ERDC MP-22-1

US Army Corps
of Engineers®
Engineer Research and
Development Center

USACE Research and Development Strategy

Communication Products

U.S. Army Corps of Engineers

January 2022

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Engineer Research and
Development Center

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USACE Research and Development Strategy

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U.S. Army Corps of Engineers

Headquarters
Washington, DC 20314

Final report

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Prepared for Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314

Under USACE R&D Program

Abstract

This paper provides the U.S. Army Corps of Engineers (USACE) communication products sent by LTG Scott A. Spellmon to help as we discuss the first USACE Research and Development Strategy. The USACE R&D Strategy was approved at the 1Q22 EGM in Atlanta, and is now ready for fielding, communicating, and implementing.

The materials included here are (1) The USACE R&D Strategy, (2) USACE R&D Strategy Slide Deck, (3) USACE Top 10 R&D Priorities 2-pager, (4) USACE Top 10 R&D Priorities Placemat.

The USACE R&D Strategy Slide Deck has several examples of R&D products and capabilities, aligned with the Top 10 R&D Priorities, for your use. Please add to these examples with your own, highlighting past R&D success stories as well as the need for future potential R&D.

The original materials are available online at the following link.
https://usace.contentdm.oclc.org/digital/collection/p16021coll11/id/5457

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1 USACE R&D Strategy

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U.S. Army Corps of Engineers

RESEARCH & DEVELOPMENT STRATEGY

US Army Corps of Engineers®

Laying the Foundation for a New Bold Era of USACE R&D

November 2021

US Army Corps of Engineers®

USACE
Research & Development Strategy

Developed in conjunction with
The Water Institute of the Gulf

THE WATER INSTITUTE OF THE GULF®

https://www.usace.army.mil/

Cover Images: USACE is advancing science and technology to address complex 21st century challenges such as harmful algal blooms, drought, and the changing character of war. Inside cover image: Engineers demonstrate flight landing strip crater repair.

The U.S. Army Corps of Engineers (USACE) has a trusted history of developing innovative solutions to the Nation's toughest engineering challenges. Since 1775, Army Engineers have reduced risks for disasters, enabled commerce, strengthened national security, and supported our military's ability to defend the homeland.

To continue to meet the evolving and increasingly complex engineering challenges facing the Nation and the world, USACE Research & Development (R&D) must evolve as well. Bold action is needed to solve the challenges of today and tomorrow through rapid advancements in science and technology.

This Research & Development Strategy, a first for USACE across all mission sets, catapults us into a bold era of R&D that is strategic, collaborative, proactive, and challenge-focused.

We cannot simply "build our way" out of these challenges. While today's priorities are clear, tomorrow's may not be. R&D, when done strategically and collaboratively with partners within the federal government and beyond, can identify innovative and cross-disciplinary solutions with applications across priority areas as they evolve over time. Strategic R&D done now can also prevent operational and tactical needs from becoming mission critical in the future, as well as act as a force multiplier to save money, time, and effort by coordinating research for tomorrow's challenges spanning a range of applications.

This Strategy lays out a new programmatic approach to R&D to elevate R&D's role within USACE and increase our value to the Nation. The USACE Research & Development Program built from this Strategy will continuously identify future challenges for research needs, focus on collaborative application of R&D across mission areas and external to USACE, encourage broad engagement and leadership in the global R&D community, and commit USACE to being a key partner for whole-of-government action.

The future of R&D at USACE is bright and exciting! USACE is founded on an ecosystem of innovative problem-solvers—from the Districts and Divisions, to Headquarters, to R&D laboratories and researchers across and integrated throughout the Corps of Engineers. By executing this R&D strategy, USACE will - in collaboration with stakeholders and partners - take R&D to the next level to nimbly solve the toughest engineering challenges facing the Nation, both now and into the future.

Building Strong!

LTG Scott A. Spellmon
55th Chief of Engineers
Commanding General, USACE

The Strategy identifies the current **Top Ten USACE R&D Priorities** to address the Nation's toughest challenges with multi-disciplinary solutions.

- Mitigate and Adapt to Climate Change
- Win Future Wars
- Modernize Our Nation's Infrastructure
- Support Resilient Communities
- Enable Smart and Resilient Installations
- Ensure Environmental Sustainability and Resilience
- Secure Reliable Installation Energy
- Revolutionize and Accelerate Decision-Making
- Improve Cyber and Physical Security
- Protect and Defend the Arctic

USACE is a nationally and globally recognized leader in developing and testing new technology in research areas such as blast protection. This expertise – established through a broad spectrum of research to meet civilian and warfighter needs – has made Soldiers safer while helping defend military installations, governmental buildings, and critical infrastructure from terrorist attack.

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1 The Greatest Challenges of Today and Tomorrow Require Integrated Engineering Solutions

The USACE vision is to provide engineering solutions to our Nation's toughest challenges. For 245 years, USACE has continuously risen to meet the challenges of the day, and today is no exception. But the challenges of today and tomorrow are not like yesterday's. From droughts and wildfires across the western states, to harmful algal blooms in Florida and the Great Lakes, to increasingly frequent disasters faced by communities across the country, to the evolving nature of international warfare, 21st century challenges are increasingly complex and interconnected.

Climate change is intensifying many of our Nation's toughest challenges at home and abroad, and other priority challenges have compounding effects on our Nation's communities, economy, and environment. Building Strong in the face of today's and tomorrow's challenges demands building differently.

Proactive innovation and strategic investment in interdisciplinary research and development (R&D) is paramount for success. While near- and mid-term tactical and operational R&D remains important to support USACE needs in the field as they arise, increased far-term strategic R&D investment is critical to continued delivery of the USACE mission and vision into the future.

The **Top Ten R&D Priorities** in this section will drive the USACE Research & Development Program. These priorities are challenge-focused, identifying critical areas of need where USACE can provide the greatest value to the Nation with innovative science and engineering solutions.

Case studies throughout this section highlight examples where USACE is already developing innovative and impactful solutions that can be further expanded upon in support of each of these priorities.

As a Nation, we cannot afford to approach these challenges in silos. Taking a programmatic approach to R&D, USACE will continuously identify opportunities where science and technology in support of one priority may be adapted for another. Working together with federal and academic partners, USACE will also ensure that engineers are at the table with researchers from other disciplines to ensure integrated solutions to these complex challenges are collaboratively developed.

Strategic R&D investment is a force multiplier. Successful outcomes in each priority area will be measured in two ways: how well they support the advancement of national priorities and how they enable USACE to deliver its mission more efficiently and effectively (faster, cheaper, stronger, safer, smarter).

Flooding from hurricanes in coastal communities like Norfolk, Virginia, is expected to worsen with sea level rise. USACE efforts, such as the Risk Quantification for Sustaining Coastal Military Installation Assets and Mission Capabilities that included Norfolk and Hampton Roads, identify flood-prone areas to help communities prepare.

Dixie Fire in Plumas National Forest, California.

Mitigate and Adapt to Climate Change

Advancing National Priorities:

Net Zero Greenhouse Gas Emissions by 2050. The White House has set a goal for the country to reach net zero by 2050, in line with the Paris Agreement and other international climate change agreements.

Delivering the USACE Mission:

Adapt installations and infrastructure to **reduce destructive impacts of climate change.**

Climate change and extreme weather are pervasive existential threats requiring innovation and mobilization on an unprecedented scale. Nearly one in three Americans lives in a county or state impacted by a federal disaster declaration in 2021 alone, and approximately two in three Americans have experienced a multiday heat wave this year. As a world-class engineering organization, USACE is key to any national response to climate change. This includes accelerating the national energy transition to renewable and zero-carbon energy, sequestering greenhouse gas emissions, developing and constructing projects to defend communities from the impacts of extreme weather, and improving our national understanding of, and adaptation to, risks and hazards.

To meet this challenge, USACE R&D will focus on the following:

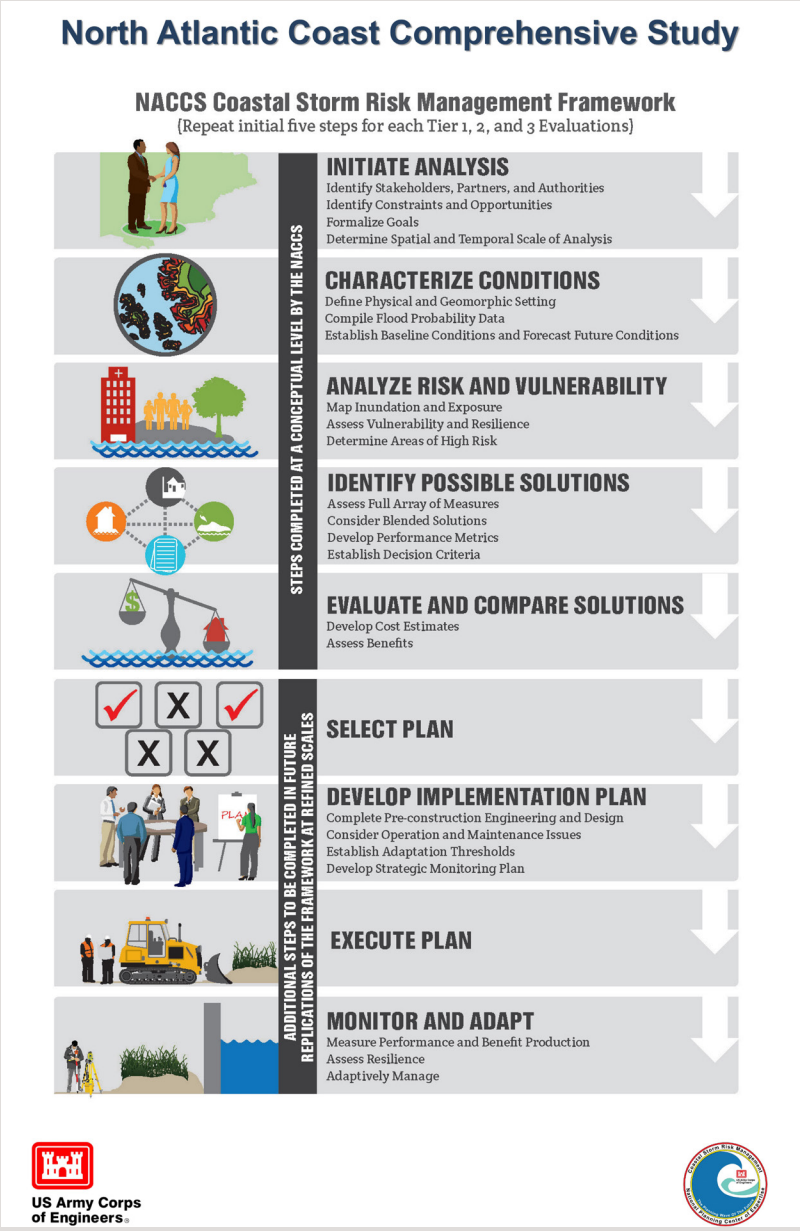
- **Adapt to a changing environment and the impacts of increasingly extreme weather at home and abroad.** USACE research will prioritize adaptation strategies that protect DoD missions, communities, and critical infrastructure from relative sea level rise, floods, coastal storms, drought, extreme heat, and other impacts from climate change.
- **Advance innovative practices to mitigate DoD greenhouse gas (GHG) emissions.** USACE research will develop new practices for mitigation including enhanced land management techniques, as well as other materials and methods that maximize GHG sequestration while minimizing emissions.
- **Support resilient and renewable energy production.** Reducing GHG emissions will require R&D to advance the implementation and benefits of renewable energy like hydropower, solar, and wind to meet the growing energy needs of our Nation and the DoD.

Understanding the Risks of Climate Change: Actionable Information for Robust Preparation

One of the key needs for adapting to climate change is **understanding the future challenges facing the Nation** at the time and spatial scales needed for action. To provide the foundation for mitigating these risks, USACE quantifies the danger that climate-related threats - such as tropical storms, wildfires, and droughts - pose to military installations, civilian communities, and the Nation's infrastructure.

Coastal Studies

Within the civilian domain, USACE has predicted the risk that storms, sea level rise, and other hazards pose to coastal communities and infrastructure through regional studies such as the North Atlantic Coast Comprehensive Study and ongoing South Atlantic Coastal Study and similar local studies such as the Greater DC Metro Coastal Study.



Army Climate Assessment Tool

To support military operations, USACE has developed the Army Climate Assessment Tool and Defense Climate Assessment Tool, which use data from across federal agencies to predict future climate-related threats to military installations.

Photo: Wildfires threaten Camp Pendleton in southern California.

Win Future Wars

Advancing National Priorities:

Advance the National Defense Strategy (NDS). The DoD has developed the NDS as a road map for the U.S. to maintain its competitive edge over global adversaries.

Delivering the USACE Mission:

Align with Army Modernization Priorities. The Army Modernization Strategy enables readiness on the ever-changing world stage.

USACE R&D support for Soldiers begins with tools like Engineered Resilient Systems for planning equipment acquisitions and Map Based Mission Planning Systems for rapidly updating operations plans.

The military must be prepared to engage enemies by land, sea, air, space, and cyberspace. New technology and the dawn of the information age has changed the character of war: future conflicts will occur at longer range and greater speed than ever before. American troops must understand their environment and adversaries and be nimble enough to rapidly respond to evolving threats. USACE provides the innovation, creativity, and entrepreneurship to prepare the military for the conflicts of today and tomorrow.

To meet this challenge, USACE R&D will focus on the following:

- **Develop engineering and geospatial technologies that transform our warfighter's ability to WIN in Multi-Domain Operations.** USACE research will develop tools to mount a coordinated response to adversaries across all theaters and environments.
- **Ensure decisive advantage in mission command, intelligence, force protection, force projection, maneuver, maneuver support, fires, logistics, and sustainment.** USACE research will advance all aspects of American warfighter activities, from the first stages of mission planning through the last phases of combat.

Service members are protected by innovations such as rapidly deployable Modular Protective Systems to shield troops from attacks, while offensive capabilities are preserved through advancements such as Expedient and Expeditionary Airfield Damage Repair to bring damaged runways back online faster than ever before.

Modernize our Nation's Infrastructure

Advancing National Priorities:

Support rebuilding aging and inadequate infrastructure.

Delivering the USACE Mission:

Reduce unscheduled navigation infrastructure downtime by 25%.

Extend service life of existing and future infrastructure by 50%.

The country's infrastructure is rapidly deteriorating. Dams, levees, and other structures are at or beyond their originally expected lifespans, even as climate change, population growth, and other stressors increase demands on these systems. USACE will develop new materials and practices, advanced maintenance and construction techniques, innovative data analysis and computer models, and other approaches to ensure America's infrastructure is resilient and supports the economy of tomorrow.

To meet this challenge, USACE R&D will focus on the following:

- **Develop and deploy more efficient and resilient engineering solutions in materials science, construction techniques, and advanced inspection technologies.** These advances in building and renovating infrastructure will ensure reliability into the future.
- **Improve risk analysis, performance forecasting, and modeling approaches for existing and new infrastructure.** Upgrading infrastructure is expensive and time consuming. Innovative analysis techniques allow investments to be prioritized based on the most pressing needs.

Advancing Engineering Solutions

Although many of tomorrow's challenges require interdisciplinary solutions, new technology will still be needed. Developing engineering solutions is a unique USACE strength within the federal government and the agency will continue to provide leadership to the R&D community. These improvements can prevent catastrophes through advancements such as Structural Health Monitoring, sensors that warn of potential dam failures, and the Multifunctional Assessment Reconnaissance Vehicle (MARV), which can inspect and create a 3D computer model of damaged structures in hours. These technologies can also save lives by using robotics to perform dangerous tasks, such as the Robotic Assessment of Closure Gates for Safe Entry (DamBot) that uses an autonomous vehicle to ensure dam gates and tunnels are safe for personnel, and ARMOR1 that installs Mississippi River revetments without putting lives at risk.

Support Resilient Communities

Advancing National Priorities:

Ready the Nation for catastrophic disasters. USACE supports implementation of the Federal Emergency Management Agency (FEMA) Strategic Plan.

Delivering the USACE Mission:

Predict water levels and flow in all watersheds 50x faster and 50x more accurately to support infrastructure risk reduction.

A community's quality of life is tied to the natural environment. Communities face increasing challenges in reducing risk from climate-related disasters such as floods and droughts, maintaining commerce vital to the economy, supplying drinking water to a growing population, and preserving local ecosystems. These issues are magnified for communities of color, Indigenous peoples, and other marginalized groups that must overcome longstanding social and environmental injustice. Through science and technology to improve engineering solutions for flood risk reduction, reservoir management, and more, USACE can position communities for a better, safer future.

To meet this challenge, USACE R&D will focus on the following:

- **Develop advanced predictive models and tools to support integrated water resource management and proactive disaster prevention or mitigation.** These tools enable proactive preparation rather than reactive response, increasing safety and reducing costs.
- **Develop new approaches for improved emergency response and multi-purpose risk reduction infrastructure that make communities safe while adding social and environmental benefits.** Through tools to support a holistic approach to water management, USACE R&D enables a "win-win" of reduced risks and maximum gains.
- **Develop geospatially enabled, data-driven tools to better assess community vulnerabilities and support more equitable and environmentally just decision making.** These methods enable equitable delivery of the USACE mission by supporting robust evaluation of the unique risks and challenges facing each community.

Safeguarding Communities: Disaster Preparation and Response

The devastating impacts of floods, droughts, wildfires, and other emergencies continue to increase. USACE R&D provides innovative solutions that enable communities to actively prepare for disasters that, combined with a rapid response when they occur, save lives and property. For example, USACE has developed numerical models to predict the complex movement of flood waters in regions impacted by wildfires, enabling targeted evacuations when needed. Similarly, the Coastal Storm Modeling System predicts coastal storm impacts to allow for communities to minimize the impacts of deadly storm surge and destructive coastal erosion. Through these and other innovations, USACE supports the Federal Emergency Management Agency (FEMA) as a ***key partner in the whole-of-government effort for disaster response.***

Wildfire raging in central Florida

Hurricane Ida flooding in coastal Louisiana

Water release at Lake Mendocino, California

Innovating Solutions for Water Resource Management

Reservoirs in the United States supply millions of people with drinking water and recreational opportunities every year, while also being managed to reduce flood risk and minimize negative impacts to ecosystems. USACE has recognized a need for new research into holistic water management that does not rely exclusively on infrastructure construction, including developing tools that enable smarter and more nimble infrastructure operations. For example, Forecast Informed Reservoir Operations (FIRO) uses environmental data and advanced weather forecasting to better manage water releases and retention. Understanding reservoir level changes before the first drop of water hits the ground helps to conserve water for communities while protecting citizens from flooding risks.

Enable Smart and Resilient Installations

Advancing National Priorities:

Improve Soldier and family **quality of life.**

Delivering the USACE Mission:

Achieve outcomes of the Army Installations Strategy.

The Army's greatest strength is its people, and to recruit and retain the best, the force's installations must keep pace with civilian infrastructure and support a modernized formation. USACE will help develop advanced technologies and analytical capabilities in facilities and support infrastructure, integrating 'smart' features that save money and energy while making installations more resilient to risks and hazards.

To meet this challenge, USACE R&D will focus on the following:

- **Develop and integrate advanced technologies to modernize military installations and enhance their strategic readiness.** USACE will enable the Installation of the Future, lowering life-cycle costs through adaptive design, construction, and operations.
- **Promote resilient installations by using a coordinated approach to energy, water, and waste management.** Technologies and processes to integrate installation energy, water, and waste operations will improve efficiency, independence, and resource conservation.

Hospital facility upgrades at Fort Irwin, California

Building Installations of the Future

In addition to facing the same challenges as civilian cities to meet the needs of Soldiers and their families, military installations must always be mission-ready. USACE R&D enables installations to operate as robustly and cost-effectively as possible through advancements such as the BUILDER™ Sustainment Management System, which uses infrastructure condition data and predicted performance to determine where to focus maintenance and avoid costly breakdowns. This information can be used by the Virtual Testbed for Installation Mission Effectiveness (VTIME), a centralized tool for supporting operations and optimizing maintenance investments. USACE R&D can also improve the lives of civilians through tools such as the Small Arms Range Noise Assessment Model (SARNAM), which allows practice ranges to be designed to reduce noise in nearby communities.

Ensure Environmental Sustainability and Resilience

Advancing National Priorities:

Enable the *America the Beautiful* national call to action to conserve and restore lands, waters, and wildlife.

Delivering the USACE Mission:

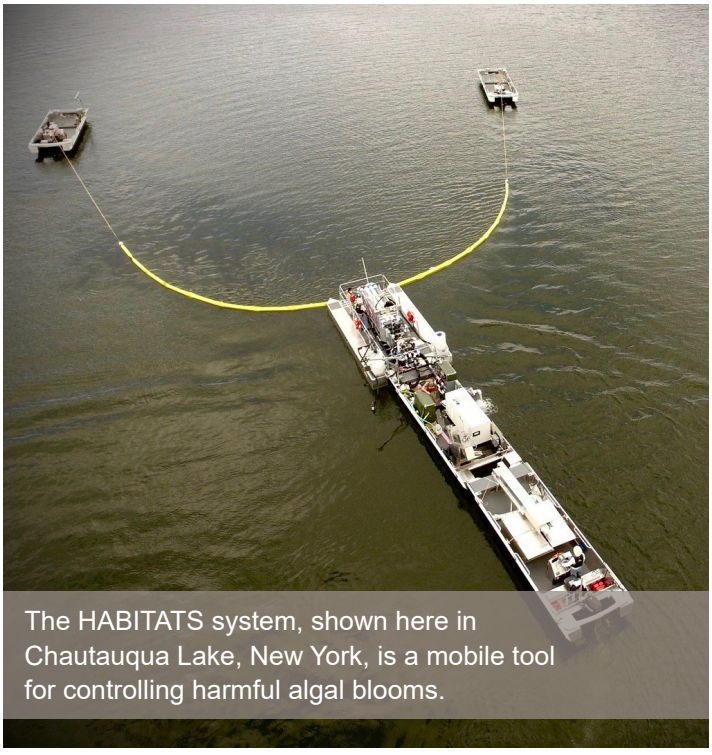
Reduce impacts from harmful algal blooms and invasive/ nuisance species on USACE projects by 50%.

Use over 70% of the **sediment dredged from navigation channels for environmental benefit.**

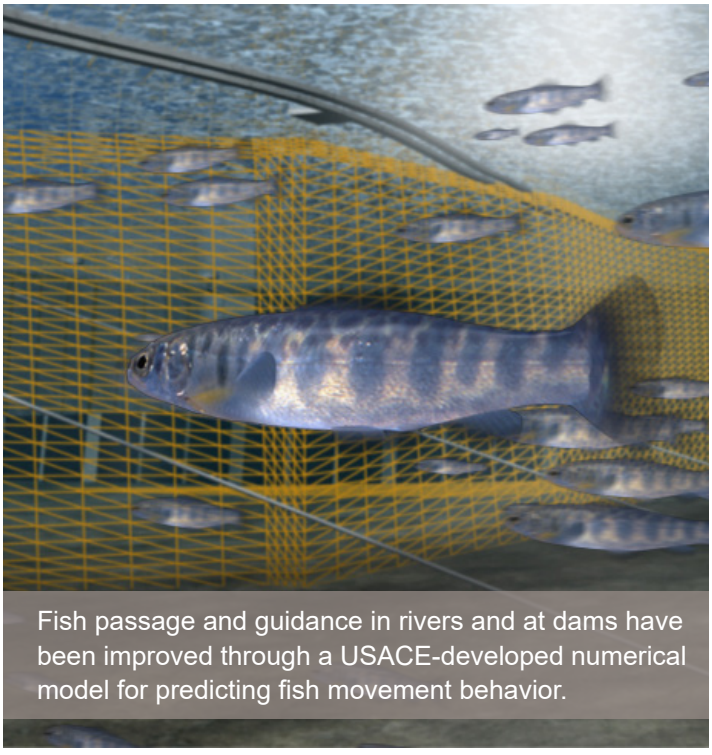
In addition to leading ecosystem restoration activities throughout the country, USACE can support communities, commerce, and the Armed Forces through its other mission areas while minimizing potential harm to sensitive ecosystems. USACE R&D is a key component of guiding design and execution of projects that maximize benefit to local habitats and species. The Corps develops innovative technologies and approaches that improve and sustain the health and resilience of ecosystems and, in many cases, have application and benefit far beyond USACE.

To meet this challenge, USACE R&D will focus on the following:

- **Innovate holistic approaches to aligning Civil Works projects with ecosystem benefits, such as Engineering with Nature©.** The Corps will develop methods to use dredged sediment and other materials to restore habitat while reducing the risks to life and property from hazards like floods.
- **Generate innovative technologies to reduce the impacts of harmful algal blooms (HABs), nuisance species, and toxic wastes.** USACE research will provide effective methods and tools to control the spread of invasive/nuisance species, reduce/manage the impacts of HABs and their toxins, and minimize and contain the threat of emerging contaminants to protect our Nation's water resources and the environment.



The HABITATS system, shown here in Chautauqua Lake, New York, is a mobile tool for controlling harmful algal blooms.



Fish passage and guidance in rivers and at dams have been improved through a USACE-developed numerical model for predicting fish movement behavior.

Engineering with Nature®

Engineering with Nature® (EWN) is an approach being pioneered by USACE in which engineering solutions are designed to utilize natural systems. The initiative supports the environment while also benefiting communities. For example, an EWN approach to reducing the risk of storm surge to communities might include building coastal dunes or planting marsh vegetation. Many EWN solutions rely on placing sediment, creating a win-win of using material dredged from navigation channels.

1) Habitat restoration along the Buffalo River in New York. 2) Sand is pumped onto Ship Island, Mississippi. 3) Site visit for navigation channel deepening and beneficial use of dredge in Nueces County, Texas.

In addition to developing new approaches for EWN, USACE R&D includes testing and quantifying its benefits. At sites as diverse as Tyndall Air Force Base, Florida; Mobile, Alabama; San Francisco, California; St. Louis, Missouri; Galveston, Texas; Buffalo, New York; and Philadelphia, Pennsylvania, new approaches are studied and being implemented. Based on the results at these and similar locations, USACE will develop guidance documents that can be used by the Corps, federal and state government, and communities implementing nature-based solutions.

The Corps' EWN investment extends well beyond studies and guidance. Throughout USACE, Districts have developed innovative ways to design and execute EWN approaches in practice. For example, USACE leads the Mississippi Coastal Improvements Program (MSCIP) to restore portions of the coast that were devastated by Hurricane Katrina in 2005. The Corps has coordinated dozens of researchers and practitioners from across the public and private sector to develop and implement a comprehensive plan for restoring the Mississippi coast that relies on EWN approaches including beach, dune, and marsh restoration.

Secure Reliable Installation Energy

Advancing National Priorities:

Improve mission and installation energy reliability by 10x.

Delivering the USACE Mission:

Achieve outcomes of the Army Installations Strategy.

Energy transformation is a cornerstone of adapting to climate change. Military installations and missions must transform their energy systems and move from carbon-intensive fuels toward zero-carbon energy while increasing resilience and grid independence. As hazards like extreme heat, hurricane winds, and ice storms intensify and test the strength of electrical grids, USACE will provide renewable and resilient energy for Army installations that improves national security and validates approaches for electrical grids across the Nation.

To meet this challenge, USACE R&D will focus on the following:

- **Deliver reliable energy at military installations and critical missions, powered by carbon-free energy.** USACE will improve energy system robustness, including availability, reliability, flexibility and redundancy, and efficiency to reduce disruptions and greenhouse gas emissions.
- **Improve energy efficiency and independence by deploying sensors, advanced battery technology, microgrids, and energy conservation technologies.** These technologies strengthen energy system performance and enable grid independence. Once proven at installations, these technologies support energy systems nationwide.

Developing Next Generation Solutions for Energy Needs

Civilian communities, military installations, and warfighters share challenges accessing reliable and safe power sources. USACE has leveraged its R&D expertise to address this need with technology that delivers resilient power and reduces greenhouse gas emissions.

For example, the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) program demonstrates that microgrids integrating renewable power sources—with potential application for civilian communities—could benefit installations with increased reliability and higher fuel efficiency. For the warfighter, USACE R&D is supporting the development of safe and reliable hybrid power systems and next generation small nuclear power systems that can be rapidly deployed by truck or aircraft to provide power as needed in the field.

Revolutionize and Accelerate Decision-Making

Advancing National Priorities:

Support the goals of the National A.I. Research Resource Task Force. This White House initiative aims to provide a roadmap to innovation and drive economic prosperity.

Delivering the USACE Mission:

Minimize planning, engineering, design, construction, and operational costs, and safety risks.

Increase operational success by accelerating decisions to the speed of relevance.

To respond to increasingly interconnected challenges, decision makers must use interconnected datasets to model impacts on the environment faster and more accurately than ever before. USACE has recognized the power that "big data" analysis, machine learning, artificial intelligence, computer simulations, autonomy, and robotics have brought to the modern era and seen the opportunity to revolutionize operations within and beyond its mission areas.

To meet this challenge, USACE R&D will focus on the following:

- **Develop data-driven decision support technologies that leverage advanced artificial intelligence, machine learning, computer simulations, and autonomous robotic systems.** USACE research targets tools that can reduce costs, streamline operations, and improve decision-making through automation and data analysis.

Mobile Information Collection Application (MICA)

This USACE smartphone app allows disaster damage data to be collected in the field, saving time that can be used instead to expedite relief on the ground.

Predictive Maintenance Analytics (PMA)

USACE R&D has developed a technique using sensors on helicopters to predict when oil coolant maintenance is needed, saving time and money. A major benefit of using innovative machine learning techniques is that they are highly adaptable. The Corps has used the same PMA approach to analyze data from dams for on-demand maintenance to be conducted only when needed, as opposed to performing scheduled maintenance at prescribed intervals, thereby reducing the need for costly shutdowns of hydropower operations.

Improve Cyber and Physical Security

Advancing National Priorities:

Advance the U.S. cyber security strategy. This White House initiative aims to secure the Nation from cyber threats.

Delivering the USACE Mission:

Accelerate the detection of and response to cyber security incidents from months to minutes. Rapid detection and response are critical to preventing costly and disruptive shutdowns.

Domestic terrorists and foreign enemies have long recognized the devastating impacts of shutting down the Nation's critical infrastructure. These threats now go beyond physical incidents to include sophisticated, equally disruptive cyber attacks, such as the 2021 Colonial Pipeline attack. Through innovations in risk detection and reduction, and leveraging expertise from warfighter support, USACE R&D helps ensure infrastructure remains safely online and meets the needs of civilians and the military alike.

To meet this challenge, USACE R&D will focus on the following:

- **Develop physical and cyber secure solutions that minimize the threat to installations and infrastructure.** USACE will advance tools and techniques that make infrastructure more resilient to potential attacks.
- **Advance control systems that quickly mitigate potential attacks.** USACE research will develop methods for identifying attacks and innovate solutions to repel them before damage occurs and operations are disrupted.

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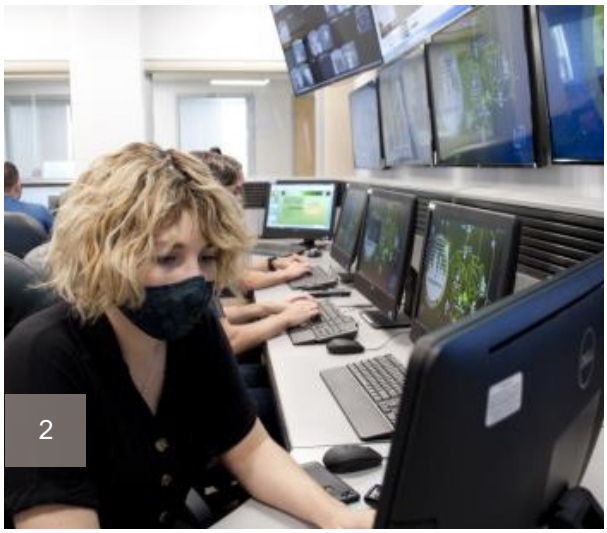
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1) The USACE Aggressor Vehicle Entry Readiness Technology (AVERT) is a rapidly deployable, portable barrier for stopping hostile vehicles.
2) USACE conducted over 100 Cooperative Vulnerability Assessments with stakeholders such as U.S. Central Command (CENTCOM) and the Department of Homeland Security (DHS) to ensure cyber security was robust despite the challenges of the COVID19 pandemic.

Protect and Defend the Arctic

Advancing National Priorities:

Maintain **U.S. Arctic dominance.**

Delivering the USACE Mission:

Achieve outcomes of the Army's and DoD's Arctic Strategy.

The Arctic is a geostrategic region undergoing significant environmental and geopolitical changes. As the Arctic ice melts, competition for resources and influence in the region increases. The Corps will lead federal efforts to understand and adapt to changes in permafrost, snow and ice cover, landscape cover, and ecosystem changes to advance science and engineering solutions promoting mission resilience, military operations, and navigation across the Arctic region and other extreme environments around the world.

To meet this challenge, USACE R&D will focus on the following:

- **Develop science and engineering solutions for the Arctic and other extreme environments that mitigate impacts to ecosystems and infrastructure while helping to protect the homeland.** USACE R&D will bring resources critical for protecting these fragile landscapes while supporting our national security objectives.

Addressing the Challenges of an Extreme Environment

The Arctic and other extreme environments around the world present unique challenges for the military and civilians alike. Existing technology may not be resilient to extreme cold, while a warming climate impacts permafrost and creates an ever-changing environment on the ground. USACE R&D advancements in mapping, modeling, construction, and other technologies ensure that operations can be maintained. For example, USACE developed the Phoenix snow runway construction technologies to support National Science Foundation research missions in Antarctica. In addition, USACE R&D developed the Traverse Route Assessment technology using satellite imagery to rapidly detect dangerous crevasses and other threats and safely route people and supplies around them.

2 Laying the Foundation for a New Bold Era of USACE R&D

Over the past 100 years, the greatest advancements in USACE R&D have been driven by the toughest challenges facing our Nation at the time. During periods of great national and global challenge, USACE has responded with innovative engineering solutions for the public good.

The Nation and the world are once again facing a period of unparalleled challenges that demand renewed bold action and innovation from one of the world's premier public engineering organizations. The past 100 years have laid the foundation for a new era of USACE R&D that will proactively address the complex and interconnected challenges of the 21st century.

Responding to Disasters

In response to a series of major disasters including the Great Mississippi Flood of 1927, Congress authorized the Waterways Experiment Station (WES) in the Flood Control Act of 1928. WES became the first-of-its-kind national civil engineering laboratory where the organization identified and addressed research needs, spearheaded multiple advances in hydraulic engineering, and worked with colleagues in the USACE Districts and Divisions to operationalize advancements to reduce flood risk. The establishment of WES marked the formalization of R&D within USACE and a long-term commitment to developing engineering solutions to mitigate disaster risk.

Photo: Outdoor hydraulic model at WES.

Responding to the War Effort

R&D efforts were significantly advanced in response to World War II and the Cold War. Wartime research included military projects relating to topography/aerial mapping, blast and weapons effects, airfields and pavements, combat engineering, mobility, and navigational equipment. WES provided critical assistance towards war preparations. In addition, the development of the Cold Regions Research and Engineering Laboratory (CRREL) in 1961 broadened research of wartime construction in cold climates. Scientific and technological advancements in this era helped save lives and also paved the way for continued scientific research moving forward.

Photo: Airfield matting developed at WES during WWII.

Responding to the Environment

During the 1970s, increased concern for environmental issues resulted in new environmental laws and regulations. In response, USACE labs, including the Coastal Engineering Research Center (CERC) and the Construction Engineering Research Laboratory (CERL), conducted an array of ecological and climate research, as the challenges of this time could only be solved by using science to understand human impacts to the environment. Innovations within USACE allowed for important advancements in pollution mitigation, alternative energy, dredge material research, and natural resources management. Following the Clean Water Act, expansion of R&D into the broad world of environmental sciences led to the formation of the Environmental Laboratory in the 1970s and introduced an important opportunity for USACE to respond to the key environmental challenges then, now, and into the future.

Photo: Aquatic plant control chamber at WES Environmental Lab.

Responding to Efficiency Demands

The 1990s brought national demands for greater efficiency in government—from a changing fiscal environment, to increasing needs for rapid deployment on the battlefield, to a shift towards an operations and maintenance focus in Civil Works. In response, USACE R&D laboratories were merged under the newly established Engineer Research and Development Center (ERDC) in 1998. ERDC enabled the USACE labs to share research facilities and support functions, reduce costs, and provide a coordinated response to engineering needs. A primary focus since the 1990s has been on tactical and operational R&D, addressing needs that arise in the field. This has included applying advancements in technology to streamlining Civil Works operations and maintenance and to the rapid expansion of R&D to support the military, including in Installations and Operational Environments and Warfighter Support. Constraints on R&D resources for strategic and operational support in these areas, however, limit the ability of USACE R&D to respond to growing 21st century challenges in a coordinated way that prepares for the operational and tactical needs of tomorrow.

Photo: The Air Automated Route Reconnaissance Kit in use during training exercises in Honduras.

Responding to the Complex Challenges of the 21st Century: A Need for a New Bold Era of USACE R&D

The increasingly complex and interconnected challenges of today and tomorrow, detailed in the previous section, demand a renewed bold response by USACE to develop innovative and integrated engineering solutions. This new era for bold R&D will require increased and long-term resources, improved collaboration across disciplines and agencies, and greater global scientific and technological leadership. USACE is poised to do this, building on the existing foundation of innovators in its research labs, Districts, and Divisions. Elevating the USACE Research & Development Program, as detailed through four strategies in the following section, will be essential to responding with the boldness required to solve the greatest challenges of today and tomorrow.

Photo: USACE pumped sand onto the beach at Brigantine, NJ. This project included an Engineering with Nature® approach of placing sand that could protect the community while also providing beach habitat and recreational opportunities.

3 Strategies for Elevating a Robust USACE Research & Development Program

Advancing world-class science and engineering solutions in the Top Ten R&D Priorities necessitates a shift in how investments in science and technology are made and operationalized at USACE.

A strategic USACE Research & Development Program, coordinated across research facilities, Divisions, and Districts and supported by dedicated funding and resources, will enable USACE to proactively prepare for challenges well before they happen, find synergies and efficiencies across priorities and mission areas, and work with partners to deliver the kind of bold interdisciplinary solutions that the challenges of today and tomorrow demand.

A robust, sustained USACE Research & Development Program will make every dollar spent go further in delivering value to the Nation. Investment in strategic R&D will help solve tomorrow's operational and tactical needs - for USACE Districts and Divisions, as well as the warfighter - before they become critical, and enable faster, cheaper, safer, and smarter mission delivery. Through partnerships, collaboration, and coordination, these advancements will support the entire federal government and beyond in facing shared challenges.

The following four strategies, detailed throughout this section, will provide the necessary framework to deliver a bold and disciplined USACE Research & Development Program that best positions our Nation to serve as a global engineering leader for the 21st century.

1 **Continuously Examine** Future Challenges for Research Needs

2 **Focus on Collaborative Application of R&D** Across Portfolios, Mission Areas, and External to USACE

3 **Encourage Broad Engagement and Leadership** in the R&D Community

4 **Commit to USACE as a Key Partner** for Whole-Of-Government Action

Continuously Examine Future Challenges for Research Needs

The best time to start solving tomorrow's problems is before they become issues; sometimes it is only possible to overcome the challenges of today because of investments in science and technology from decades ago.

A strategic USACE Research & Development Program will continuously predict future challenges, identify the science and technology needed to help solve them, and scale those capabilities for widespread application across USACE mission areas, the military, and beyond.

Investing in challenge-focused R&D will help USACE, the Army, and other federal agencies reframe and improve how projects are designed and built so that they innovatively respond to complex 21st century challenges. Success will be measured not just by how advanced capabilities enable USACE to deliver its mission more efficiently and effectively, but also with consideration for broader social, economic, and environmental benefits that support the advancement of national priorities.

Challenge-focused R&D begins with the Top Ten R&D Priorities identified based on the greatest engineering challenges facing the Nation today. But while today's challenges are clear, tomorrow's may not be. As part of the new programmatic approach, USACE will regularly re-evaluate the biggest challenges facing the agency and the Nation to identify innovative solutions to problems before they become mission critical.

Proactively Addressing the Threat of Environmental Contaminants

Keeping Soldiers safe requires rapid and effective detection of environmental contaminants, whether they are natural pollutants or created as part of a biochemical attack. USACE addressed this challenge through the development of Mobile Environmental Contaminant Sensors. Recognizing the threat that contaminants also pose to civilians, this technology has become the basis of an environmental toolkit that has been deployed all over the United States and the world. Proactive challenge-focused R&D can protect both Soldiers and civilians.

Focus on Collaborative Application of R&D across Portfolios, Mission Areas, and External to USACE

How science and technology are delivered, applied, and improved upon to solve real world problems is a key component of a successful USACE Research & Development Program. Achieving wider application of USACE R&D will involve innovative technologies, but also innovative processes and collaborations.

USACE researchers will work together with project managers, construction managers, workers, and other practitioners to identify research applications and collaborate on solutions. Technologies proven in one context (such as the battlefield) will be tested and applied in other contexts (such as domestic emergency response). This process of extending the reach of scientific and technological advancements across USACE will also reach to state and federal partners. USACE's engineering for the public good will pursue needs and challenges and learn from external applications and iterations of USACE research.

Where successful collaboration exists today, it is often on the researcher-to-researcher or researcher-to-practitioner level. A coordinated USACE Research & Development Program will provide the supportive structure to build on those successful relationships, while institutionalizing collaboration in a way that sustains the capability through staff turnover and accelerates development and application of technological and scientific advancements. Far from a zero-sum game, strategic R&D will be a force multiplier—saving money, time, and effort by coordinating research for tomorrow's challenges across a range of applications.

Leveraging Expertise

The Mini Robotic Submersible-Dredge (MRS-D) was developed by the military for digging out and removing underwater sediment to support amphibious assaults, but it can also be used for water resource management applications, such as navigation channel maintenance. A coordinated R&D program will enable USACE to expand and institutionalize similar applications of capabilities across mission areas, greatly increasing the benefits to warfighters and civilians alike.

Encourage Broad Engagement and Leadership in the R&D Community

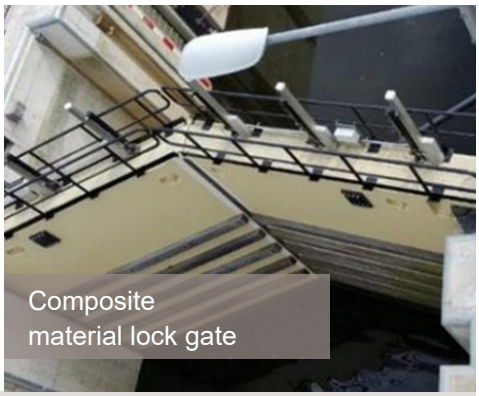
A strategic, forward-looking USACE Research & Development Program will enable the Corps of Engineers to recommit to national and global leadership for the entire discipline and profession of engineering: from working with others across agencies and borders, to publishing and presenting research, and encouraging USACE engineers to innovate at every level.

As a world-class engineering organization for the public good, USACE is uniquely positioned to serve as a global engineering innovator in its mission areas and core capacities. At the same time, engagement in the R&D community at large allows the agency to benefit from and adapt innovations from across the public, private, and academic sectors. This complementary collaboration will capitalize on the strengths of each partner, such as scientific or technical expertise, access to federal resources, flexibility, technology, or other capabilities.

This collaborative spirit of innovation will extend throughout USACE, into the Divisions and Districts. USACE engineers will have the opportunity to develop new foundational concepts, and work through a strategic USACE Research & Development Program to collaborate with private and public sector partners as well as universities and research institutes.

Additive Construction

Ultra high-performance concrete panel



Composite material lock gate

Advancing Materials Science and Engineering

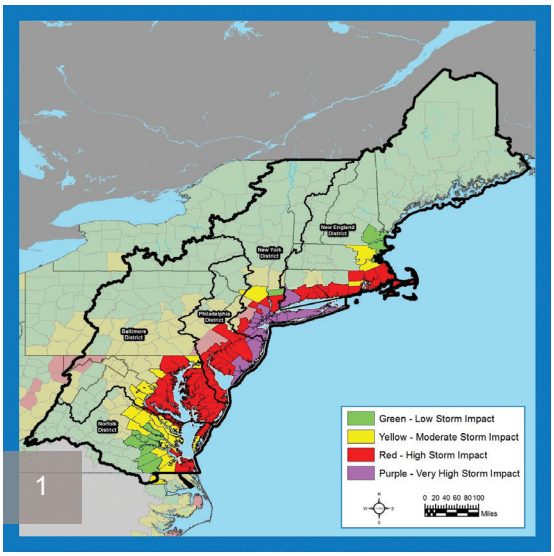
Managing infrastructure on the Nation's navigable waterways has made USACE a technological leader in novel construction materials and techniques that are longer-lasting, more economical, and require less maintenance than the status quo. For example, USACE has created new ultra high-performance concrete and composite materials for repairing or replacing navigation locks that last longer than traditional choices and can save millions of dollars. Many of these advancements stem directly from USACE expertise built through programmatic R&D investment by the Army into warfighter support, such as large-scale Additive Constructive (3D printing) technology that can build buildings, bunkers, and other infrastructure using locally available materials.

Commit to USACE as a Key Partner for Whole-of-Government Action

Many of our Nation's toughest challenges of today and tomorrow demand bold engineering innovation. However, they cannot be solved through engineering alone, and none of these challenges can be overcome solely through the action of a single government agency.

A whole-of-government response - such as the Administration's call to address the existential challenge of climate change - is essential to addressing the great needs of today and tomorrow. USACE will collaborate across the federal government (including across the Departments of Defense, Interior, Commerce, and beyond) to combine engineering with other disciplines to create innovative, integrated solutions to our national challenges.

To meet the scale of the challenges, collaboration across the federal government and with states and local partners must become faster and nimbler. The USACE Research & Development Program will contribute to integrated science and engineering solutions, but will also develop processes, governance, and communications that will speed collaboration and implementation. This new mode of R&D will ensure that USACE can lead in its core mission areas while providing the flexibility to partner across the government in innovative ways.

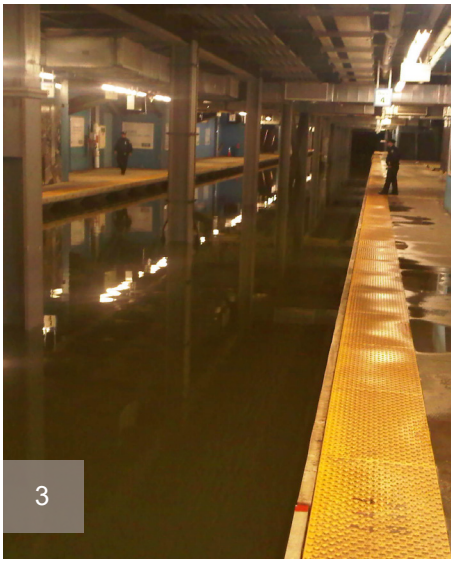


1

1) The USACE North Atlantic Coast Comprehensive Study, and a similar ongoing study in the South Atlantic, use data from multiple federal agencies to predict the risk of storms and other hazards on coastal communities and support a whole-of-government response to this climate-related threat.

2) Hurricane Sandy was the largest Atlantic hurricane on record and caused the most damage in New York and New Jersey. Over 100 houses burned to the ground in Breezy Point, New York as floodwaters isolated the community from firefighters. 3) Flooded New York City subway system.

2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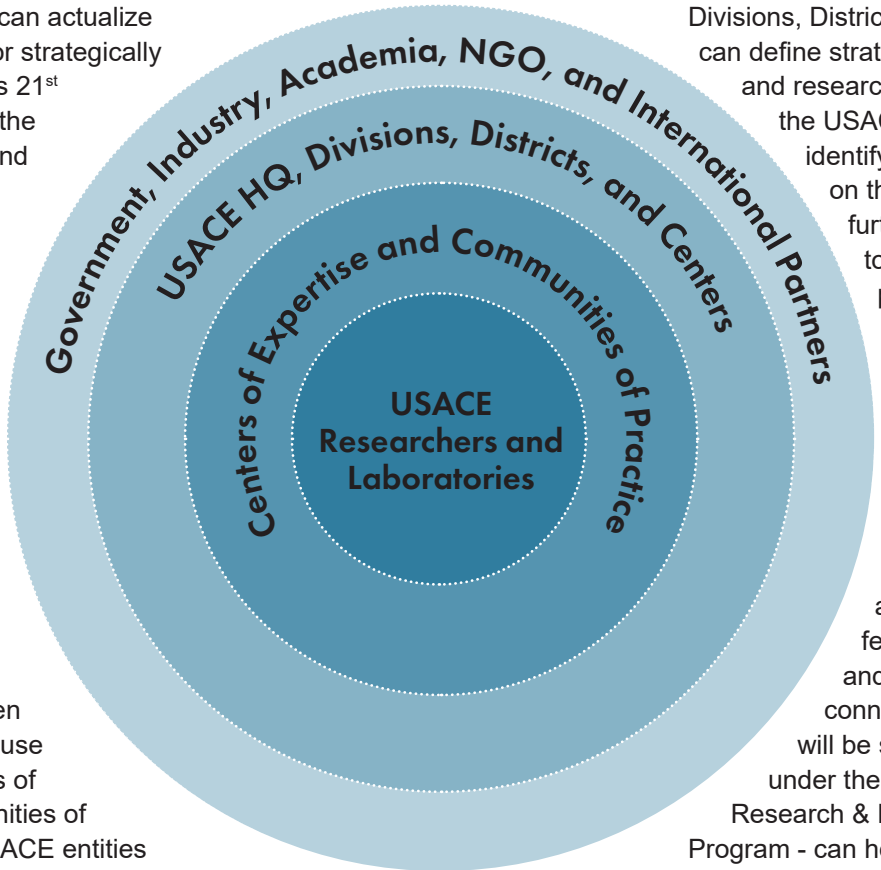
4 The Future for USACE R&D in Meeting the Nation's Challenges

Overcoming the challenges of today and tomorrow demands that USACE has the nimbleness, flexibility, and continuity that is secured through a sustained USACE Research & Development Program. For this shift to occur, however, there must be confidence that USACE - as good stewards of public investment and trust - can deliver.

The USACE R&D Ecosystem

USACE has spent decades building an R&D ecosystem that programmatic support can actualize into a cohesive force for strategically addressing the Nation's 21st century challenges. At the core are researchers and developers throughout USACE at sites and laboratories including the U.S. Army Engineer Research and Development Center (ERDC), Huntsville Engineering Center, and Institute for Water Resources, which can leverage expertise developed in addressing tactical and operational needs. The connection between research and practical use is facilitated by Centers of Expertise and Communities of Practice, which are USACE entities that support transitioning the latest planning, design, techniques, methods, and technologies into Corps projects worldwide.



Leadership and practitioners within USACE Headquarters, Divisions, Districts, and Centers can define strategic technological and research needs to deliver the USACE mission, identify new challenges on the horizon, and further enable R&D to transition to practice. Outside the organization, USACE has built connections to stakeholders and partners throughout the Army and Armed Forces, civilian agencies in the federal government, and beyond. These connections – which will be strengthened under the USACE Research & Development Program - can help USACE define strategic research directions and ensure today's technological outputs enable transformational outcomes for tomorrow.

The Path Forward: *Strategy Implementation*

Research and development to prepare the Nation for the challenges of today and tomorrow will be conducted within and across the four USACE R&D portfolios. Connections between these portfolios – and the leveraging that can be conducted across them– is enabled through a USACE Research & Development Program that allows investment to be targeted to include strategic areas that can benefit multiple interests. For example, strategic investment into Engineering with Nature® approaches for mitigating environmental threats exacerbated by climate change, such as relative sea level rise, can enhance the resilience of civilian infrastructure and military installations alike.

1 Civil Works

Research and development within this portfolio enhances USACE's ability to execute its Civil Works (CW) missions to support commercial navigation; restore, protect and manage aquatic ecosystems; and reduce flood risk. Innovations are particularly focused on improving CW projects by reducing implementation times; improving resilience in the face of climate change and other challenges; and maximizing benefits to the economy, ecosystem quality, and public health and safety as part of an integrated water resources management approach.

2 Installations and Operational Environments (IOE)

The focus of this R&D portfolio is improving the reliability, efficiency, and effectiveness of military infrastructure at installations and on the battlefield. Innovations support execution of the Army Modernization, Installation, and Innovation Strategies, and provide the infrastructure enhancements needed to ensure success in multi-domain operations. This portfolio includes improvements in military construction technology, capacity and resource planning, and minimizing negative impacts of military infrastructure to the environment and communities.

3 Warfighter Support

USACE conducts scientific research and development to improve all aspects of mission planning, preparation, execution, and sustainment, including providing innovations to protect the safety of troops. USACE focuses on R&D that can advance Army modernization priorities, ensure battlefield dominance, and prepare the Armed Forces for changes to the character of war. This work benefits and supports numerous entities including Combatant Commands, Army, Department of Defense, and other federal agencies that support the warfighter.

4 Support for Others

As the Nation's premier public engineering and environmental sciences organization, USACE often supports the delivery of projects and programs for other federal, state, and local agencies as well as private sector and international partners. This USACE R&D portfolio is highly diverse and includes providing engineering and construction services; environmental restoration and management services; research and development assistance; water and land related natural resources management, disaster relief and recovery work; national security R&D; and other management and technical support.

Catalyzing *the Full Potential of the Corps of Engineers through the USACE Research & Development Program*

The USACE R&D ecosystem has proven that it can address targeted needs as part of broad, whole-of-government action when given the opportunity to do so, such as the ground-breaking research made and implemented in storm risk reduction under the Hurricane Sandy Disaster Supplemental.

USACE has also proven time and again that the agency can meet the needs of the warfighter through strategic, sustained, systematic R&D. Many of the technologies shown throughout this document illustrate how USACE innovators have leveraged capabilities and capacities across civilian and military projects alike, built upon their success, and engaged with the R&D community at large to address specific needs.

These targeted advancements clearly demonstrate that USACE can multiply the value provided to the Nation through R&D that bridges projects and portfolios. Sustained, multiyear support for the USACE Research & Development Program will be critical to providing the reliable resources needed to institutionalize successes like these and magnify the benefits to an enterprise scale, enabling the Nation to take a proactive approach to meeting the complex challenges of today and tomorrow head on.

Supporting USACE and the Research Community with Laboratories and Field Sites

USACE is an R&D leader through it's state-of-the-art facilities. These sites include the Permafrost Tunnel Research Facility in Fox, Alaska, an underground tunnel that explores microbial threats and increases understanding regarding the changing Arctic region.

In Duck, North Carolina, the Field Research Facility has made coastal communities and infrastructure more resilient - and military operations more successful - by hosting hundreds of studies that support tools for predicting and mitigating the impacts of storms and relative sea level rise.

ERDC's seven laboratories in Vicksburg, Mississippi; Champaign, Illinois; Hanover, New Hampshire; Alexandria, Virginia; and elsewhere support a wide range of research areas that span from blast protection to Mississippi River management strategies. These facilities – and many others across the country and abroad – support critical R&D throughout USACE and beyond.

Permafrost Tunnel Research Facility, Fox, Alaska

Field Research Facility, Duck, North Carolina

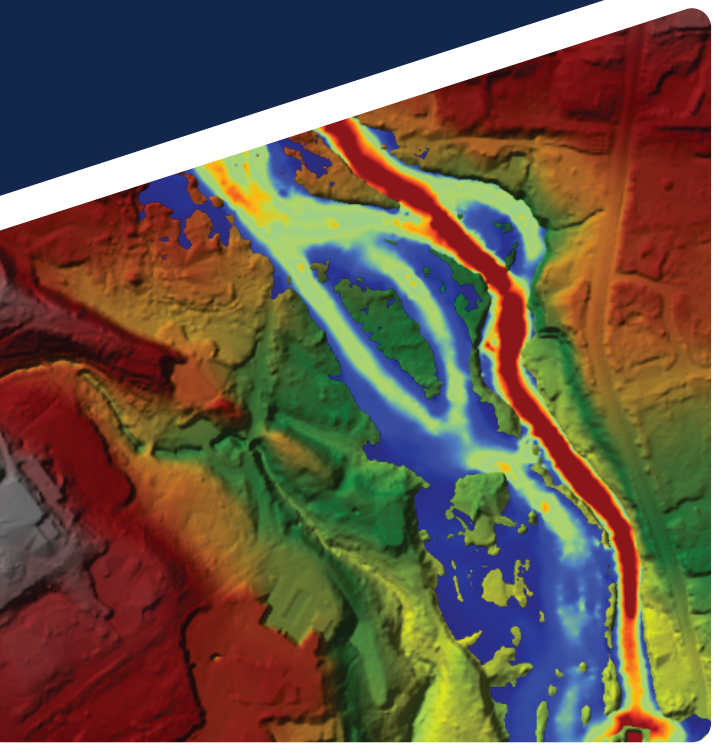
US Army Corps of Engineers®

USACE
Research & Development Strategy

Developed in conjunction with
The Water Institute of the Gulf

THE WATER INSTITUTE OF THE GULF®

https://www.usace.army.mil/



2 USACE R&D Strategy Slide Deck

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DRAFT

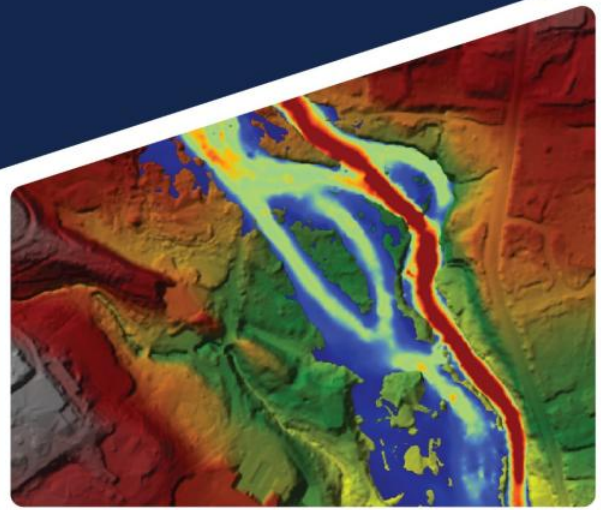
U.S. Army Corps of Engineers

RESEARCH & DEVELOPMENT STRATEGY

SPEAKER
Speaker's Title

Event
Date

US Army Corps of Engineers



Laying the Foundation for a New Bold Era of USACE R&D

DRAFT

US Army Corps of Engineers

U.S. Army Corps of Engineers

RESEARCH & DEVELOPMENT STRATEGY

Laying the Foundation for a New Bold Era of USACE R&D

SPEAKER
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Event
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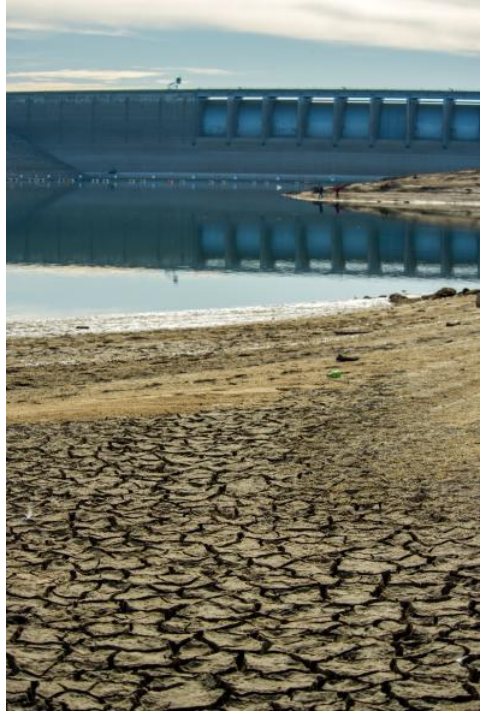
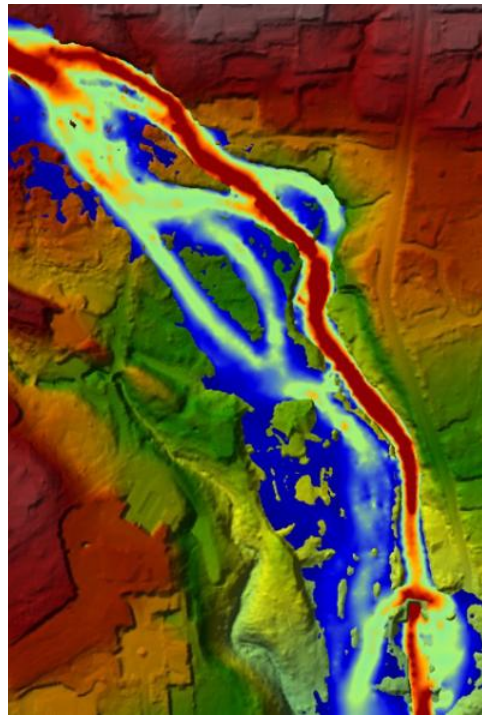




Background & Need

- USACE has **trusted history of innovation**
- Today's challenges require **new approach to R&D:**
  - Cannot "build our way out"
  - Need for sustained, strategic R&D
- Establish a comprehensive strategy for the **USACE Research & Development Program:**
  - Collaborative, proactive, and challenge-focused
  - Identifies today's **Top Ten R&D Priorities**
  - Provides a framework for programmatic R&D
  - Elevates USACE value to the Nation

LTG Scott A. Spellmon
55th Chief of Engineers
Commanding General, USACE

The USACE Research & Development Program

- Sustained and strategic R&D support is a **force multiplier** for increasing value to the Nation
- Tomorrow's operational & tactical needs can be addressed **before they become mission critical**
- Enables **faster, cheaper, safer, smarter, and effective** delivery of the USACE mission and support for the military
- Partnerships, collaboration, and coordination **supports the entire federal government and beyond** in facing shared challenges.

TOP TEN
R&D Priorities

The greatest challenges of today and tomorrow require integrated engineering solutions.

1 **Mitigate and Adapt to Climate Change**

2 **Win Future Wars**

3 **Modernize our Nation's Infrastructure**

4 **Support Resilient Communities**

5 **Enable Smart and Resilient Installations**

6 **Ensure Environmental Sustainability and Resilience**

7 **Secure Reliable Installation Energy**

8 **Revolutionize and Accelerate Decision Making**

9 **Improve Cyber and Physical Security**

10 **Protect and Defend the Arctic**

1 Mitigate and Adapt to Climate Change

Advancing National Priorities:

Net Zero Greenhouse Gas Emissions by 2050

Delivering the USACE Mission:

Adapt installations and infrastructure to **reduce destructive impacts of climate change**

Dixie Fire in Plumas National Forest, California

To meet this challenge, USACE R&D will focus on the following:

- Adapt to a changing environment and the impacts of increasingly extreme weather at home and abroad
- Advance innovative practices to mitigate DOD greenhouse gas emissions
- Support resilient and renewable energy production

BUILDING ON R&D SUCCESS:

Actionable Climate Information for Robust Preparation

Wildfires threaten Camp Pendleton in southern California

Army Climate Assessment Tool (ACAT) and Defense Climate Assessment Tool (DCAT)

- Military installations must remain online and operational despite future climate-related threats
- ACAT and DCAT quantify the risk of climate-related disasters such as storms, wildfires, and drought
- Information provided at the scale needed for targeted preparation to mitigate future impacts

2

Win
Future Wars

Advancing National Priorities:

Advance the **National Defense Strategy**

Delivering the USACE Mission:

Align with **Army Modernization Priorities**

USACE R&D support for Soldiers begins with tools like Engineered Resilient Systems for planning equipment acquisitions

To meet this challenge, USACE R&D will focus on the following:

- Develop engineering and geospatial technologies that transform our warfighter's ability to WIN in Multi-Domain Operations
- Ensure decisive advantage in mission command, intelligence, force protection, force projection, maneuver, maneuver support, fires, logistics, and sustainment

BUILDING ON R&D SUCCESS:

Rapidly Deployable Protection on the Battlefield

Modular Protective Systems are rapidly deployable, portable shelters that can shield troops from attack

Modular Protection Systems (MPS)

- Equipment supporting Soldiers in the field must be lightweight and rapidly deployable
- Modular protective systems can be quickly assembled by a handful of personnel without special tools or equipment
- Specific MPS include elevated guard towers, overhead protection units for mortar and rocket protection, and panel construction walls for shielding from small arms fire

3 Modernize Our Nation's Infrastructure

Advancing National Priorities:

Support rebuilding aging and inadequate infrastructure

Delivering the USACE Mission:

Reduce scheduled navigation downtime **by 25%**

Extend service life of existing and future infrastructure **by 50%**

DamBot uses an autonomous vehicle to ensure dam gates and tunnels are safe for personnel

To meet this challenge, USACE R&D will focus on the following:

- Develop and deploy more efficient and resilient engineering solutions in materials science, construction techniques, and advanced inspection technologies.
- Improve risk analysis, performance forecasting, and modeling approaches for existing and new infrastructure.

BUILDING ON R&D SUCCESS:

Safely Assessing Critical Infrastructure

DamBot being deployed for infrastructure inspection.

Robotic Assessment of Closure Gates for Safe Entry (DamBot)

- USACE dams require frequent inspection to assess maintenance needs
- DamBot is an amphibious, semi-autonomous robotic vehicle that can inspect dam gates and tunnels
- Helps keep human lives safe by preventing personnel from entering potentially dangerous areas

4 Support Resilient Communities

Advancing National Priorities:

Ready the Nation for catastrophic disasters

Delivering the USACE Mission:

Predict water levels and flow in all watersheds **50x faster and 50x more accurately** to support infrastructure risk reduction

To meet this challenge, USACE R&D will focus on the following:

- Develop advanced predictive models and tools to support integrated water resource management and proactive disaster prevention or mitigation.
- Develop new approaches for improved emergency response and multi-purpose risk reduction infrastructure that make communities safe while adding social and environmental benefits.
- Develop geospatially enabled, data-driven tools to better assess community vulnerabilities and support more equitable and environmentally just decision making.

BUILDING ON R&D SUCCESS:

Innovative Solutions for Water Resource Management

Water release at Lake Mendocino, California

Forecast Informed Reservoir Operations (FIRO)

- Dam releases must be carefully managed to meet community water needs while also reducing flood risk, a task made challenging by storms and drought
- FIRO uses weather forecasting to predict reservoir level changes before the first drop of water hits the ground
- Enables water releases to be managed for optimal benefits

5 Enable Smart and Resilient Installations

Advancing National Priorities:

Improve Soldier and family **quality of life**

Delivering the USACE Mission:

Achieve outcomes of the Army Installations Strategy

Hospital facility upgrades at Fort Irwin, California

To meet this challenge, USACE R&D will focus on the following:

- Develop and integrate advanced technologies to modernize military installations and enhance their strategic readiness.
- Promote resilient installations by using a coordinated approach to energy, water, and waste management.

BUILDING ON R&D SUCCESS:

Building Military Installations of the Future

Hospital facility upgrades at Fort Irwin, California

Virtual Testbed for Installation Mission Effectiveness (VTIME)

- Military installations must meet the needs of Soldiers and their families while being mission-ready at all times
- VTIME is a tool to support operations and optimize investments in infrastructure maintenance
- Streamlines operations for personnel and reduces costs

6 Ensure Environmental Sustainability and Resilience

Advancing National Priorities:

Enable the **America the Beautiful** national call to action to conserve and restore lands, waters, and wildlife

Delivering the USACE Mission:

Reduce impacts from harmful algal blooms and invasive/nuisance species on USACE projects **by 50%**

Use **over 70%** of the sediment dredged from navigation channels for environmental benefit

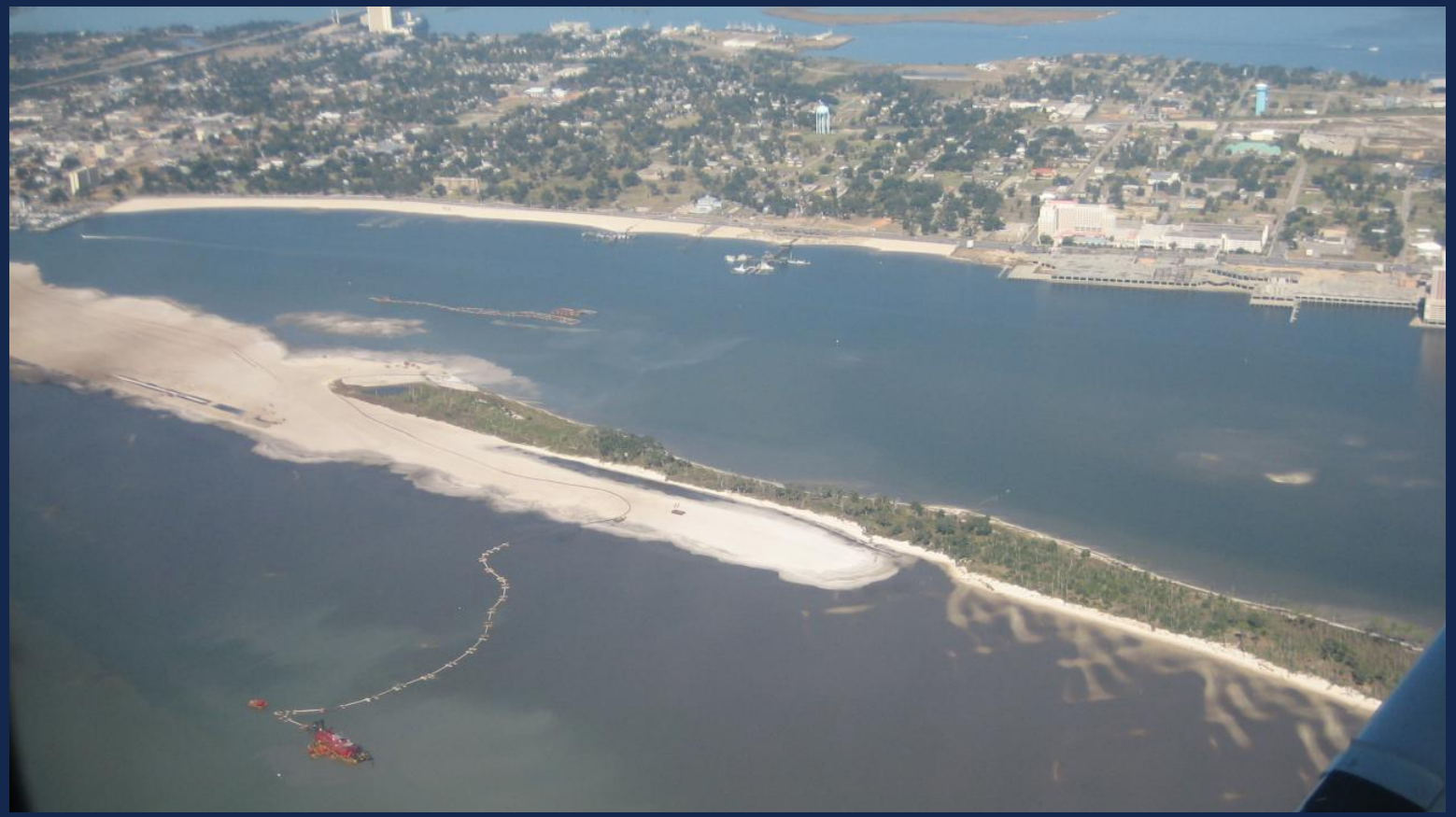
The HABITATS system, shown here in Chautauqua Lake, New York, is a mobile tool for controlling harmful algal blooms

To meet this challenge, USACE R&D will focus on the following:

- Innovate holistic approaches to aligning Civil Works projects with ecosystem benefits, such as Engineering with Nature®
- Generate innovative technologies to reduce the impacts of harmful algal blooms (HABs), nuisance species and toxic wastes

BUILDING ON R&D SUCCESS:

Pioneering Engineering with Nature® Approaches



Dredge material was beneficially used to restore Deer Island, Mississippi as part of an Engineering with Nature® approach

Engineering with Nature® (EWN) and Beneficial Use of Dredge (BUD) Material

- Sediment from navigation channels that would otherwise require costly disposal can be used for ecosystem restoration in my cases
- BUD integrates well with EWN, an approach being pioneered by USACE in which engineering solutions are designed to work with natural systems and processes
- BUD material can be used to build coastal beaches and marshes that provide habitat while also protecting communities from storms

BUILDING ON R&D SUCCESS:

Mitigating the Impacts of Harmful Algal Blooms

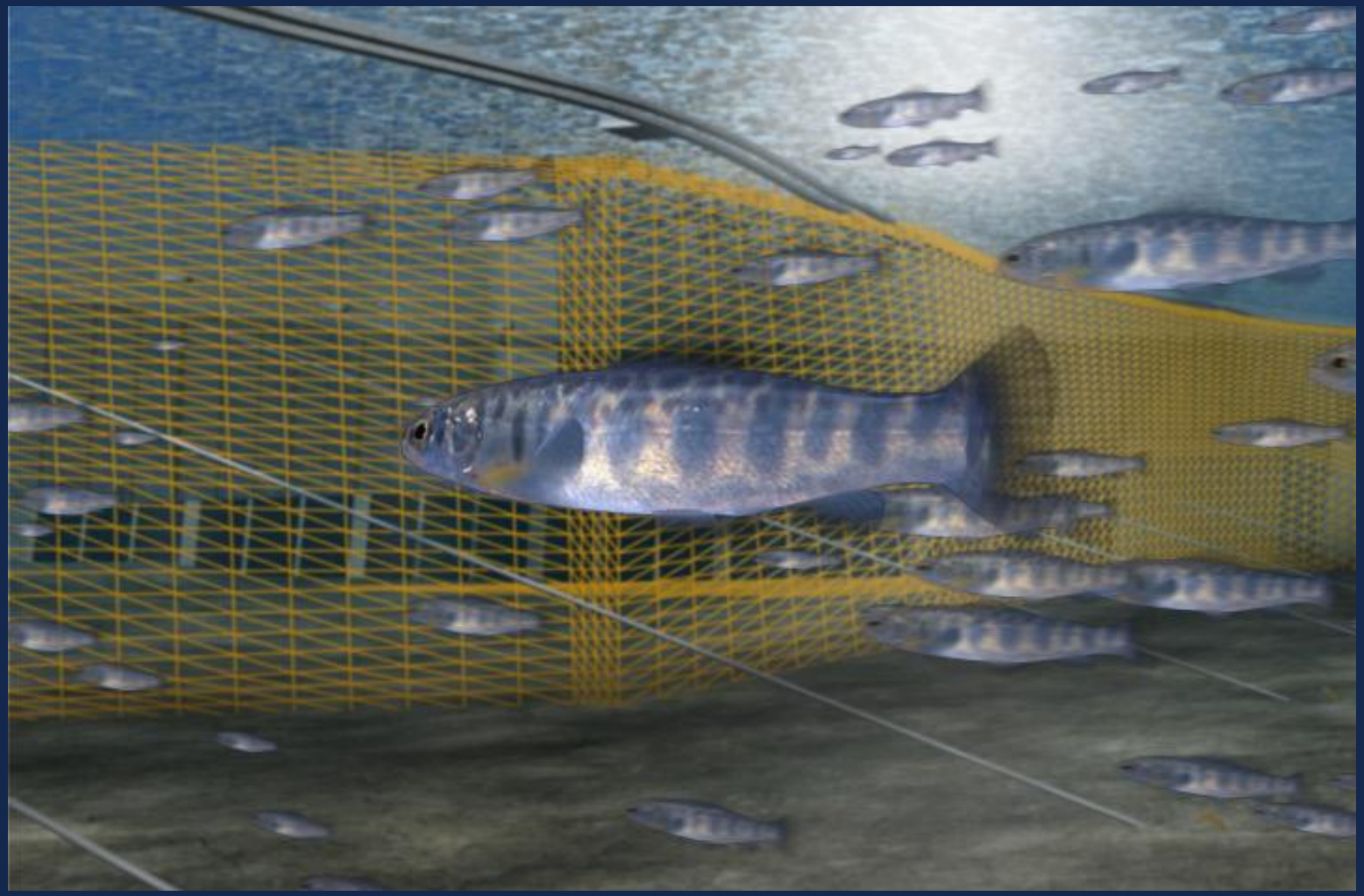
The HABITATS system can help mitigate the impacts of harmful algal blooms.

Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS)

- Harmful algal blooms (HABs) that occur nationwide in lakes and waterways can devastate ecosystems and cause health risks to human communities
- HABITATS can detect, manage, and reduce HAB impacts
- Other benefits include cleaner output than conventional treatments and co-production of biofuel and fertilizer

BUILDING ON R&D SUCCESS:

Protecting Species through Innovative Management



Fish passage and guidance in rivers and at dams have been improved through a USACE developed numerical model for predicting fish movement behavior.

Fish Behavior Modelling

- Waterways management infrastructure like dams can provide impassable barriers to fish species like salmon that must swim up- and downstream rivers as part of their life cycle
- Numerical behavior models predict how species will interact with structures like fish ladders
- Enables fish ladders to be designed to minimize the negative impact of infrastructure on fish populations

7

Secure Reliable Installation Energy

Advancing National Priorities:

Improve mission and installation energy reliability **by 10x**

Delivering the USACE Mission:

Achieve outcomes of the Army Installations Strategy

To meet this challenge, USACE R&D will focus on the following:

- Deliver reliable energy at military installations and critical missions, powered by carbon-free energy
- Improve energy efficiency and independence by deploying sensors, advanced battery technology, microgrids, and energy conservation technologies

BUILDING ON R&D SUCCESS:

Developing Next Generation Energy Solutions

Mobile Nuclear Power Plant vehicle.

Mobile Nuclear Power Plants (MNPP)

- Traditional power require regular refueling, incurring costs and increasing risk to Soldiers in hostile territories
- USACE supporting development of an MNPP, a safe and reliable next generation power source for warfighters
- MNPP would reduce refueling needs and the associated costs and risks to Soldiers

8 Revolutionize and Accelerate Decision Making

Advancing National Priorities:

Support the goals of the **National A.I. Research Resource Task Force**

Delivering the USACE Mission:

Minimize planning, engineering, design, construction, and operational costs, and safety risks

Increase operational success by accelerating decisions to the speed of relevance.

To meet this challenge, USACE R&D will focus on the following:

- Develop data-driven decision support technologies that leverage advanced artificial intelligence, machine learning, computer simulations, and autonomous robotic systems

BUILDING ON R&D SUCCESS:

Smarter Maintenance Scheduling

Predictive Maintenance Analytics (PMA)

- Costly preventative maintenance is prevalent across numerous applications including navigational channel dredging, waterway infrastructure, and military equipment
- PMA is an artificial intelligence-based approach to shift the maintenance paradigm from regularly scheduled to as-needed
- Saves money, limits shutdowns and downtimes, and is readily adaptable to new applications as needed

9 Improve Cyber and Physical Security

Advancing National Priorities:

Advance the **U.S. cyber security strategy**

Delivering the USACE Mission:

Accelerate the detection of and response to cyber security incidents **from months to minutes**

To meet this challenge, USACE R&D will focus on the following:

- Develop physical and cyber secure solutions that minimize the threat to installations and infrastructure
- Advance control systems that quickly mitigate potential attacks

BUILDING ON R&D SUCCESS:

Rapidly Deployable Physical Security

AVERT shown stopping a vehicle.

Aggressor Vehicle Entry Readiness Technology (AVERT)

- Military and civilian infrastructure alike face threats from vehicle-based attacks
- AVERT can be deployed in less than 30 minutes, requires no special tools, and can be easily disassembled and reused
- Provides protection and security when permanent defensive systems are impractical or unnecessary

10

Protect and Defend the Arctic

Advancing National Priorities:

Maintain **U.S. Arctic dominance**

Delivering the USACE Mission:

Achieve outcomes of the Army's and DoD's Arctic Strategy

To meet this challenge, USACE R&D will focus on the following:

- Develop science and engineering solutions for the Arctic and other extreme environments that mitigate impacts to ecosystems and infrastructure while helping to protect the homeland.

BUILDING ON R&D SUCCESS:

Addressing the Challenges of an Extreme Environment

Traverse Route Assessment Technology

- Extreme cold weather environments create additional hazards such as dangerous and impassable crevasses
- Traverse Route Assessment Technology uses satellite imagery to detect crevasses and other threats, then route people and supplies around them
- Increases personnel safety and supply chain security

Laying the Foundation for a New Bold Era of USACE R&D

The past 100 years has laid the foundation for a new era of USACE R&D that will proactively address the complex and interconnected challenges of the 21st century.

Responding to Disasters

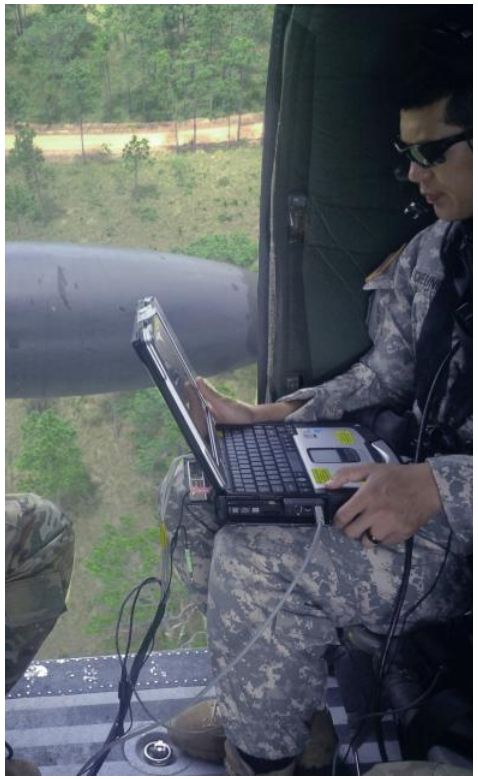
Photo: Outdoor hydraulic model at WES in the 1930s

Responding to the War Effort

Photo: Airfield matting developed at WES during WWII

Responding to the Environment

Photo: Aquatic plant control chamber at WES Environmental Lab (1978-1979)



Responding to Efficiency Demands

Photo: The Air Automated Route Reconnaissance Kit in use during training exercises in Honduras.

Responding to Complex 21st Century Challenges:

NEW BOLD ERA

Strategies for Elevating a Robust USACE Research & Development Program

Advancing world-class science and engineering solutions in the Top Ten R&D Priorities necessitates a shift in how investments in science and technology are made and operationalized at USACE.

1 **Continuously Examine** Future Challenges for Research Needs

2 **Focus on Collaborative Application of R&D** across Portfolios, Mission Areas, and External to USACE

3 **Encourage Broad Engagement and Leadership** in the R&D Community

4 **Commit to USACE as a Key Partner** for Whole-of-Government Action

1 **Continuously Examine** Future Challenges for Research Needs

- The **challenges of tomorrow** may differ from the challenges of today
- USACE will **regularly reevaluate challenges facing the Nation** to identify innovative solutions before they become mission critical

Photo: *Mobile Environmental Contaminant Sensors developed to keep Soldiers safe have also been the basis of an environmental toolkit for civilians deployed all over the U.S. and the world.*

BUILDING ON R&D SUCCESS:

Blast Protection on the Battlefield and at Home

USACE mobile blast protection technology has kept American solders safe in the field.

Blast protection technology incorporated into the Pentagon helped lessen the damage from the 9/11 attacks.

Blast Protection Technology

- Civilian infrastructure and military installations face risks from terrorist attacks
- USACE R&D recognized opportunity to leverage expertise developed through warfighter support
- **A programmatic approach provides USACE with *flexibility* and *adaptability* to identify – and address – the Nation's challenges *before they are mission critical.***

2 **Focus on Collaborative Application of R&D** across Portfolios, Mission Areas, and External to USACE

- Broad application underlies R&D providing the highest possible **value to the Nation**
- **USACE researchers will work together** with project managers, construction managers, workers, and other practitioners to identify research applications and iterate on solutions
- Process will extend to **state and federal partners**

Photo: *Mini Robotic Submersible-Dredge was developed by the military for digging out and removing underwater sediment to support amphibious assaults, but it can also be used for water resource management applications, such as navigation channel maintenance*

BUILDING ON R&D SUCCESS:

Dredging Technology for the Warfighter and Civil Works

Mini Robotic Submersible-Dredge (MRS-D)

- MRS-D developed to remove underwater sediment in support of amphibious assaults
- Same technology can support USACE Civil Works by enabling targeted navigation channel maintenance
- **A programmatic approach institutionalizes leveraging science and technology developed for one need, such as warfighter support, into other applications**

3 Encourage Broad Engagement and Leadership in the R&D Community

- **Integration with the R&D community** enables USACE to lead in areas of strength while also building on external advancements
- **USACE will provide national and global engineering leadership**, working with partners across the public and private sector and sharing research findings for widespread benefit
- Innovation will be encouraged **throughout USACE**

Photo: *Managing infrastructure on the Nation's navigable waterways has made USACE a technological leader in novel construction materials and techniques (such as ultra high-performance concrete) that are longer-lasting, more economical, and require less maintenance than the status quo.*

BUILDING ON R&D SUCCESS:

Advancing Materials Science and Engineering

Additive Constructive Technology (Large-Scale 3D Printing)

- On-site construction technique for buildings, bunkers, and other infrastructure
- Flexible and adaptable to use locally available construction materials
- **A programmatic approach can ensure USACE has access to the latest and greatest technology for warfighter and civilian needs, and that investment in USACE R&D provides the broadest benefit to American taxpayers**

4 Commit to USACE as a **Key Partner** for Whole-of-Government Action

- USACE R&D **must be integrated into whole-of-government action** to prepare the Nation for the challenges of today and tomorrow
- USACE will collaborate across the federal government for **innovative, integrated solutions**.
- The USACE R&D Program will include processes to **support collaboration and implementation**.

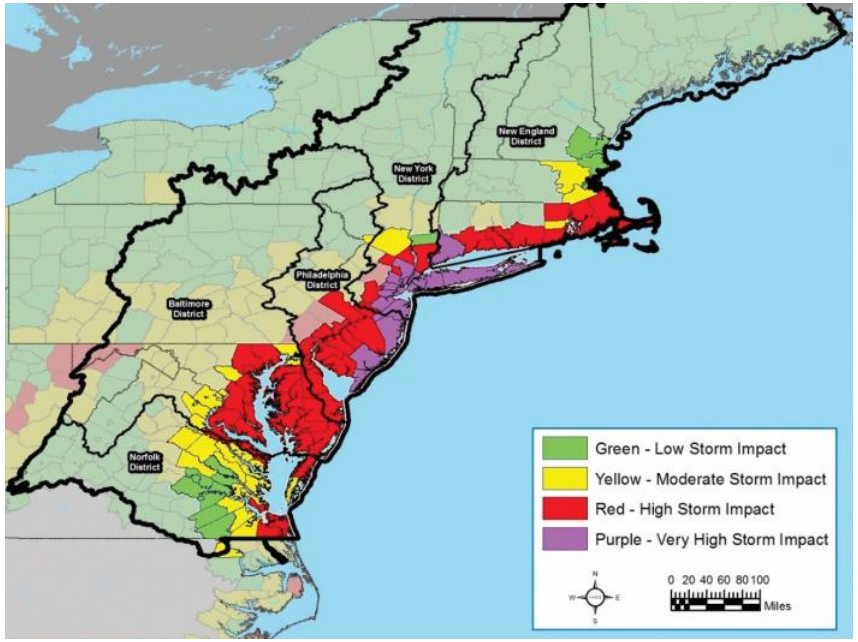


Photo: *The USACE North Atlantic Coast Comprehensive Study, and a similar ongoing study in the South Atlantic, use data from multiple federal agencies to predict the risk of storms and other hazards on coastal communities and support a whole-of-government response to this climate-related threat*

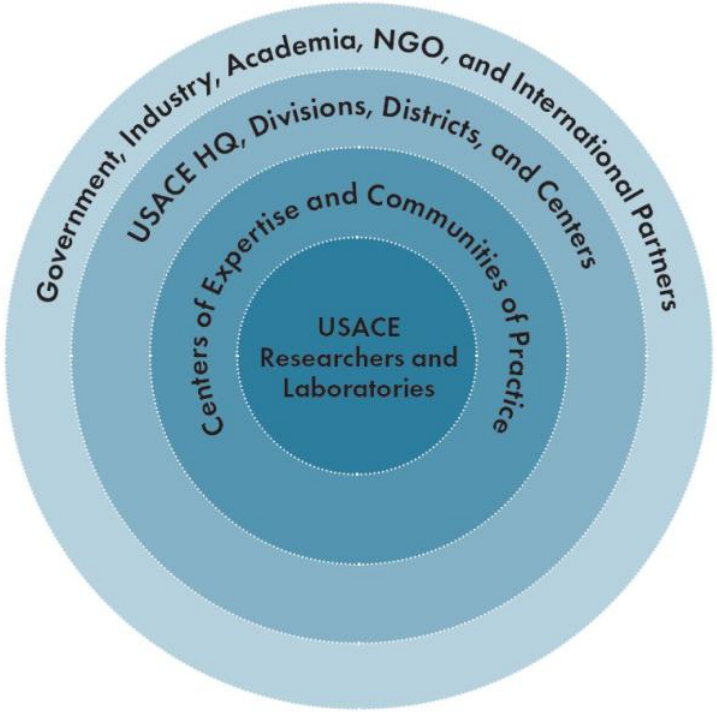
BUILDING ON R&D SUCCESS:

Federal Agency Coordination on Climate Risk

North Atlantic Coast Comprehensive Study
South Atlantic Coastal Study

- Modeling and tools used to predict the future risk that storms and relative sea level risk pose to coastal communities and infrastructure
- Developed in coordination with multiple federal agencies that – along with state and local agencies – can use the outputs
- **A programmatic approach would provide continuity needed to expand coordinated efforts, enabling a whole-of-government response to national challenges like climate change**

The Future for USACE R&D in Meeting the Nation's Challenges



USACE R&D Ecosystem

- Provides a trusted structure through which the Program will be implemented.
- Extends beyond USACE to include the collaborations and partnerships built over years of engineering innovation.

Strategy Implementation

The USACE R&D Program will span and integrate the four research portfolios:

1. **Civil Works**
2. **Installations and Operational Environments**
3. **Warfighter Support**
4. **Support for Others**

NEXT STEP:
Internal and External Communication Strategy

The communication strategy will include:

- **External Communication Materials,** including a placemat overviewing the USACE Research & Development Program; modular slide deck for use in briefings; social media engagement plan; etc.
- **Internal Communication Materials,** including fact sheets, short briefs, or one-page overviews on the USACE Research & Development Program; modular slide deck for internal presentations; etc.

3 USACE Top 10 R&D Priorities

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U.S. Army Corps of Engineers 2021

TOP TEN R&D Priorities

Advancing National Priorities » Delivering USACE Mission

1 Mitigate and Adapt to Climate Change

- Adapt to a changing environment and the impacts of increasingly extreme weather at home and abroad
- Advance innovative practices to mitigate DOD greenhouse gas emissions
- Support resilient and renewable energy production

Net Zero Greenhouse Gas Emissions by 2050 | *White House*

» Adapt installations and infrastructure to **reduce destructive impacts of climate change**

2 Win Future Wars

- Develop engineering and geospatial technologies that transform our warfighter's ability to WIN in Multi-Domain Operations
- Ensure decisive advantage in mission command, intelligence, force protection, force projection, maneuver, maneuver support, fires, logistics, and sustainment

Advance the National Defense Strategy

» **Align with Army Modernization Priorities** | *DOD*

3 Modernize Our Nation's Infrastructure

- Develop and deploy more efficient and resilient engineering solutions in materials science, construction techniques, and advanced inspection technologies
- Improve risk analysis, performance forecasting, and modeling approaches for existing and new infrastructure

Support rebuilding aging and inadequate infrastructure

» **Reduce unscheduled navigation infrastructure downtime** by 25%

» **Extend service life** of existing and future infrastructure by 50%

4 Support Resilient Communities

- Develop advanced predictive models and tools to support integrated water resource management and proactive disaster prevention or mitigation
- Develop new approaches for improved emergency response and multi-purpose risk reduction infrastructure that make communities safe while adding social and environmental benefits
- Develop geospatially enabled, data-driven tools to better assess community vulnerabilities and support more equitable and environmentally just decision making

Ready the Nation for catastrophic disasters | *FEMA Strategic Plan*

» **Predict water levels and flow** in all watersheds 50x faster and 50x more accurately to support infrastructure risk reduction

5 Enable Smart and Resilient **Installations**

- Develop and integrate advanced technologies to modernize military installations and enhance their strategic readiness
- Promote resilient installations by using a coordinated approach to energy, water, and waste management

- Improve Soldier and family **quality of life**
- **Achieve outcomes** of the Army Installations Strategy | *DOD*

6 Ensure **Environmental** Sustainability and Resilience

- Innovate holistic approaches to aligning Civil Works projects with ecosystem benefits, such as *Engineering with Nature*©
- Generate innovative technologies to reduce the impacts of harmful algal blooms (HABs), nuisance species, and toxic wastes

- **Enable the *America the Beautiful*** national call to action to conserve and restore lands, waters, and wildlife
- **Reduce impacts from harmful algal blooms and invasive/nuisance species** on USACE projects by 50%
- Use over 70% of the **sediment dredged from navigation channels for environmental benefit**

7 Secure Reliable Installation **Energy**

- Deliver reliable energy at military installations and critical missions, powered by carbon-free energy
- Improve energy efficiency and independence by deploying sensors, advanced battery technology, microgrids, and energy conservation technologies

- **Improve mission and installation energy reliability** by 10x
- **Achieve outcomes** of the Army Installations Strategy | *DOD*

8 Revolutionize and Accelerate **Decision Making**

- Develop data-driven decision support technologies that leverage advanced artificial intelligence, machine learning, computer simulations, and autonomous robotic systems

- **Support the goals of the National A.I. Research Resource Task Force**
- **Minimize planning, engineering, design, construction, and operational costs, and safety risks**
- **Increase operational success** by accelerating decisions to the speed of relevance

9 Improve Cyber and Physical **Security**

- Develop physical and cyber secure solutions that minimize the threat to installations and infrastructure
- Advance control systems that quickly mitigate potential attacks

- **Advance the US cyber security strategy**
- **Accelerate the detection of and response to cyber security incidents from months to minutes**

10 Protect and Defend the **Arctic**

- Develop science and engineering solutions for the Arctic and other extreme environments that mitigate impacts to ecosystems and infrastructure while helping to protect the homeland

- Maintain **US Arctic dominance**
- **Achieve outcomes** of the Army's and DOD's Arctic Strategy

4 USACE Top 10 R&D Priorities Placemat

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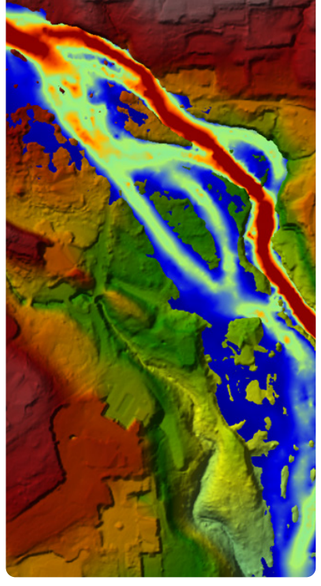
U.S. Army Corps of Engineers

RESEARCH & DEVELOPMENT STRATEGY

Laying the Foundation for a New Bold Era of USACE R&D



U.S. ARMY

US Army Corps of Engineers®

This R&D Strategy catapults USACE into a new bold era of R&D that is ***strategic, collaborative, proactive, and challenge-focused.***

The R&D Strategy

- Identifies the **Top Ten USACE R&D Priorities** to address the Nation's toughest challenges
- Provides a framework for a new **USACE Research & Development Program**
- Positions USACE to **support the needs of the Nation** now and for decades to come

Benefits of the USACE Research & Development Program

- Magnifies the impact of USACE R&D and increases value to the Nation
- Addresses tomorrow's operational & tactical needs before they become mission critical
- Enables faster, cheaper, safer, smarter, and effective delivery of the USACE mission and support for the military
- Supports the entire federal government and beyond in facing shared challenges

The Greatest Challenges of Today and Tomorrow Require Integrated Engineering Solutions

The **Top Ten R&D Priorities** will drive the USACE Research & Development Program. These priorities are challenge-focused, identifying critical areas of need where USACE can provide the greatest value to the Nation with innovative science and engineering solutions.

1 Mitigate and Adapt to **Climate Change**

2 Win Future **Wars**

3 Modernize Our Nation's **Infrastructure**

4 Support Resilient **Communities**

5 Enable Smart and Resilient **Installations**

6 Ensure **Environmental** Sustainability and Resilience

7 Secure Reliable Installation **Energy**

8 Revolutionize and Accelerate **Decision Making**

9 Improve Cyber and Physical **Security**

10 Protect and Defend the **Arctic**

The Foundation for a New Bold Era of USACE R&D

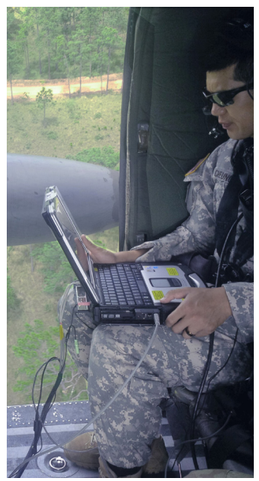
During periods of great national and global challenge, USACE has responded with innovative engineering solutions for the public good. The past 100 years has laid the foundation for a new era of USACE R&D that will proactively address the complex and interconnected challenges of the 21st century.

Responding to Disasters

Responding to the War Effort

Responding to the Environment

Responding to Efficiency Demands



Responding to Complex 21st Century Challenges: *A Need for a New Bold Era of USACE R&D*

Strategies for Elevating a Robust USACE R&D Program

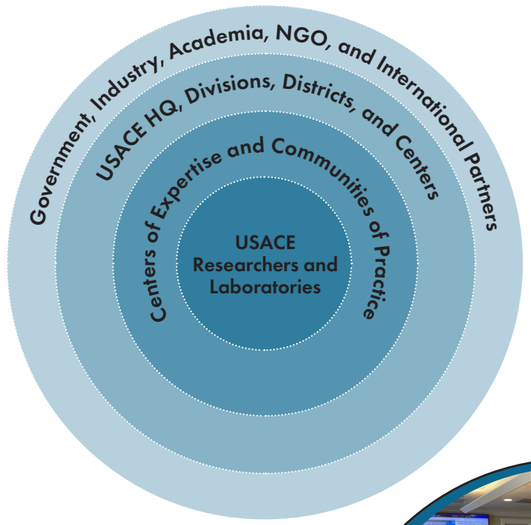
The benefits of programmatic USACE R&D can only be fully realized through **a disciplined approach** founded on forward-looking, challenged-focused innovation; internal coordination; and external partnership and collaboration.

The following strategies will ensure the USACE Research & Development Program delivers for our communities, citizens, and the military now and in the years to come:

1. **Continuously Examine** Future Challenges for Research Needs
2. **Focus on Collaborative Application of R&D** Across Portfolios, Mission Areas, and External to USACE
3. **Encourage Broad Engagement and Leadership** in the R&D Community
4. **Commit to USACE as a Key Partner** for Whole-Of-Government Action

The Future for USACE R&D in Meeting the Nation's Challenges

The USACE Research & Development Program will maximize success in implementation by catalyzing R&D throughout the agency.



Each component of the USACE Ecosystem, along with their connections to each other and to external partners, will be strengthened.

The coordination and integration of innovation across the four USACE R&D portfolios will be enhanced to better prepare the Nation for the challenges of today and tomorrow.

1. Civil Works, 2. Installations and Operational Environments (IOE), 3. Warfighter Support, and 4. Support for Others

USACE Research & Development Strategy

Developed in conjunction with The Water Institute of the Gulf

November 2021

https://www.usace.army.mil/

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14. ABSTRACT

This paper provides the U.S. Army Corps of Engineers (USACE) communication products sent by LTG Scott A. Spellmon to help as we discuss the first USACE Research and Development Strategy. The USACE R&D Strategy was approved at the 1Q22 EGM in Atlanta, and is now ready for fielding, communicating, and implementing.

The materials included here are (1) The USACE R&D Strategy, (2) USACE R&D Strategy Slide Deck, (3) USACE Top 10 R&D Priorities 2-pager; (4) USACE Top 10 R&D Priorities Placemat.

The USACE R&D Strategy Slide Deck has several examples of R&D products and capabilities, aligned with the Top 10 R&D Priorities, for your use. Please add to these examples with your own, highlighting past R&D success stories as well as the need for future potential R&D.

The original materials are available online at the following link.
https://usace.contentdm.oclc.org/digital/collection/p16021coll11/id/5457

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