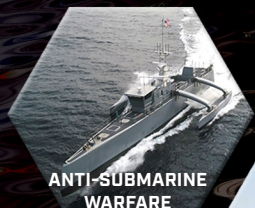




DEPARTMENT OF THE NAVY
SCIENCE & TECHNOLOGY **STRATEGY** FOR

INTELLIGENT AUTONOMOUS SYSTEMS



JULY 2, 2021

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MESSAGE FROM LEADERSHIP

The threats facing our nation today are not only different; they are evolving more rapidly than at any time in history. Similarly, the technologies available to warfighters around the world are advancing faster than ever and much of this innovation is originating outside of the defense sector. These are the fundamental attributes of today's world that the Navy and Marine Corps will transform into advantages for our nation's security. We will do this by synthesizing the intersections of Unmanned Systems, Artificial Intelligence, and Autonomy into a future enabled by Intelligent Autonomous Systems (IAS).

The primary challenge in realizing this future lies not only with scientific discovery and technology invention, but it equally involves accelerating the development, operationalization, and adoption of emerging technologies into IAS-enabled warfighting capabilities.

To realize this future, we chartered the Naval Enterprise to develop this naval S&T Strategy for IAS and to follow it with the companion IAS Strategy Execution Plan. The Strategy sets the Naval IAS Vision; provides the strategic investment framework; and guides coherence to accelerate development, operationalization, and adoption. The Execution Plan is a living document that provides the actionable and measurable steps the Enterprise must accomplish, and it assigns accountability, responsibility, and metrics for success.

These two documents—the Strategy and Execution Plan—are designed to guide the entire Naval Enterprise: Military and civilians across government, industry, and academia. They guide our leaders as they make resource investment and divestment decisions; our development and procurement workforce as they seek coordination and leverage in their efforts; and our Warfighters as they envision future naval impact achieved through integration of IAS across our force structure. Success of this Strategy requires leadership's ongoing commitment to sustain focus and emphasis on execution.

Time is critical if we are to impact the direction of the 21st century. Naval Power will be paramount in this century, and IAS will become a cornerstone of future Naval Power.


Joan L. Johnson

Deputy Assistant Secretary of the Navy, Research,
Development, Test and Evaluation


Lorin C. Selby

Chief of Naval Research





WHY IAS

THE IMPERATIVE

WHY WE MUST ADAPT

"It is not the strongest nor the most intelligent that survives; it is the one that is the most adaptable to change."
—Principle of Darwinism

"America is not prepared to defend or compete in the AI era."

—National Security Commission on Artificial Intelligence
March 2021

WHY ARE WE NOT PREPARED?

America's Navy, Marine Corps, and Joint Forces have been globally dominant since World War II, and the institutions generating this maritime and joint power have continued to improve. However, the world has profoundly changed around us.

WHAT HAS CHANGED?

The Threat

- A peer rival is eclipsing us in raw capacity.
- Kinetic, information, and Gray Zone warfare are disruptively changing worldwide.

Technology

- The rate of technological innovation has accelerated significantly.
- Innovation epicenters have shifted globally from defense to commercial.

These interconnected and rapidly accelerating shifts in threat and technology are the underlying forces necessitating the Department of the Navy (DoN) to fundamentally redesign the journey from Science and Technology (S&T) to adoption of warfighting capability.

In this new era, we must drastically improve the way we develop, operationalize, and adopt disruptive capabilities based on rapidly emerging technologies. This must be coupled with an equivalent acceleration of the rate at which we evolve the way we fight based on these rapidly evolving capabilities. This foundational shift in focus aimed at disruptive capabilities and warfighting approaches must be balanced against sharpening our focus on rapidly improving the subset of existing, proven capabilities that will matter most in the decades to come.

Mastering these two foci at a pace and scale that outstrip our adversaries is the specific challenge of the AI era. This is the challenge for which we are not currently prepared. Rising to this challenge is our charge.

Case Study

In the fall of 2020, Azerbaijan decisively defeated Armenia in a 44-day conflict. Despite both sides' modern air defenses precluding traditional (manned) air combat, Azerbaijani employed superior unmanned air systems (UAS) in multiple ways. Kinetically, they used UAS as targeting assets for loitering munitions and weaponized UAS to directly strike tanks, radars, etc. In the Information Warfare domain, UAS live-streamed footage of Armenian losses, enabled viral videos on social media, and supported a devastating propaganda campaign. While UAS were not the sole contributor to the overall decisive victory, this yet again illustrates the highly disruptive potential of unmanned systems—and signals what the future potentially holds as these unmanned systems become IAS.

THE NAVAL RESPONSE

WHAT THE ENTERPRISE MUST DO

"A problem well-stated is a problem half solved."
—Charles Kettering

Prevailing in the IAS competition requires us to move rapidly and focus on the most impactful outcomes. Accordingly, DoN leadership chartered this strategy to meet three objectives:

IAS S&T STRATEGY OBJECTIVES

IAS STRATEGY OBJECTIVES

Set the
Naval IAS
Vision

Provide the Investment
Management framework
for funding, workforce
and infrastructure

Guide coherence to
accelerate development,
operationalization,
and adoption

IAS STRATEGY FOCUS AREAS

CAPABILITIES

PEOPLE & PROCESSES

PARTNERSHIPS

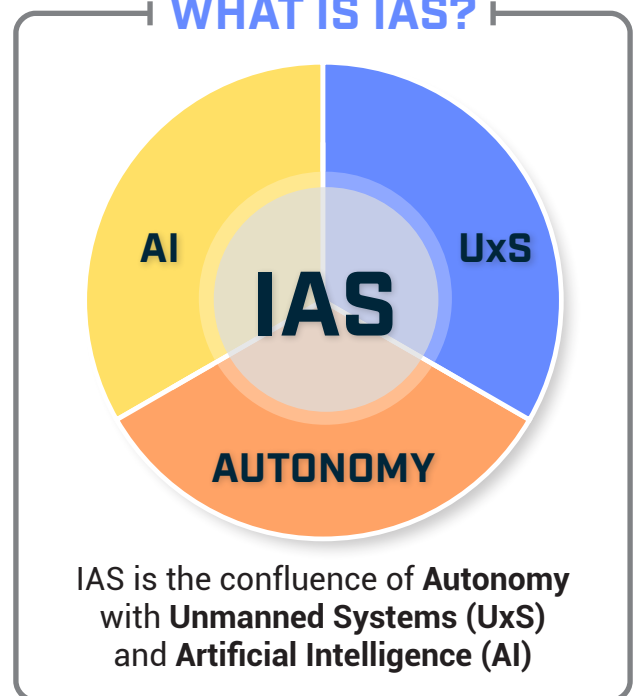
WHY WILL IAS MATTER?

Recent conflicts are proving that smaller asymmetric forces can decisively dominate larger forces traditionally thought to be superior.

Key IAS-enabled advantages we seek:

- Smaller, more numerous, and distributed capabilities as a complement to larger, more powerful, and proven capabilities
- Intelligent machines that can adapt in unstructured environments, at machine speed, and given overwhelming data...and are attritable when necessary
- Decision superiority achieved through ubiquitous and persistent data collection, situational understanding at the edge, and support to a robust Information Warfare capability

WHAT IS IAS?



WHY WE WILL SUCCEED

While there is much work to be done this decade, the DoN is well-positioned for success if we act now: Achieving the IAS-enabled future requires continuous and disruptive innovation, a broad collaborative ecosystem, and a vibrant scientific community. These are the hallmark traits of free society. They are the competitive advantage we will exploit to succeed.





**WHAT WE
MUST DO**

THE ENVISIONED FUTURE

WHAT WE SEEK TO ACHIEVE

"The only way of discovering the limits of the possible is to venture a little way past them into the impossible."

—Arthur C. Clarke's 2nd Law

This Strategy seeks both disruptive and evolutionary change to the way we fight. These changes are guided by the Naval IAS Vision and envisioned via multiple innovative yet realistic descriptions of future Naval Power that will be possible once the Vision is achieved.

THE NAVAL IAS VISION

TO SEAMLESSLY INTEGRATE IAS AS TRUSTED MEMBERS OF THE NAVAL ENTERPRISE

The Naval Enterprise includes every Sailor and Marine combined with everyone supporting them across government, industry, and academia. This Enterprise is our most valuable asset, and we must leverage its boldness and creativity to realize the Vision.

To illustrate and amplify this vision, the Naval Enterprise developed a family of Envisioned Futures. These Envisioned Futures address the spectrum of threats, theaters, warfighting, and mission areas. They illuminate a future where IAS enables fundamentally new capabilities, expands multi-domain capabilities, and enhances existing capabilities.

Critical to achieving this Vision is recognizing the temporal nature of advancements: Small tactical steps can enhance the intelligence of existing capabilities, while bold strategic commitments can simultaneously drive a fundamentally new future. This strategy focuses on both. Of equal criticality is the spectrum of human-machine interdependence enabled by trust and the spectrum of Joint and Allied interoperability and interchangeability. These spectra represent the broader systems of which IAS are a part. Thoughtful consideration must be given to how the contributions of IAS may evolve and expand over time.

The Naval Enterprise has articulated over 100 Envisioned Futures to date. Many more remain to be discovered, and six are presented here in abbreviated form:





ENABLE FUNDAMENTALLY NEW CAPABILITIES

Swarming and counter-swarming—The Warfighter employs intelligent and self-managing swarms of tailored unmanned systems for both offensive and defensive capabilities. Autonomously deployed sensors, enablers, and effectors provide both increased capacity against enemy targets and reduced risk from enemy unmanned systems and swarm tactics.

Battlespace expansion, clarity, and precision—The Warfighter's employment of IAS produces a wider, more penetrating, and more surgical view of battlespace activities. Intelligent information processing at the tactical edge enhances this view, enabling more timely, informed, and precise decisions.



EXPAND MULTI-DOMAIN CAPABILITIES

Intelligent Security—IAS serves the Warfighter as part of an integrated cyber-physical system. They furnish physical security across air, surface, undersea, and land domains for facilities, ports, and mobile assets, while providing cover, active protection, and timely alerts. Simultaneously, they provide real-time cyber monitoring and defense through their connection to the digital network.

Distributed and persistent sensors—The Warfighter depends upon IAS for ubiquitous, continuous, and intelligent situational awareness across all domains including comprehensive environmental characterization, biologics detection, real-time and predictive battlespace conditions.



ENHANCE EXISTING CAPABILITIES

Personalized, targeted, on-demand, relevant training—IAS are individualized for each Warfighter providing education and training that accounts for performance, learning style, preferences, and abilities as well as administrative support throughout the duration of service.

Supporting sea control and sea denial—IAS complements and strengthens forward operations including kill chain execution as well as logistics, sustainment, dynamic reconfigurations, non-combat / humanitarian assistance, etc. This occurs via a family of platform-independent, expeditionary IAS capable of operating at machine speed, on big data, and in trusted roles that support offensive and defensive missions.

STRATEGIC GOALS

WHAT WE MUST DO TO ACHIEVE THE VISION

"We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

—Amara's Law

Nine Strategic Goals are synthesized from the Vision. They are categorized by **Capabilities, People & Processes, and Partnerships**. Individually, these goals address critical long-term challenges and will take time to achieve. Together, they define the comprehensive outcomes that once achieved will fully realize the IAS Vision.

The **IAS Strategy Execution** Plan provides the actionable Lines of Execution (LOEs) required to achieve each Strategic Goal. For every Strategic Goal, there are multiple LOEs, and they will be attacked over time in priority order. Each LOE contains short-term and measurable objectives, details the approach for realizing each objective, and includes assignments of accountability and responsibility.

STRATEGIC GOALS

1. Create superiority in peacetime and wartime operations using evolutionary to disruptive IAS
2. Employ IAS to better staff, equip, and train our forces
3. Utilize IAS to expedite the connectivity between digital and physical environments

4. Establish leadership, governance, and advocacy to achieve the IAS Vision
5. Recruit, educate, train, and retain a world-class workforce to excel in the IAS-enabled future
6. Build the requisite physical, digital/data, and process infrastructure to accelerate continuous integration and interoperability maturation, test and evaluation, capability refinement, and sustainment
7. Tailor acquisition methods and policy usage along with operational concept development to operationalize and adopt IAS at the speed of innovation

8. Maximize IAS innovation by fostering key partnerships, removing barriers, and sharing knowledge across the DoN, warfighter community, U.S. government, industry, academia, and Allied partners
9. Achieve dynamic teaming across the Naval Enterprise and realize seamless IAS interoperability with the other Services and Allied partners

CAPABILITIES

IAS has the potential to provide high-impact, transformative operational and administrative capabilities in peacetime and wartime. These Strategic Goals cultivate a continuous development and operationalization process for evolutionary and disruptive IAS technologies and concepts. They also drive the adoption of operational IAS-based capabilities to provide continuous, effective, and efficient support to the Warfighter across all phases of force development and force application.

The capability-focused Strategic Goals address the full spectrum of IAS technologies from dynamically reconfigurable systems to attritable and swarming systems to systems enhancing proven high-end platforms. As IAS become increasingly intelligent, their abilities will morph from simply collecting data and delivering effects to interacting with and adapting to the environment and task based on what they perceive and understand. This will strengthen human-machine collaboration, unencumber human decision-making, and underscores the criticality of developing and sustaining trust.

PEOPLE & PROCESSES

Leadership, the Naval Enterprise, and Warfighters are the keystones to executing the Strategic Goals and realizing the IAS Vision. Strong and dedicated leadership is critical to advocating and applying meaningful governance to realize the IAS Vision. An IAS- and AI-literate Enterprise of researchers, developers, procurement professionals, and Warfighters is equally critical. As IAS will transform the nature of many jobs across the Enterprise, this must be accounted for in recruitment, education, training, and new incentive structures.

An effective data ecosystem, physical, digital, and process infrastructure must stretch across the entire naval technology life cycle, across all warfare domains, across the Services. These processes and ecosystem must be optimized to mature, test, evaluate, verify, validate, and continuously refine new technologies that will capture the full potential of IAS. These communities, processes, and infrastructure components must focus on solving operational problems to drive the necessary change through all phases of capability development and procurement including contracting approaches, operationalization processes, and requirements refinement.

PARTNERSHIPS

IAS share attributes that apply across the DoD, and they require strategic partnerships to ensure appropriate design, development, and interoperable deployment. Integrating IAS will not be effective or create positive impact if performed in silos. High levels of collaboration, communication, and knowledge sharing both within the DoN and with external, joint, and Allied partners are essential to creating alignment and working toward common goals.

IAS must be interoperable and where appropriate interchangeable across the Joint Force and our Allies. This improves warfighting impact, increases opportunities for discovering disruptive applications, and ultimately decreases development cost and time due to technology leverage.

ALIGNMENT

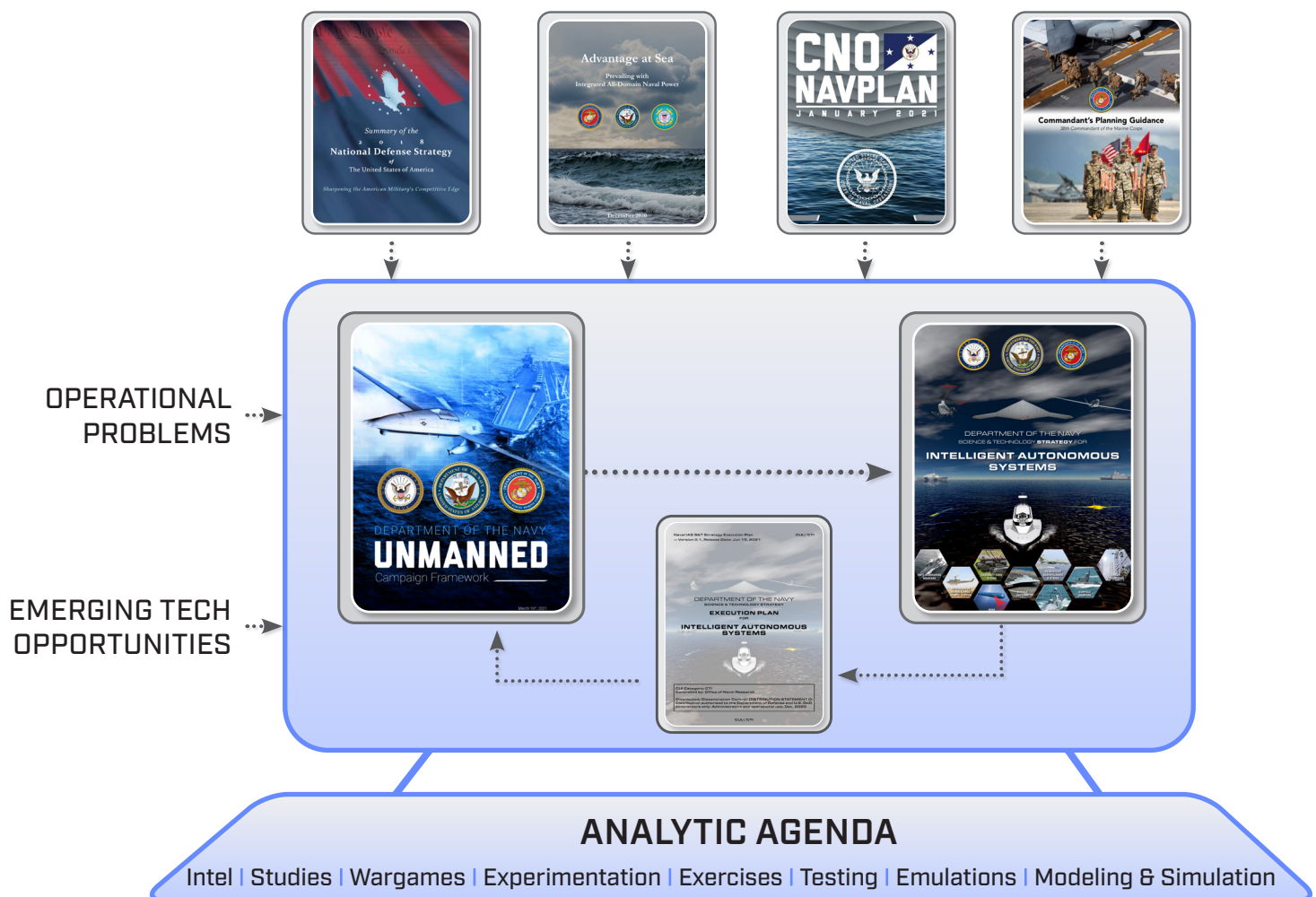
FROM NATIONAL DEFENSE STRATEGY TO IAS

"...plans are useless, but planning is indispensable."

—Dwight D. Eisenhower

On March 16, 2021, the DoN published its Unmanned Campaign Framework. This Framework outlines an overarching Campaign that will realize a future where unmanned systems serve as an integral part of the Naval Force Structure. For this warfighting value to endure in our rapidly changing future, these unmanned systems must be more than uninhabited, remotely controlled vehicles—they must be Intelligent Autonomous Systems. It is this transformation of unmanned systems into IAS that will facilitate adaptation at machine speed; adaptation given overwhelming data; and adaptation in dynamic, unstructured, and uncertain environments.

Together, the IAS S&T Strategy and Unmanned Campaign are aligned with and support higher-level strategic guidance. Simultaneously, they are informed by and leverage Operational Problems and Emerging Technological Opportunities. Individually, they are mutually reinforcing whereby IAS is informed by the Campaign. The IAS Strategy Execution Plan then directly informs the Campaign's Plan of Actions & Milestones. This is specifically captured via the Campaign Framework's governance structure surrounding the Functional Area of "RDT&E/Science & Technology."



STRATEGY DEVELOPMENT

The Strategy is the result of Enterprise-wide effort. A Strategy Development Team was constituted by members of the Naval Research and Development Establishment. They engaged across government, industry, and academia to amass a broad representation of input from a wide array of stakeholders. The aggregate of these engagements guided Strategy development, and it will continue to provide coherence in the Execution Plan by representing all aspects of technology development, operationalization, and adoption.

IMPACT

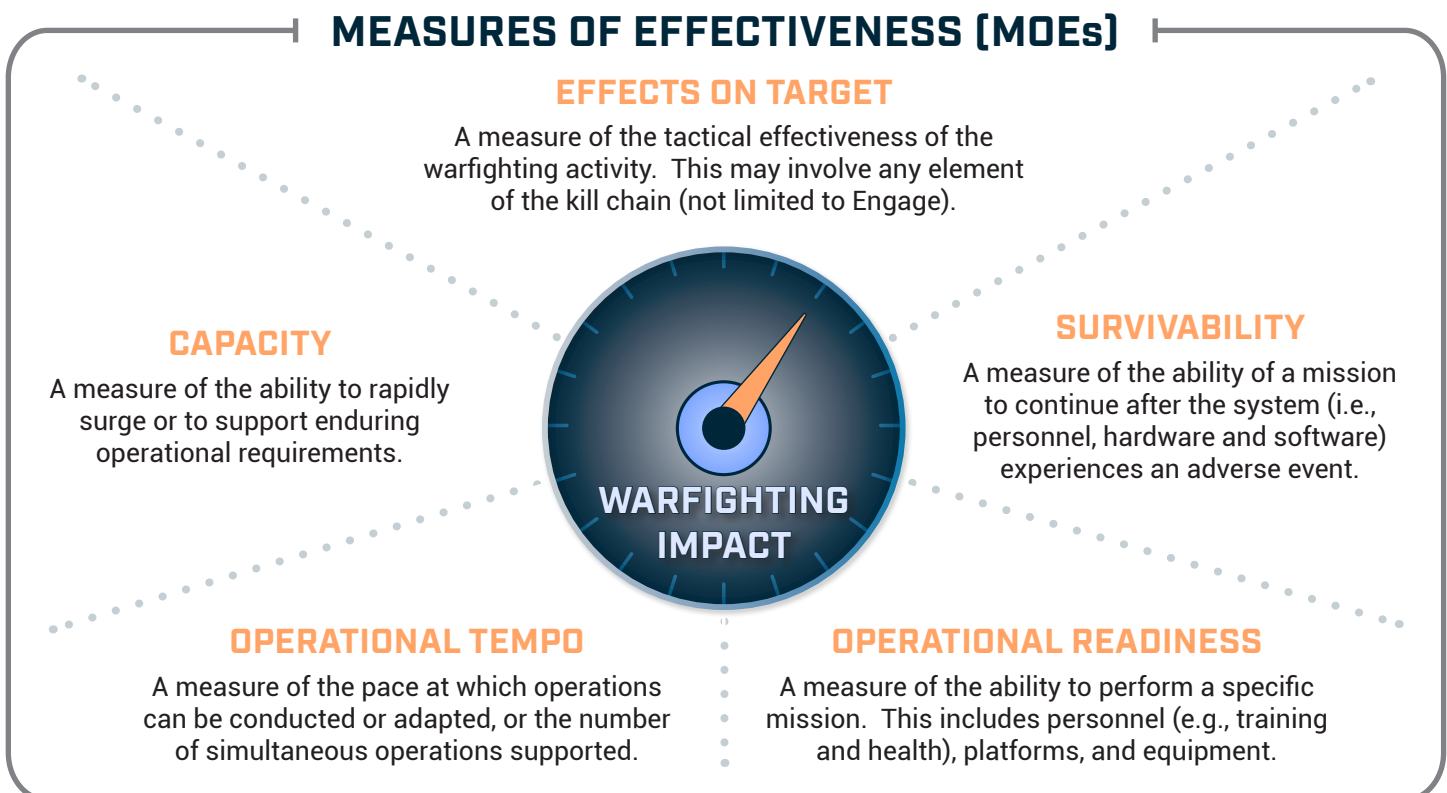
WHY THIS WILL MATTER AND HOW WE WILL KNOW

"In theory there is no difference between theory and practice. In practice there is."

—Yogi Berra

WARFIGHTING IMPACT

The DoN invests in IAS to achieve both evolutionary and disruptive gains in warfighting impact. While this impact does depend on the warfighting problem at hand, it is universally quantified via five Measures of Effectiveness (MOE). It is through various combinations of these MOEs that the value of IAS materializes.



Subordinate to these MOEs are Measures of Performance (MOPs) that capture system attributes such as interoperability, mission-performance parameters, command and control efficacy, allowance for human-machine interdependence levels, etc. These MOPs will be developed as needed and used to constitute the MOEs that quantify the Warfighting Impact of IAS.

SCIENTIFIC IMPACT

Continually advancing IAS capabilities requires ongoing discovery of new knowledge. While the IAS Strategy must be tightly focused on warfighting impact, all mid- and far-term future capability development is underwritten by a foundation of basic research that must be broad in scope and highly risk tolerant.

This is not a strategic choice or managerial preference but rather a foundational principle of invention—it is based on the fact that it is impossible to predict *a priori* which set of basic research investments will enable the next applied breakthrough. For IAS, this mandates that the DoN must maintain a broad basic and early applied research portfolio in the critical focus areas of autonomy, unmanned platform enablers, and artificial intelligence. This portfolio must also emphasize research areas that contribute to IAS that are safe, secure, reliable, predictable, trustworthy, and ethical.





**HOW WE
WILL
SUCCEED**

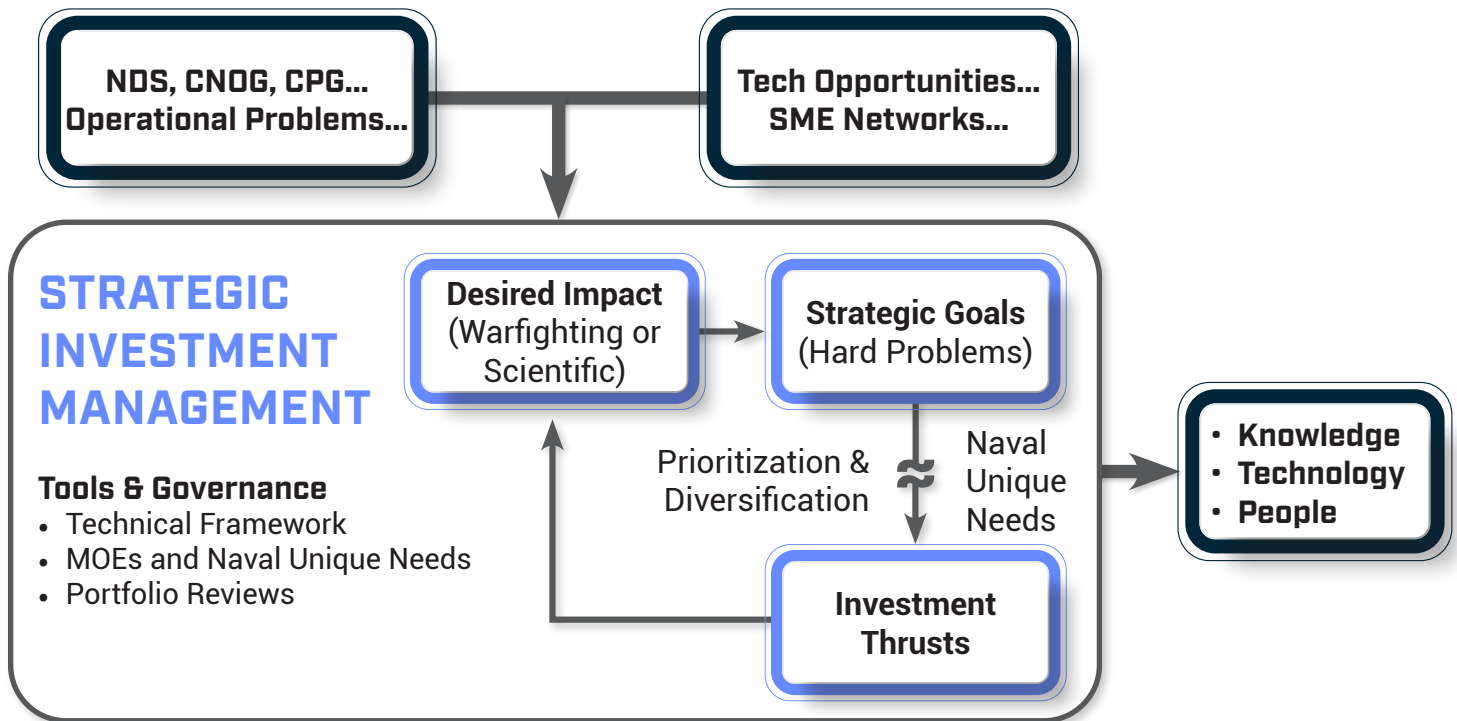
LEADERSHIP AND GOVERNANCE—STRATEGIC STRATEGIC INVESTMENT MANAGEMENT

“Management is doing things right; leadership is doing the right things.”

—Peter Drucker

This Strategy requires strong leadership and governance across the entire Naval Enterprise to achieve the Vision. Only then can the Warfighting Impact of IAS progress from S&T through operationalization and into the hands of Warfighters. Leadership and governance must synchronize essential organizational components such as education, training, recruitment, infrastructure, data ecosystems, and better acquisition methods along with advances in science and technology.

Strategic Investment Management is a cornerstone of leadership and governance. It is necessarily strategic because it is informed by DoD, Naval, and Maritime strategic guidance as well as operational problems. An emphasis on operational problems will be increasingly critical in the 21st century as our Nation faces novel and rapidly evolving threats. A second and equally critical set of inputs comprises technological opportunities and our networks of world-class experts—both within and outside of the DoD. These inputs will also be increasingly critical as technology evolution is accelerating, and much of it is occurring beyond the DoD ecosystem.



This Strategic Investment Management process must be exercised by leaders across the Enterprise. It begins by deriving the Desired Impact from the previously discussed inputs and assessing that impact via the five MOEs. From this Desired Impact, Hard Problems are synthesized, which for IAS are the aforementioned nine Strategic Goals. These Strategic Goals then drive the Investment Thrusts, which constitute the Lines of Execution in the IAS Strategy Execution Plan. Because significant innovation occurs beyond the DoD ecosystem, this Strategy employs Naval Unique Needs to filter the DoN's IAS investments to only those that the commercial sector will not adequately address absent DoN leadership or support.

The resulting investment portfolio must be appropriately diversified. This diversification must be balanced along the dimensions of technical maturity, risk vs. reward in technical approach, evolutionary vs. disruptive, and focusing on known needs vs. broad exploration to enable tomorrow's breakthroughs. Employment of this Strategic Investment Management framework will guide leadership across the Naval Enterprise as they make investment and divestment decisions relating to funding, workforce, and infrastructure.

LEADERSHIP AND GOVERNANCE—OPERATIONAL DEVELOPMENT, OPERATIONALIZATION, AND ADOPTION

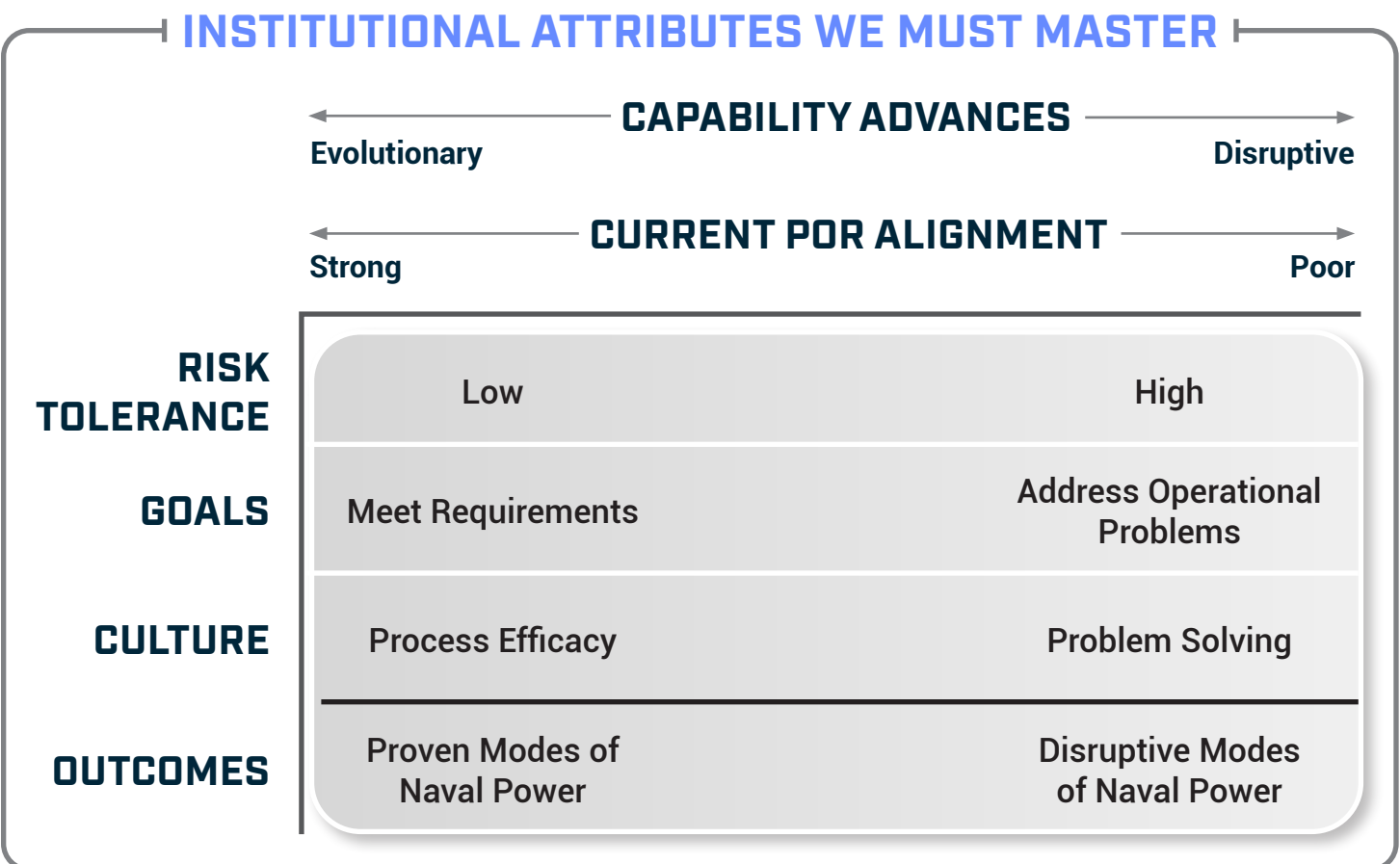
"If you need a machine and don't buy it, then you will ultimately find that you have paid for it and don't have it."

—Henry Ford

Strategic Investment Management provides the principled framework to combine high-level guidance, operational problems, and technical opportunities to produce the individual and prioritized Investment Thrusts. Executing the S&T component of these Investment Thrusts then produces the primary S&T outputs: discovery of **knowledge**, production of **technology**, fostering of **people**, and contributions to future warfighting options. Traditionally, these S&T outputs transition to Acquisition by informing Programs of Record (PORs)—but in today's world of rapidly evolving threats and technologies this model is ineffective.

EVOLUTIONARY VS DISRUPTIVE

A primary function of leadership and governance today must shift to redesigning and shepherding how we develop, operationalize, and adopt S&T outputs into warfighting capability. There are two tremendous opportunity spaces where IAS will force this shift. They are disruptive capability advances with no corresponding POR (right side of the below table) and evolutionary capability advances that are weakly aligned to our current PORs (middle region of the below table). These opportunity spaces require us to master competing sets of institutional attributes—attributes that must be nurtured in different components of the same institution. The key insight is that the left side of the below table involves known solutions to known problems. As we shift to also address the right side, we must embrace discovery of novel and disruptive solutions in parallel to problem refinement. This requires us to think differently about prototyping / testing vs. requirements generation; capacity targets vs. rapid capability upgrades; and collaborative planning across industry, government, and academia. Adapting our organization, structures, and incentives to support this full spectrum of evolutionary to disruptive capability advance is our charge.



NAVAL UNIQUE NEEDS

HOW WE LEVERAGE EXTERNAL INNOVATION

"When we all agree only one of us is doing the thinking"

—Paraphrased from Lyndon B. Johnson

Industry investment in S&T now dwarfs that of government by orders of magnitude. Yet there are science and technology areas in which the commercial sector will not invest absent naval funding or leadership. Consequently, the Strategic Investment Management process employs the Naval Unique Needs to guide the Investment Thrusts based on needs that are truly militarily unique, maximize leverage of the non-defense commercial sector, or inform potential investment areas for defense-guided, dual military-commercial use. They are employed by leadership when prioritizing investment and divestment decisions. The Naval Unique Needs require the DoN to push the state of the art both ahead of and beyond industry's needs.

Naval Unique Needs for IAS

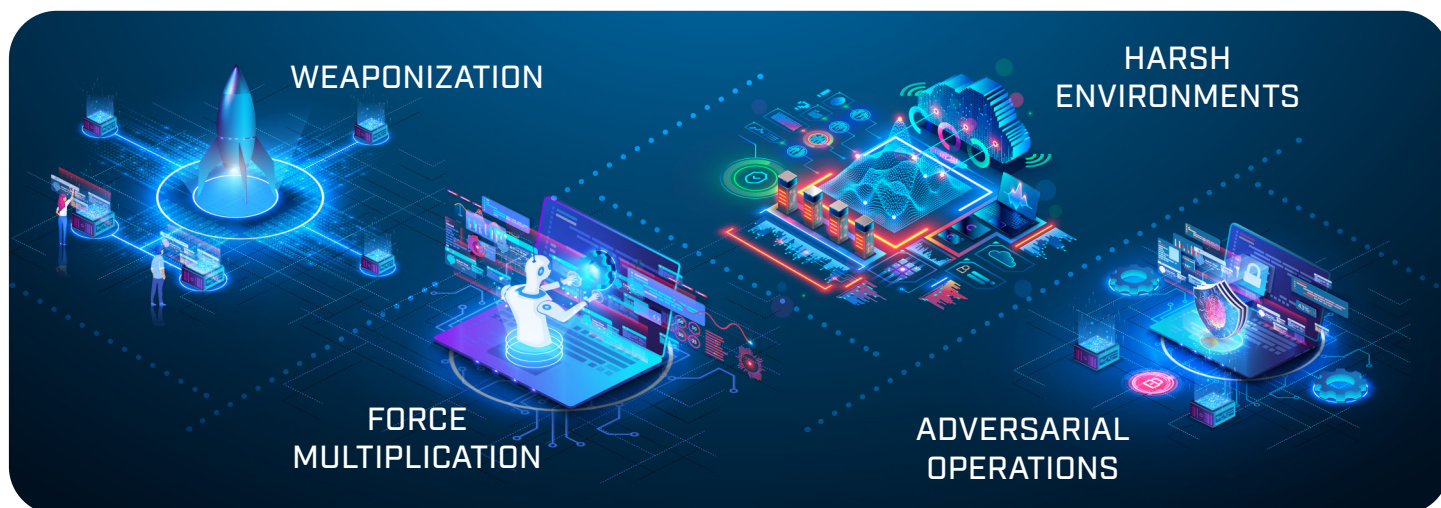
Uniquely Naval Mission Attributes

- Weaponization, kill chain execution or disruption
- Non-permissive, adversarial, covert, or clandestine operations
- Dynamic, unstructured, uncertain, or harsh environments
- Force multiplication, high-tempo, or attritability

Common Drivers Requiring Unique Military Advances

- Long duration, large standoff, or disadvantaged communication/navigation
- Scalable, distributed, or decentralized adaptation
- Workload or manning reduction, employment by non-specialist
- Rapid human-machine information exchange
- Cross-domain/multi-domain
- Trustworthy assimilation of highly-variant, non-intuitive, "target-poor" data sets

The Naval Unique Needs are constituted by the Uniquely Naval Mission Attributes. Additionally, there are drivers common to both military and the non-defense commercial sector that when paired with a Uniquely Naval Mission Attribute produce additional Naval Unique Needs. For example, a long-duration mission in a non-permissive maritime environment drives the need for adaptive behaviors that are not present in commercial long duration applications or in military (shorter-duration) non-permissive applications.



TECHNICAL FRAMEWORK

HOW WE WILL MANAGE THE PROGRAMS

“What I cannot make,
I do not understand”
—Richard Feynman

This Strategy provides a Technical Framework to aid in Leadership and Governance at both the strategic and operational levels. The Technical Framework is a multipurpose tool for informing critical decision-making about IAS with respect to program planning, resource allocation, and portfolio management.

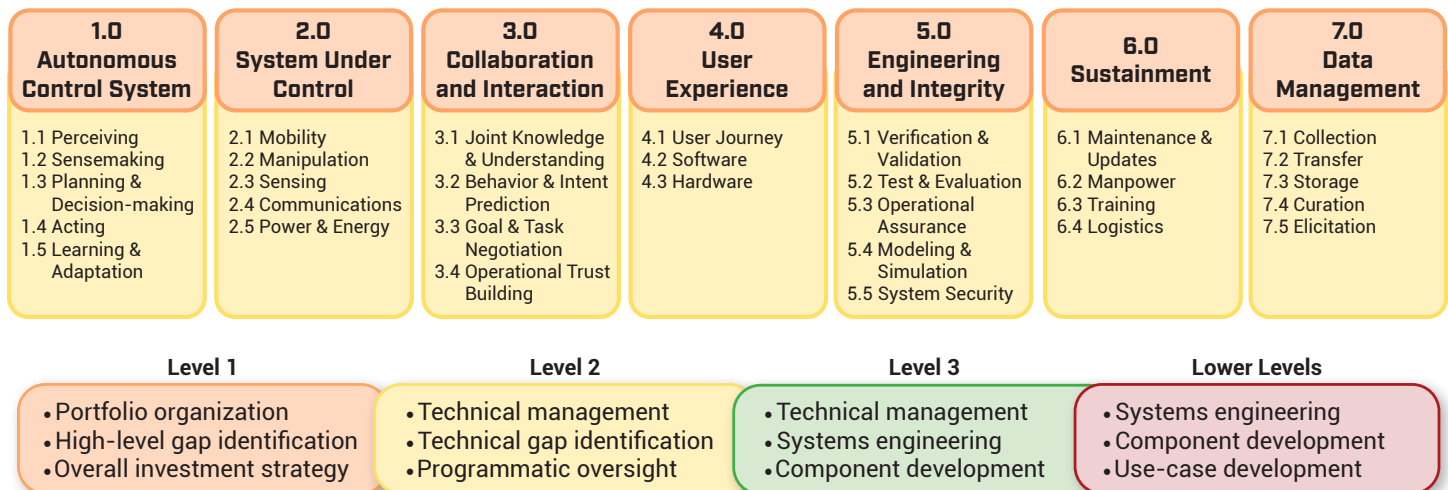
The Technical Framework identifies key functional areas of IAS essential to the operational success of a new system, organizes the functional areas that need significant investment and risk management, and provides a structure for articulating the needed technology development areas. It also provides

a common taxonomy and lexicon through which stakeholders can effectively communicate. Finally, it offers a general guide to managing relevant aspects of IAS programs.

The Technical Framework is designed to evolve with the pace of technology. It will be revised periodically to ensure it tracks the state of the art and captures the evolving practices of industry, academia, and government. A high-level synopsis of the Technical Framework is illustrated here, and it is presented in full detail along with user guidelines in the IAS Strategy Execution Plan.

IAS TECHNICAL FRAMEWORK

Foundational: Policy, Ethics & Missions



LEVEL 1 identifies the main elements that comprise an IAS Program. These top-level considerations are intended for use by resource sponsors and senior leadership as part of the process of identifying technology gaps, operational needs, and areas for investment / divestment.

LEVEL 2 summarizes the core functions that the Level 1 elements must perform and the fundamental capabilities they must provide. From a systems engineering perspective, this level bridges key capabilities and functions to methods by which they can be achieved.

LEVEL 3 and below is where users begin developing more detailed definitions of program-specific types of technologies and requirements. These levels relate specific solutions for closing technology gaps, supporting desired capabilities, and enabling the requisite processes or procedures.

ETHICS AND TRUST

HOW WE PROVIDE LEADERSHIP ON THESE CRITICAL ISSUES

"We don't see things as they are; we see them as we are."

—Anaïs Nin

ETHICS

From an ethical perspective, the primary goal is to develop and field IAS-based capabilities that preserve and maximize warfighting effectiveness while conforming to law, policy, and ethical principles. This goal applies equally to weaponized, non-weaponized, and non-combat systems. To achieve this goal, primary IAS design and employment objectives must include safety, security, reliability, predictability, trustworthiness, and ethical boundaries. Beyond design and employment, the Naval Enterprise must accomplish the following:

- Ensure U.S. and Allied ethical and policy positions are correctly informed by the realities of technology.
- Ensure the Naval Enterprise understands U.S. ethical principles and positions.
- Equip members of the Naval Enterprise to constructively engage in the ethics conversation—includes dispelling the myths that jeopardize the responsible use of IAS.

The DoD recently adopted and fully committed to a set of Ethical Principles for AI. As AI continues to enable increasingly intelligent IAS, the Naval Enterprise must take a leadership role in ensuring robust and complete ethical considerations across all applications of IAS. This will be actively managed via the IAS Strategy Execution Plan providing direct support to the Unmanned Campaign's Functional Area on Policy, Law, and Ethics.

TRUST

A major design goal in human-machine systems is appropriate reliance—too little reliance and performance is subpar, too much and avoidable mistakes ensue. For many military systems and situations, trust is a critical component of reliance. For IAS, there are multiple facets of trust, and each must be addressed differently. Two major facets are:

- **Individual Trust**
How/when should the human trust the machine?
- **Institutional Trust**
How should the DoN assess trust for the machine and human-machine team?

There are many other facets of trust to be discovered as machines become increasingly intelligent (e.g., should a machine trust a remote human possessing partial, outdated, or incorrect information?). For improving each facet of trust, the Naval Enterprise must provide tailored and concentrated focus. For example, Individual Trust requires a tight user-developer feedback loop: the developer must teach the art of the possible while the user must guide how the technology is operationalized. Institutional Trust will require new approaches to assure safe, secure, reliable, predictable, and ethical IAS operations.

MYTHS OF IAS AND ETHICS

Myth: Ethics inhibits operational effectiveness.

FACT: Ethics serve as a critical enabler of U.S. and Allied competitive advantage.

Myth: U.S. policy prohibits autonomous weapons.

FACT: U.S. policy requires review and approval for autonomy in weapon systems.

Myth: Ethics requires "human control" of IAS at all times.

FACT: Ethics requires appropriate levels of human judgement in employment of IAS.

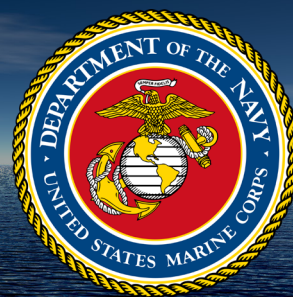
CONCLUSION

The 21st Century is being shaped by rapidly evolving threats and accelerating technologies that are broadly available. This is enabling new and asymmetric forms of conflict that are proving they can decisively dominate forces traditionally thought to be superior. As the CNO has stated, our actions in this decade will shape the balance of maritime power throughout the 21st Century.

To shape this century around the security of our Nation and freedom of the global commons, the DoN must drastically improve the pace and scale by which we develop, operationalize, and adopt disruptive capabilities based on rapidly emerging technology. This focus on disruptive capabilities and transformational warfighting approaches must be balanced against an equal improvement focusing on the subset of existing, proven capabilities that will matter most in the decades to come.

IAS will be a cornerstone of future naval power—and the IAS Vision is to seamlessly integrate IAS as trusted members of the Naval Enterprise. The IAS S&T Strategy sets this Vision; provides the Investment Management Framework; and accelerates this development, operationalization, and adoption. The IAS Strategy Execution Plan provides the actionable and measurable steps to execute the Strategy.

Our most valuable assets are the men and women of the Naval Enterprise—the Warfighters and civilians alike across government, industry, and academia. Inspiring and rewarding their boldness and creativity is how we will succeed.



DEPARTMENT OF THE NAVY
SCIENCE & TECHNOLOGY **STRATEGY** FOR
INTELLIGENT AUTONOMOUS SYSTEMS