CNA | ADDRESSING AI'S OPERATIONAL CHALLENGES: PUTTING THE HUMAN IN HUMAN-MACHINE TEAMING

INTRODUCTION

Artificial intelligence (AI) and unmanned/autonomous systems are poised to revolutionize modern-day warfighting, and Department of Navy (DON) leaders have stated that these systems will make the difference between victory and defeat in great power competition (GPC). Our review of DON strategy documents, however (see table), indicates that DON is paying insufficient attention to the full range of DOTMLPF-P (doctrine, organization, training, materiel, leadership & education, personnel, facilities, and policy) implications that these technologies will have. In particular, more attention needs to be paid to the Manpower, Personnel, Training, and Education (MPT&E) to enable human-machine teaming (HMT). Ironically, humans are HMT's missing ingredient in DON's strategic planning for GPC.
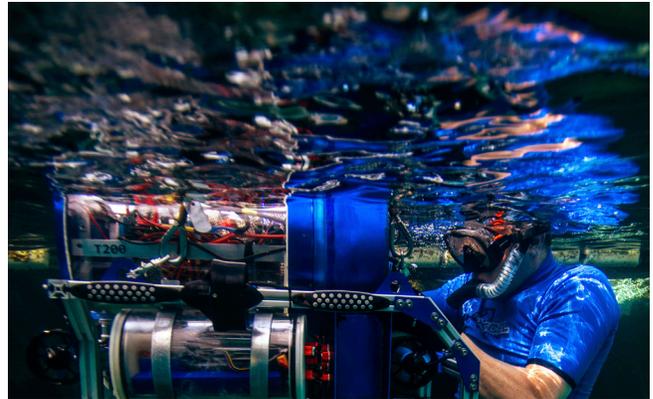
Photo: US Navy, Petty Officer 1st Class Charles White

ADVANTAGE AT SEA (THE TRI-SERVICE MARITIME STRATEGY)

"We must maintain our advantage at sea with new platforms, new thinking, and new technologies," and *"recruit, train, educate, manage, and retain diverse, versatile, professional personnel."* HMT will *"increase the capacity of the fleet."* **This strategy recognizes the importance of MPT&E, but is silent regarding the impact of HMT on MPT&E.**

CNO'S NAVIGATION PLAN

CNO acknowledges MPT&E, noting that our Sailors will *"remain the best trained and educated force in the world."* **MPT&E reform is not addressed**, but there is an unambiguous statement regarding the need to reform technology acquisition by developing *"innovative systems, modernizing legacy ones, and rigorously aligning our acquisition enterprise with operational requirements."*

38TH COMMANDANT'S PLANNING GUIDANCE (AND ITS UPDATES)

"Marines are the centerpiece of the Corps—our principal emphasis must focus on recruiting; educating and training; instilling our core values and sense of accountability." Unmanned systems and AI figure as prominent enablers, but **the relationship between technology acquisition and personnel "acquisition" to enable HMT remains unexplored.**

DEPARTMENT OF THE NAVY UNMANNED SYSTEMS CAMPAIGN FRAMEWORK

This framework recognizes that HMT must span the entire DOTMLPF-P construct, acknowledges that material solution acquisition needs reform, and calls for the *"talent recruitment and education necessary to field and sustain autonomous operations,"* but **does not suggest that MPT&E reform is needed** to accomplish this. It explicitly recognizes our poor record of developing platform "enablers," and then it lists them: networks, control systems, infrastructure, interfaces, AI, and data. It **does not specifically list people as HMT enablers**.

DON S&T STRATEGY FOR INTELLIGENT AUTONOMOUS SYSTEMS

This strategy defines intelligent autonomous systems as *"the confluence of autonomy with unmanned systems and AI"*—but not with people. It recognizes that AI requires changes to recruitment, education, and training, but its **MPT&E focus is limited to a "world-class workforce" capable of the necessary innovation and process reforms—not the HMT human teammates**.

THE PROJECT OVERMATCH MEMORANDUM

In this document, the CNO recognizes the need for *"Distributed Maritime Operations through a teamed manned/unmanned force."* He presents Project Overmatch strictly as a technical engineering problem, however, directing OPNAV N9 to provide *"a novel force"* **but giving no similar direction to OPNAV N1 to provide the HMT human teammates.**

This document highlights the potential challenges HMT will present for DON MPT&E systems, and the questions that DON must answer to overcome those challenges. It then recommends that DON develop a comprehensive research agenda to proactively address the challenges HMT will present to all of the DOTMLPF-P components.

Man and Machine: How HMT Could Change Military Manpower

The introduction of unmanned and autonomous systems and the human-machine teams needed to employ them raises three fundamental questions about DON's MPT&E systems. These questions begin with the desired end result, working backward to the changes needed to achieve those results:

1. How will HMT change the work and capabilities needed to accomplish DON missions?

2. Can DON manpower management accurately and efficiently translate changes in work into changes in manpower requirements and authorizations?

3. Can DON MPT&E respond to HMT-driven changes in manpower requirements by providing the right numbers and right types of personnel at the right times?

Photo: US Navy, Senior Chief Petty Officer Brandon Raile

Underlying these three broad questions are several more specific questions that DON must address to ensure that it can provide the human teammates HMT requires.

1. HOW WILL HMT CHANGE THE WORK AND UNDERLYING CAPABILITIES NEEDED TO ACCOMPLISH THE DON MISSION?

Will HMT change the rank and/or organizational structures needed for DON work?

HMT is likely to change both the nature and amount of work needed across the force, but the impacts may not be the same across unit types. Nor will the changes in work and required capabilities necessarily mirror those associated with past technological changes. Many machines have both physical and cognitive functionality, but whereas past machines tended toward the physical, contemplated future machines tend toward the cognitive.

For example, Mosaic Warfare is a concept of operations that gives a commander's planning staff AI-enabled decision aids. Offloading the "how" to machines may allow staff to spend more time on the uniquely human activity of operational art. This is most likely to affect officers, who may need to become more creative and adaptable as they respond to the information and data that machine learning (ML) algorithms generate in both combat and peacetime environments. It also will affect

Photo: US Navy, Petty Officer 3rd Class Rebekah M. Rinckey

noncommissioned officers (NCOs) and junior enlisted personnel, who may increasingly take "direction" from machines instead of officers.

The introduction of HMT could also blur the lines between officer and enlisted functions. NCOs and lower-level enlisted personnel may increasingly be able to execute some tasks that currently are the exclusive purview of officers. For example, developing new air combat tactics, techniques, and procedures (TTPs) is primarily an officer function because the aircraft used to develop and test these new concepts are expensive to operate. In the age of AI and ML, however, NCOs and junior Sailors and Marines could develop TTPs in a virtual environment. More broadly, HMT-related changes also may increase the need for alternative personnel types. For example, the Navy recently created a new community of directly accessed warrant officers to operate its first carrier-based, unmanned tanker.

Photo: US Navy, Petty Officer 1st Class Michael B Zingaro

Will HMT-related work require new knowledge, skills, and abilities (KSAs)?

In administrative units, HMT may drive an increased need for more technical KSAs. DOD leaders already have recognized this in the context of technology development, so efforts are underway to ensure that the DOD engineering workforce gets the requisite training and educational opportunities to be on the leading edge of technology. DOD leaders also are questioning the size and quality of the DOD manpower management workforce based on the expectation that technology change, including HMT, will increase the need for specialists who understand the details of both manpower management and the new technologies that are driving change.

Will HMT create more or less work for DON personnel?

There is a natural tendency to assume that technology will be labor saving. For example, as digitization becomes more prevalent, the pool of analog data that currently contributes to the need for human participation may shrink. However, even if the net effect of HMT is to reduce the overall amount of human work needed to accomplish DON missions, demand for certain types of work may increase. For example, in the Air Force, the introduction of unmanned systems has not decreased the human work needed to fulfill related missions. Although the unmanned systems do not require pilots, they have generated more maintenance, intelligence, surveillance, and reconnaissance work.

How fast will these changes occur?

Technological advances may change the work performed by Sailors and Marines at an unprecedented pace, and DON's MPT&E systems must be ready to respond.

2. CAN DON MANPOWER MANAGEMENT ACCURATELY AND EFFICIENTLY TRANSLATE CHANGES IN WORK TO CHANGES IN MANPOWER REQUIREMENTS AND AUTHORIZATIONS?

Are manpower management processes sufficiently integrated with acquisition and DOTMLPF-P processes?

In determining whether a machine or a human will do DON's mission-essential work, emerging design methods take a "both-and"—instead of "either-or"—approach to task assignment. Emerging methods identify whether and how each task can be led by either a human or a machine, supported by the other. This creates force-multiplier effects that DON will have to measure and incorporate into its warfighting system designs and into processes for determining manpower requirements and authorizations. System designers and manpower managers will have to work together

to do job-task and workload analyses to determine how new HMT systems and platforms will affect the number of people needed, the skills they must have, and the training and education they will need.

Does DON have the right manpower management policies and workforce?

Some current DON policies and practices may discourage early and adequate focus on the implications that technology change will have for manpower. For example, a 2003 GAO study found that Navy efforts to use technological innovations to optimize crew sizes for several ship classes were impeded by DOD acquisition policies and discretionary Navy guidance that allowed program managers latitude in deciding when and how to incorporate manpower considerations into the acquisition process. Personnel policies that could not be revised without the consensus of multiple stakeholders were also a factor. A more recent CNA study found evidence of training and skill gaps among DOD manpower managers, which could widen or proliferate as manpower management processes and tools become more complex. Discussions with Navy and Marine Corps subject matter experts also indicate that, outside of the organizations that focus on manpower management, there is an attitude that "anyone can do manpower."

Photo: US Navy, Petty Officer 1st Class Arthurgwain Marquez

Can DON easily and swiftly update occupation-specific requirements or develop new occupation requirements? How forward-looking does DON need to be?

The current processes for generating or updating KSAs and manpower requirements for new or existing occupations are time, labor, and data intensive. If DON cannot speed up these processes, it may need to develop ways to be more forward looking. Some studies, however, have shown that past efforts at long-range requirements forecasting have not been particularly successful. Fortunately, technology change may assist in these efforts; in the future, virtual HMT simulations and sensors in real work environments may help identify required KSAs.

3. CAN DON MPT&E PROVIDE THE RIGHT NUMBERS AND RIGHT TYPES OF PERSONNEL AT THE RIGHT TIMES?

Can the system efficiently increase or decrease personnel inventories in response to changes in manpower authorizations?

The current MPT&E processes allow for independent changes in manpower requirements, authorizations, and personnel inventories. Changes in requirements and authorizations occur by decree and are implemented immediately. In contrast, changes in personnel inventory are primarily incentivized and come about over time. If HMT changes authorized endstrengths, DON must consider ways to both access new personnel and separate unneeded personnel more quickly and without breaking trust with its members. DON also may need to develop processes and collect data to ensure that personnel whose

Photo: US Navy, Petty Officer 1st Class Scott Bigley

occupations are being eliminated but who have the KSAs associated with new work requirements are productively reassigned rather than separated.

How will HMT change the ability of the Navy and Marine Corps to find and select suitable human teammates?

If HMT significantly changes the types of people needed to fill DON manpower requirements, it also may redefine the relevant recruiting pool and the services' approaches to identifying appropriate candidates within it. The current MPT&E system generally recruits both officer and enlisted candidates based on age, fitness, and assessed aptitudes, then provides military-specific training and education to develop desired KSAs. New KSAs may require new assessment tools, such as the selection battery being

Photo: US Navy, Petty Officer 3rd Class Adam Butler

developed for operators of large unmanned aerial vehicles. HMT also may require the military to find people who already have advanced or technical skills, so DON must not only be equipped to identify them within the national workforce, but also be able to offer the types of compensation, benefits, and seniority that educated and trained people can get from private-sector employers.

How should DON organize and manage personnel to execute new work effectively and efficiently?

HMT also may require changes to the way DON organizes and manages its personnel. The current MPT&E system has separate enlisted and officer rank structures and allows for little lateral entry. With few exceptions, it assigns members to occupations early in their careers and these occupational assignments define their subsequent career paths. These career paths provide experiences and on-the-job training that members need to achieve the technical or leadership capabilities required at each successive career point and rank. Current policies require officer promotions to be timed uniformly across occupations based on seniority, and education and training opportunities for both officers and enlisted personnel often do not align with the times when members will need to use the acquired skills. Although both

DON services' personnel systems identify the KSAs that each Sailor or Marine has and that each billet requires, several distribution system features—including inventory shortages, billet vacancy timing, and competing service and servicemember priorities—make it difficult to match people to billets based on those KSAs. In practice, members in a given occupation and rank are generally treated interchangeably, and more detailed member-billet KSA matches are made only when doing so is convenient or a high priority.

Some have argued that the military should eliminate separate enlisted and officer rank structures to create a force that is sufficiently flexible and adaptable to benefit fully from HMT. The potential blending and blurring

Photo: US Marine Corps, Cpl. J'Vonnta Taylor

of officer and enlisted roles and responsibilities—and shifts back and forth over time—might have significant ripple effects in an MPT&E system that uses this rigid division of labor as an organizing principle. Others have argued that career path uniformity should be relaxed and promotion timing should instead be based on the timing of skills

acquisition, which HMT could cause to vary by occupation. As a result, DON may need to make career paths less restrictive, particularly since HMT may require near-constant training to keep pace with evolving technologies—greatly increasing the costs of skill decay.

HMT may require billet structures that do not conform to the pyramid shape that the current MPT&E system dictates. Changing this structure may require additional lateral entry, increased retention, or both. HMT may also increase billet churn because of rapid changes in requirements; may require KSAs that are not uniformly distributed within, or directly aligned to, occupations and paygrades; and may increase the importance of person-billet matching beyond occupation and paygrade. All of these possible changes would make it more difficult to get the right people to the right places at the right time. Ultimately, making higher-quality member-to-billet matches will enhance job satisfaction and retention, helping alleviate inventory shortages.

Photo: US Navy, Seaman Apprentice Juan Ruiz-Lazcano

Will unit leaders know enough about their unit members' KSAs, even those not associated with billet assignments, to rethink and reimagine human roles at an adequate pace?

Finally, HMT likely will change not only how people work with machines, but also how they work with each other. Effective unit-level management is a key determinant of individual productivity and job satisfaction. It also is a determinant of team or unit productivity, because unit-level management is especially important for teams that are diverse in function, organizational structure, and demographics.

RECOMMENDATIONS

DON strategic guidance indicates a need for HMT-driven reforms to materiel acquisition systems, but the unanswered questions posited here indicate that DON needs additional information to make informed decisions about the possible need to modify or reform MPT&E systems. Answering these questions will require analysis and coordination. To that end, we recommend the following:

- Create an OPNAV HMT Cross Functional Team (CFT): Clearly, analysis of *humans* and *machines* requires coordination among OPNAV N72, N1, and N9, respectively. The success of teaming between people and machines in the fleet will reflect the level of teaming between the resource sponsors for each, informed by directed outputs from the Navy Annual Studies Plan (NASP). This CFT should take ownership of four required actions:

  ◦ **Monitor and mature HMT engineering design principles.** The way in which human-machine teams are designed will drive everything else—and will raise the questions that the NASP must answer. HMT design tools are currently in their infancy. The CFT should identify tools suitable for Navy use and invest in them via the Navy research, development, test, and evaluation (RDT&E) enterprise.

- Identify MPT&E "ripple effects" via an iterative HMT analytical framework. Engineering design tools result in engineering specifications. HMT design tools result in "design specifications" for both people and machines. Acquisition specialists and MPT&E specialists can determine whether existing systems can deliver what is required and make necessary adjustments or reforms. These adjustments will be iterative as HMT design tools and operational concepts mature.
- Identify and close data gaps. Any analysis-intensive approach requires data to fully describe the constituent (human and machine) parts of the HMT. The CFT should constantly look for data generation and collection opportunities. These will enable "what if" analyses of HMT configurations in simulated environments in order to maximize HMT warfighting effectiveness.
- Conduct organizational roles and responsibilities analyses. MPT&E's ripple effects may reveal the need for new organizational roles and responsibilities. This analysis will embed the CFT's efforts into the appropriate DON organizations for long-term execution.

CONCLUSION

The tremendous promise of AI and robotics demands their inclusion in GPC concepts of operation, but leveraging their promise requires a thorough understanding of how they will affect DOTMLPF-P processes. Executing the recommendations above will enable DON to proactively determine aspects of the current MPT&E systems that may require change. Ultimately addressing all the operational challenges that AI will present will require subject matter expertise in DON human capital, technology, concepts of operation, data and analytics, strategy, policy, and plans, and GPC enemies. As DON's federally funded research and development center, CNA has an operating division staffed by subject matter experts dedicated to each of these areas, and a matrixed organizational structure that pulls this expertise together to form interdisciplinary research teams. We look forward to partnering with DON leadership and the proposed CFT to execute the supporting studies and analyses.

ABOUT CNA

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