fast Track Action Subcommittee on Critical and Emerging Technologies

The NSTC established this Fast Track Action Subcommittee in 2020 to identify critical and emerging technologies to inform national security-related activities. In support of this work, the Subcommittee coordinated across the NSTC and the National Security Council (NSC) to identify priority critical and emerging technology subfields, updated no less than every two years.

About this Document

This document identifies critical and emerging technologies.

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Abbreviations and Acronyms

AI	artificial intelligence
CET	critical and emerging technology(ies)
NSTC	National Science and Technology Council
OSTP	Office of Science and Technology Policy
RF	radio frequency

Overview

Critical and emerging technologies (CETs) are a subset of advanced technologies that are potentially significant to U.S. national security. The 2022 *National Security Strategy* identifies three national security interests: protect the security of the American people, expand economic prosperity and opportunity, and realize and defend the democratic values at the heart of the American way of life.[1] The NSTC established this Fast Track Action Subcommittee in 2020 to identify critical and emerging technologies to inform national security-related activities. This list identifies CETs with the potential to further these interests and builds on the October 2020 *National Strategy for Critical and Emerging Technologies,* which contains an initial list of priority CETs.[2] This updated document expands upon that original CET list and the February 2022 update by identifying subfields for each CET with a focus, where possible, on core technologies that continue to emerge and modernize, while remaining critical to a free, open, secure, and prosperous world. While enabling or supporting technologies are sometimes referenced, other enabling capabilities, like a modernized, technically capable workforce, are excluded. Though certain enabling capabilities are not explicitly included, they remain critical to the promotion and protection of all CETs.

Though not a strategy document, this updated CET list may inform government-wide and agency-specific efforts concerning U.S. technological competitiveness and national security. This list may also inform future efforts to prioritize across CETs and their component subfields; however, *this list should not be interpreted as a priority list for either policy development or funding*. Instead, this list should be used as a resource to: inform future efforts that promote U.S. technological leadership; cooperate with allies and partners to advance and maintain shared technological advantages; develop, design, govern, and use CETs that yield tangible benefits for society and are aligned with democratic values; and develop U.S. Government measures that respond to threats against U.S. security. Departments and agencies may consult this CET list when developing, for example, initiatives to research and develop technologies that support national security missions, compete for international talent, and protect sensitive technology from misappropriation and misuse.

To generate this updated CET list, the Office of Science and Technology Policy (OSTP) facilitated an extensive interagency deliberative process through the National Science and Technology Council (NSTC) and in coordination with the National Security Council (NSC). The responsible NSTC subcommittee included subject matter experts from 18 departments, agencies, and offices in the Executive Office of the President, who identified CET subfields that their home organizations determined may be critical to U.S. national security. As such, this updated CET list, which was coordinated through both the NSTC and the NSC, reflects an interagency consensus on updates to the 2022 CETs.

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[1] https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf

[2] https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/10/National-Strategy-for-CET.pdf

Critical and Emerging Technologies List

The following critical and emerging technology areas are of particular importance to the national security of the United States:

- Advanced Computing
- Advanced Engineering Materials
- Advanced Gas Turbine Engine Technologies
- Advanced and Networked Sensing and Signature Management
- Advanced Manufacturing
- Artificial Intelligence
- Biotechnologies
- Clean Energy Generation and Storage
- Data Privacy, Data Security, and Cybersecurity Technologies
- Directed Energy
- Highly Automated, Autonomous, and Uncrewed Systems (UxS), and Robotics
- Human-Machine Interfaces
- Hypersonics
- Integrated Communication and Networking Technologies
- Positioning, Navigation, and Timing (PNT) Technologies
- Quantum Information and Enabling Technologies
- Semiconductors and Microelectronics
- Space Technologies and Systems

Critical and Emerging Technology Subfields

Each identified CET area includes a set of key subfields that describe its scope in more detail.

Advanced Computing

- Advanced supercomputing, including for AI applications
- Edge computing and devices
- Advanced cloud services
- High-performance data storage and data centers
- Advanced computing architectures
- Advanced modeling and simulation
- Data processing and analysis techniques
- Spatial computing

Advanced Engineering Materials

- Materials by design and material genomics
- Materials with novel properties to include substantial improvements to existing properties
- Novel and emerging techniques for material property characterization and lifecycle assessment

Advanced Gas Turbine Engine Technologies

- Aerospace, maritime, and industrial development and production technologies
- Full-authority digital engine control, hot-section manufacturing, and associated technologies

Advanced and Networked Sensing and Signature Management

- Payloads, sensors, and instruments
- Sensor processing and data fusion
- Adaptive optics
- Remote sensing of the Earth
- Geophysical sensing
- Signature management
- Detection and characterization of pathogens and of chemical, biological, radiological and nuclear weapons and materials
- Transportation-sector sensing
- Security-sector sensing
- Health-sector sensing
- Energy-sector sensing
- Manufacturing-sector sensing
- Building-sector sensing
- Environmental-sector sensing

Advanced Manufacturing

- Advanced additive manufacturing
- Advanced manufacturing technologies and techniques including those supporting clean, sustainable, and smart manufacturing, nanomanufacturing, lightweight metal manufacturing, and product and material recovery

Artificial Intelligence (AI)

- Machine learning
- Deep learning
- Reinforcement learning
- Sensory perception and recognition
- AI assurance and assessment techniques
- Foundation models
- Generative AI systems, multimodal and large language models
- Synthetic data approaches for training, tuning, and testing
- Planning, reasoning, and decision making
- Technologies for improving AI safety, trust, security, and responsible use

Biotechnologies

- Novel synthetic biology including nucleic acid, genome, epigenome, and protein synthesis and engineering, including design tools
- Multi-omics and other biometrology, bioinformatics, computational biology, predictive modeling, and analytical tools for functional phenotypes
- Engineering of sub-cellular, multicellular, and multi-scale systems
- Cell-free systems and technologies
- Engineering of viral and viral delivery systems
- Biotic/abiotic interfaces
- Biomanufacturing and bioprocessing technologies

Clean Energy Generation and Storage

- Renewable generation
- Renewable and sustainable chemistries, fuels, and feedstocks
- Nuclear energy systems
- Fusion energy
- Energy storage
- Electric and hybrid engines
- Batteries
- Grid integration technologies
- Energy-efficiency technologies
- Carbon management technologies

Data Privacy, Data Security, and Cybersecurity Technologies

- Distributed ledger technologies
- Digital assets
- Digital payment technologies
- Digital identity technologies, biometrics, and associated infrastructure
- Communications and network security
- Privacy-enhancing technologies
- Technologies for data fusion and improving data interoperability, privacy, and security Distributed confidential computing
- Computing supply chain security
- Security and privacy technologies in augmented reality/virtual reality

Directed Energy

- Lasers
- High-power microwaves
- Particle beams

Highly Automated, Autonomous, and Uncrewed Systems (UxS), and Robotics

- Surface
- Air
- Maritime
- Space
- Supporting digital infrastructure, including High Definition (HD) maps
- Autonomous command and control

Human-Machine Interfaces

- Augmented reality
- Virtual reality
- Human-machine teaming
- Neurotechnologies

Hypersonics

- Propulsion
- Aerodynamics and control
- Materials, structures, and manufacturing
- Detection, tracking, characterization, and defense
- Testing

Integrated Communication and Networking Technologies

- Radio-frequency (RF) and mixed-signal circuits, antennas, filters, and components
- Spectrum management and sensing technologies
- Future generation wireless networks
- Optical links and fiber technologies
- Terrestrial/undersea cables
- Satellite-based and stratospheric communications
- Delay-tolerant networking
- Mesh networks/infrastructure independent communication technologies
- Software-defined networking and radios
- Modern data exchange techniques
- Adaptive network controls
- Resilient and adaptive waveforms

Positioning, Navigation, and Timing (PNT) Technologies

- Diversified PNT-enabling technologies for users and systems in airborne, space-based, terrestrial, subterranean, and underwater settings
- Interference, jamming, and spoofing detection technologies, algorithms, analytics, and networked monitoring systems
- Disruption/denial-resisting and hardening technologies

Quantum Information and Enabling Technologies

- Quantum computing
- Materials, isotopes, and fabrication techniques for quantum devices
- Quantum sensing
- Quantum communications and networking
- Supporting systems

Semiconductors and Microelectronics

- Design and electronic design automation tools
- Manufacturing process technologies and manufacturing equipment
- Beyond complementary metal-oxide-semiconductor (CMOS) technology
- Heterogeneous integration and advanced packaging
- Specialized/tailored hardware components for artificial intelligence, natural and hostile radiation environments, RF and optical components, high-power devices, and other critical applications
- Novel materials for advanced microelectronics
- Microelectromechanical systems (MEMS) and Nanoelectromechanical systems (NEMS)
- Novel architectures for non-Von Neumann computing

Space Technologies and Systems

- In-space servicing, assembly, and manufacturing as well as enabling technologies
- Technology enablers for cost-effective on-demand, and reusable space launch systems
- Technologies that enable access to and use of cislunar space and/or novel orbits
- Sensors and data analysis tools for space-based observations
- Space propulsion
- Advanced space vehicle power generation
- Novel space vehicle thermal management
- Crewed spaceflight enablers
- Resilient and path-diverse space communication systems, networks, and ground stations
- Space launch, range, and safety technologies