Lessons for the DoD when Planning for the Future of S&T

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ABSTRACT

Telling the future is not yet possible, but we have nearly come to expect it, thanks to incredible achievements in technology which presents us with an ever-improving sense of what is probable. This has introduced interesting challenges, for example, when DoD prepares for future states of the world. This was a challenge recently undertaken by researchers at OUSD (R&E), where a glimpse into science and technology out to the year 2045 was explored as part of a Congressionally mandated report included in the 2020 NDAA. A credible team of experts was commissioned for the effort, who additionally organized a complement of technology analysts and writers. A parallel project was conceptualized and nominated by a few researchers who felt it important to investigate the thoughts and perspectives of professionals whose worldview is dominated by such matters: futurists, technology forecasters, and science fiction writers. Thus, the OUSD (R&E) Principal Director for Cyber agreed to launch Project Valence (the namesake being a nod to the gregarious nature of valence electrons); the members of which successfully reached a dozen such luminaries, and recorded nearly 30 hours of unbridled exploration about the world to come. Notably, regardless of whether visions prove to be true, such a world will undoubtedly feature a fighting force charged with the defense of America, comprised of experts many of whom have not yet been born.

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25 YEARS OUT IS FAR

> "...And so, I should say that 2045, for me, is a little far, to be honest. And so I'm going to go outside of my comfort zone, because I do 10 years out. So, this means that you must do the forecasting and envisioning of the future differently with different voices. Because the range is so far, that **you really are going to trip into the impossible, you're going to trip into the fact that well, that couldn't happen. [But] when you get right up to the edge of the impossible, you've got the possible, right?**"
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> *- Brian David Johnson*[1]

It is an enormous task to think so far out in the future and expect to get anything right. Up until the 20th century, the future unfolded in fairly predictable ways for most people, who tended to live similar lives across a couple of generations, and where "quantum leaps" in lifestyle-changing technology or other disruptions might be experienced every 100 years.

Generations would pass, and the circumstances that affected people would remain somewhat static. Certain discoveries caused disruptions, such as the aqueduct and the printing press, and numerous weapons and tactics that, when adopted, would change the expected outcomes of wars in some cases. But the lives people generally led and the opportunities they experienced tended to only change in slight, incremental ways that were as detectable to them as the movement of glaciers. The future was not as tangible to people then, and futurists of the time provided more entertainment than anything else.

This idea of slow and metered change seems to adequately describe life in the past and yet, it is undeniably an inaccurate description of modern life. The information age is characterized by major shifts in lifestyle changes occurring numerous times inside a single

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generation and with disruptions that can upend markets and entire nations without warning. The combination of smartphones and socially-oriented applications, for example, have brought us increasingly extreme examples of semi-orderly but rather effective "flash campaigns," which range in effect from the mass uprising of the Arab Spring in 2011 to the decentralized amalgamation of disorderly interests that came together in the January 6th riot and insurrection at the U.S. Capitol in 2021. On a more metaphysical, but all the while equally concerning front, the deliberate manipulation of stock prices in the case of the GameStop "meme" stock frenzy of 2021 shows that deliberately disruptive activity need not include active physical violence, but could still pose insidious threats to order across the global financial system. These and many other worldwide events demonstrate that technology and the flow of information have outpaced collective government understanding, leaving political leaders and strategists confused on how to keep pace with these unceasing changes. Nefarious actors abound, looking to exploit what have become key digital frontlines shaping the nature and character of global competition and conflict.

In the information age, a person can experience a drastically changing world, the changes of which unfold without warning numerous times across one's lifetime leaving many to feel like they are hanging on to the rear bumper of a world as it fishtails through these hyperactive rates of change; bringing uncertainty, anxiety, and tension along in the wake. The Department of Defense (DoD) has learned to take notice, but there is a new problem. Whereas the static nature of futurism in generations past involved a high degree of fantastical speculation, the circumstances of today have established conditions where there is a dire need to make such speculations. The permutations of potential futures can cause a sense of analytical paralysis, partly because there are too many plausible futures to consider, resulting in an increased opportunity to present

inaccurate views. For example, speculative conversations on the future of quantum computing can evoke an array of non-committal opinions from experts in terms of the likelihood of its implications on national security (particularly in terms of timelines and level of detriment). This has resulted in an inconsistent narrative and a broader lack of appreciation for what achievements in this area of research will mean to people. Attempting to tell this future is risky for experts because the actual state of the situation will be observable in their lifetime and their assertions could be visibly proven wrong.

Some of this is considered more a reflection of our inability to think exponentially, coupled with the phenomenal game-changer that is the modern information environment, with its unending, radically increasing offerings of knowledge. This, in turn, has become somewhat of a grand equalizer for the masses in terms of the proliferation of ideas and concepts which might otherwise be kept as state secrets. An empire might hold significant advantages over this new world for generations if able to control information within its borders. Keeping secrets is exceedingly difficult, and the ubiquitous presence of sophisticated computers allows the average person to make great use of what was otherwise only interesting information. The culmination is rapid change across the world and a clearer sense on how the future will unfold in ways we can observe and experience outside of novels, comic books, and movies.

Therefore, the military and the government must evolve how it thinks about the future and the range of possible and potential threats in multiple futures—an undertaking requiring considerable time, effort, and inclusion from modern theorists such as technology forecasters, futurists, and science fiction writers. To get at what is possible, we first need to think about what seems impossible and walk backwards a little. This thinking will provide a broader range of potentials to contemplate as traditional military planning and strategic planning are necessary but insufficient for the 21st Century. If we do not change the way we think about the future, how we talk about it, and who is forecasting (i.e., with respect to age, gender, ethnicity, domain specialty), we will suffer from a failure of imagination and the resulting inability to comprehend what we can affect in the present. This failure of imagination is a failure of national security and carries potentially catastrophic consequences.

TEAM VALENCE

Amid the pandemic challenges and the political turbulence brought about in the last Presidential election, the Office of the Under Secretary of Defense for Research and Engineering (OUSD R&E) carried out a little-known effort to predict the future of science and technology. Tasked by Congress, the organization had to produce a Science and Technology (S&T) roadmap spanning the coming quarter of a century (note: a separate article featuring the resulting S&T roadmap, still under edit at this time, is anticipated closer to its release in late spring 2022).

Supported by a team of writers, analysts, engineers, and other technical minds, OUSD (R&E)'s Principal Director for Cyber (serving as the effort's primary office of responsibility and

roadmap's signatory) also looked for support beyond the Pentagon to help explore less common perspectives not bound by programmatic and budgetary cycles (PPBE, FYDP, etc.). After a couple of academic discussions regarding the more philosophical points on thinking and writing about the future, a small team devised a plan to use their collective networks to help gather such perspectives from expert futurists, forecasters, and science fiction writers. Project Valence—a self-defined group of "free radicals, orbiting the outer shell of the DoD," looking to make strong bonds with external audiences in pursuit of the broadest view possible on matters of the future—was born out of this. Valence, a collective of hackers with technical backgrounds who had found their way into industry, the Defense Digital Service, as faculty at West Point, and a Senior Fellow at the Atlantic Council, were excited to provide the Pentagon new insights into what the future of technology could look like and how it could affect future military operations. Valence was in a direct position to assist OUSD (R&E) with what would become, for itself, a rather unconventional approach of reaching out to veritable strangers, holding semi-structured interviews, and exploring the minds of modern-day oracles to reset how one part of the Pentagon thinks about the future.

> "It occurred to us that there is a natural inclination for roadmap projects and for the professionals that conduct them to focus on technology in timeframes that relate too closely with programmatic budgetary epochs like the FYDP (Future Years Defense Program) and the POM (Program Objective Memorandum) Cycle. We live in that space, and so departing it is an active and deliberate exercise which would prove critical to exploring the world out to 2045."
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> *– Alex Ruiz, Project Valence researcher*

Based on the team's collective decades of experience within DoD, they were aware of many doctrinal writings, strategies, flight plans, roadmaps, etc., that had failed to accomplish their intended purpose. Many of these thoughtful and thoroughly prepared works ultimately offered platitudes about the most critical national security challenges and offered minor changes (e.g., a new cup holder for a fighter jet) to current technical capabilities as the solution. Their common flaw was that they neglected to obtain a deeper sense of the layered problems of global conflict and the broader matters which cause wars to happen, along with their limited understanding of the insane speed of technological development and adoption in this Century.

To bring a different view of the future to the Pentagon, Valence first organized these layers into three distinct axes. These axes provide a framework to understand what the next 25 years may look like, showing what science and technology capabilities might be necessary to accomplish the DoD's mission. Using outside voices helped the team re-think the typical military approach to the future and technology.

Axis I dealt with natural and phenomenological matters—the independent variables to which humankind is wholly reactive. The obvious ones are climate change and pandemics, but other events such as extra orbital incursions from asteroids, volcanoes, or other potential cataclysmic

events were considered. These variables were examined in the context of the existential challenges and the corresponding forcing function such events play in demanding human cooperation on a grand scale.

Axis II centered on the psychosocial responses of humankind as they pertain to our orientation and behavior triggered by events from Axis I. Billions of people's collective reaction to the stressors of living in an unpredictable environment make up most of the story about the life of humans on Earth. Telling stories is central to the human experience. We craft narratives based on the human condition, positioning ourselves at their center, often with the hopeful outlook of heroic triumph over impossible odds. In the context of global challenges, the notion of Axis II was that humankind could either exacerbate resulting challenges from Axis I through matters of competition and conflict or rise heroically above them through cooperation and coalition. And indeed, there would be much to either fight over or collectively work to overcome. Climate change, for example, will undoubtedly create conditions of failed crops, uninhabitable spaces, and displaced persons (especially in considering the combination of Axis I phenomena and Axis II failures)—which we are already struggling to bear witness to at the southern US border, for example. Valence considered an extrapolation of these and other conditions as they play out around the world, intensifying in volume and urgency from now to 2045, stressing governments and constituents, and calling for solutions to the growing number of people stranded without a country and in search of survival. All of these things, and a range of other such matters left to chance, will cause suffering, induce competition and conflict, and lead to circumstances compelling the US to intervene, setting future challenges for an increasingly stressed DoD.

"The best way to predict the future is to invent it!"

–Alan Kay[2]

And of course, Axis III, which is meant to be injected into the aforementioned lines of thinking and driving a central question: Can the choices we make with science and technology (S&T) help us produce desirable outcomes amid the aforementioned challenges?

"The best way to predict the future...is to prevent it."

–Alan Kay

More specifically, can DoD use S&T to reduce the suffering introduced by both nature and humankind's orientation to its challenges? And, in so doing, could we bend the arc of US (and therefore, global) futures such that we all but eliminate most reasons for committing kinetic warfare, reducing, or perhaps eliminating our need to send younger generations into physical combat? In previous generations, such thinking might have been met with ire, but the US (and the civilian and military leadership of DoD) is poised for a moment of clarity after two decades of fighting in the Middle East. Combined with the notion of Axis I dangers already setting conditions for Axis II incursions (refugee crises, pandemic-triggered scarcity, contested water

sources), Valence encapsulated the notion of reducing suffering while realizing that S&T could exacerbate conflict as much as alleviate it, and that the choices we make now have critical implications on where we end up in 2045.

Beyond the questions regarding the plight of weapon systems and nature and character of war, Valence wanted to understand if the DoD could:

1) Introduce the idea of thinking "to, and through" conflict

2) Understand the potential origins of future fighting

3) Solve it like treating technical problems in advance of complex systems failures

This bit of guided thinking brought the team to a period of planning and internal literature review. Matched with the validating wisdom of renowned experts, Valence sought to make sense of a world whose future had been wrapped in a growing abundance of information but a lack of meaning for many.

The team embraced Dr. Alan Kay's notions about inventing the futures we desired and preventing the ones we do not. However, these notions would remain an enduring challenge of the project—namely, gaining the diversity of thought (from outside the DoD or defense industrial base) to think about the technological challenges and solutions in the next quarter of a century. Like many government agencies, DoD is strongly influenced by retired military officers reprising their professional worldview as civil servants; and the defense industrial base is motivated by selling things to the DoD. While neither of these influences is inherently wrong, they do tend to stifle innovation and thinking, particularly because the two worlds combine with a third in the planning, programming, budget, and execution (PPBE) cycle creating a small universe that consumes most thinking to compete for limited fiscal resources. Ideas of the future, particularly the lofty, must survive immediate resource fights of the "here and now."

To help confront what prospective readers might assume is a Pentagon-produced report on what the future of S&T through 2045 might look like, Valence reached out to experts for a counter-voice. The team created a notional list of futurist luminaries each member could potentially get some time with. List in hand, the team then developed a basic structure for collaborative discussions that would go for hours, all conducted in late evenings so that the team could free its collective mindset for some rather unique and unconventional conversations. Valence members took turns leading the dialogue, and all members took turns presenting questions. All respondents agreed to have the sessions recorded, and an application was used to sort through each one, creating transcripts of the events. Within a few days of each occurrence, the team would collaborate on analysis papers to help distill important points and draw conclusions to aid with the ongoing OUSD (R&E) roadmap (known as the 2021 NDAA, Section 257 report) development. Right away, the team achieved its objective—a giant leap out of the terrestrial confines of DoD future speculation, into the deep and odd questions regarding the state and nature of the world and what life will be like for us in years to come.

The following sections of this article are highlights from the aforementioned Project Valence interviews, each offering some critical concepts that we must pay attention to over the next quarter of a century. They mostly revolve around misconceptions and underlying assumptions that permeate typical military futures thinking. The experts that Valence interviewed brought these ideas to life. Ultimately, the DoD (and even the wider US Government) should incorporate these ideas into their future wargames, simulations, and development of strategies and roadmaps to ensure that our military continues to develop and invest in the S&T capabilities that will meet our needs in the future.

THE FUTURE IS LOCAL

> "And it turns out, actually, that the future is different depending upon where you live, because the future is local. There is no one global future to plan for."
>
> *–Brian David Johnson*

The future happens where you are. Often when people think about the future, it is flawed thinking because they can only imagine that it happens "over there," as if the future happens in Washington DC or Moscow or Beijing or Norway but not in their home. But the fact is that the future happens where you are: all futures are local.

Indeed, spending a day in Seoul and the next in Dhaka can show you how the future unfolds differently for different people and that where you are matters. For example, the future of privacy looks very different in the continental US versus the European Union versus Russia versus China. These fundamental differences directly relate to worldviews, competition, and play a major part in the potential for conflict.

In creating the S&T roadmap, the OUSD (R&E) team was challenged to plan and prepare for the future, yet their standard assumption was that the future would be "a" future that linearly progresses. While scenarios used in the roadmap addressed different threat types to tease out specific technological aspects of the future operating environment, they still followed the same future progression. This is typical of military thinking, where one path to the future is selected, and then the effort is focused on developing plans and capabilities to succeed on this path, minimizing alternatives. Additionally, this limits practical reasoning and expectation not to consider how other nations/societies will embrace visions of the future, instead to assume that the US-centric mentality will hold across the globe.

Adopting the mindset that the future is not a global future, but a local future will help drive a sense of the underlying issues we must be more prepared to engage with. In the combined stressors of budgetary austerity, hyperpolar information and cyber conflict, aggressor nations and regional hegemony, and the imminent threat of climate change, the DoD will be unable to respond symmetrically to every failed matter of geopolitics. The picking and choosing that planners and decision-makers will have to do will be eternally dependent on understanding

the Axis II matters of people and culture and any underlying Axis I phenomenology potentially bringing out the worst in humankind.

As DoD thinks about how the S&T investments in cyber over the next decade unfold, one element that can help disambiguate the synchronous multi-verse problem is the reminder that S&T presents incredible opportunities to help level playing fields between population centers experiencing the least desirable of these futures. For generations, the US has observed struggles in far-flung parts of the world and responded with limited charity and humanitarian aid. The current state of technology offers unprecedented opportunities to help underserved communities gain sustainable footholds across the basic matters of survival: electricity, water, food, and shelter. A major change agent that will help illuminate paths to success for all populations is information technology, which is undergoing its latest chapter of expansion in the form of higher throughput for urban areas and increasing overall reach to far-flung areas thanks to expanded broadband programs and the prospect of space-based internet provisioning projects like Starlink. Vast communications infrastructures that bring the ultimate public library to the hands of anyone with a capable device can and will ultimately bring about progress if we take Joy's law of management[3] to heart.

We must consider that the future not only plays out differently depending on where one lives on Earth, but that technology going forward allows for some degrees of freedom in designing the reality to unfold. Considering this unevenness, and that lack of opportunity contributes to conflict, it is important to understand the state of the world in aggregate beyond our borders.

THE CHARTER TO GET THINGS RIGHT HAS BEEN WRITTEN: THE PLIGHT OF FAILED AND FAILING STATES IN THE FUTURE

> "Roughly **a third of the world's countries** are what would be called **failing states** by any set of measures, for example from the Fragile States Index or the World Population Review, with almost **another quarter on the verge of failure.** And these are the countries where a lot of wars of contagion will occur. Many of them will be internal wars, though sometimes they'll bleed over to involve other nations, as the Congo war that killed 5 million did. These conflicts should matter to us, in terms of trying to prevent or deter them, or at least to respond effectively to them. Because they have led, and will continue to lead, disproportionately, to terrible, terrible human suffering."
>
> *–Dr. John Arquilla*[4]

As DoD looks at the investments they should make over the next few decades in the cyber S&T spaces, it is essential to also think about where DoD assets might be deployed in that same time period. As stated by then-Secretary of Defense Robert Gates to a class of West Point cadets in 2011, "when it comes to predicting the nature and location of our next military engagements, since Vietnam, our record has been perfect. We have never once gotten it right, from the Mayaguez to Grenada, Panama, Somalia, the Balkans, Haiti, Kuwait, Iraq, and more– we

had no idea a year before any of these missions that we would be so engaged."[5] This trend becomes increasingly concerning as the future of failing states should give us pause. We should not be planning for a Fulda Gap remix or the "classic blunder of land war in Asia."[6] Still, we could be called on as a peace-keeping force or humanitarian aid providers around the globe in small countries where our adversaries are attempting to co-opt and take advantage of their dire circumstances. These are the same small countries that will benefit or suffer from the evolution of and deployment of technology. How, with a small force, can we deter our adversaries in competition before conflict in a location that, potentially, we never saw coming?

The US will continue to face the same adversaries over the next two decades (the 2+3),[7] but must embrace and harness S&T to achieve its political and military aims in ways unlike the previous two decades. As such, the DoD should expect to employ forces in new locations/countries, accept and embrace new ways to present task-organized and/or force structure, which accounts for the sharply increased cyber capabilities we will need in the future. This holds especially true in terms of electromagnetic spectrum implications inherent in our pivot away from the austere "last mile" challenges of Southwest Asia to the dense backdrop of digital noise present across rising areas of interest in the Indo-Pacific. Complex operations we have mastered in one part of the world do not readily translate to others (e.g., LTE, 4G, trusted 5G, non-trusted 5G, authorized spectrum bands, or trusted/non-trusted telecommunications infrastructure). Considering that global trends show a sustained increase in cyber and information warfare, these classes of assets should, from now on, be regarded as foundational to fighting conflict as runways, fighters, bombers, and carrier battlegroups have been. Investment in these technologies and an extreme focus on integrating cyber and electronic warfare capabilities are required to ensure that we can compete in the active warfighting domain of our time, and help to define norms that reduce the circumstances of a hostile information environment.

FUTURE CONFLICT SOURCES

> "If anything, the next 10 years will be really sorting out how do we operate in this world. And if we wanted to hedge our bets and get ahead on future conflicts, I would be **investing in as much technology as possible to make abundant things that are currently not abundant, such as water, food, and electricity. If you can make those things abundant**, then you remove sources of future conflict."
>
> *–Dr. David Bray*[8]

> "**And the simple fact is, every new abundance creates an adjacent scarcity**. So if you want to look for the scarcities you're gonna fight over, look at what's next to the new abundance."
>
> *–Paul Saffo*[9]

DoD's mission, as the largest USG agency, is to provide the military forces needed to deter war and ensure our nation's security.[10] The DoD has continued to adapt to an overall declining

state of physical conflict since World War II, but an increasingly multi-polar, and now hyper-polar threat environment in terms of armed nation-states, low-intensity conflict, and what will undoubtedly be a continued rise in trans-national threats such as narco-terrorists, complex criminal syndicates, hacking groups, and cyber weapons proliferation and trading across the dark web. These threats represent a significant increase in potential destabilization, and all such elements are being further stressed by climate change. DoD will have to consider these concepts alongside their more traditional undertakings, such as: confronting nuclear-armed states and their outlying threat rings of kinetic weapon systems. Ultimately, interventions across all conceivable domains of conflict will be required to secure a future state recognizable to us (today) in terms of Western, democratic values.

The DoD needs to consider how it will combine focusing on developing and purchasing the next generation of tanks, fighter jets and aircraft carriers while also developing technology and promoting scientific research which can adequately affect the survival needs of the lowest level of others around the globe. Simply put, a world where a third of nations are failed states, with another major tranche on the brink, is a net failure for everyone, most certainly in the recognition that climate change will create challenges that defy political borders. Alleviating these matters results in a direct payoff here at home, but this notion can be hard to sell.

The US is engaged in a great power competition. It has become increasingly clear that our adversaries wish to shape a world consistent with their authoritarian model by gaining authority over other nations' economic, diplomatic, and security decisions. This occurs most readily when small nations are struggling with scarcities that our adversaries offer in abundance. As part of the DoD's mission to ensure our nation's security, we must realize some S&T investments create capabilities that achieve military objectives on the battlefield could have a dual-use purpose of balancing the playing field in other countries during competition.

WHAT DO WE WANT FROM TECH?

> "What we're building right now is a whole bunch of Russian sailors. We're training our AI systems to do exactly what they are told when they are told to do it and not to think. What we really **want to do is build a whole bunch of 1943 farm boys from Iowa,** who see something and can improvise the living daylight out of it because of what they understood."
>
> *–John-Francis Mergen*
>
> "When will we have a robot give a bath to an elderly person at home?"
>
> *–John Markoff*[11]
>
> "...whenever we have a new technology, we always use the new technology to pave the cowpaths...to do some new thing in an old way. And, that gets me to what we're doing today is the ultimate cow-path-paving technology. We're using the power of the web and the awesome processing power on our desktops to simulate in a really inefficient way...

to march backwards into the future. You know, **let's let technology be truly novel.**"

–Paul Saffo

One of the most considerable challenges regarding S&T investment is to first pause and analyze what we really want from S&T. Twenty years from now, what do we want technology to be able to do for us? And, perhaps more broadly, what do we want the world to be like?

As children, the Jetsons[12] gave us a possible view of the future world full of advanced, digital technology. It was a world of push-button simplicity. Everything could be done with the push of a button in 2062 (the notional calendar year for the Jetsons). That is all that George does all day (all 3 hours) at work, and all that Jane needs to do to keep the household running. And yet, we were also introduced to Rosey, the robot maid – the imperfect, humanoid robot helper that did all the things that needed more than a push of the button. Just as Hanna-Barbera studios had to make conscious design choices on what activities would be acceptable for a robot or technology to perform and what activities still needed a human to action, DoD must spend resources (time and thinking) to explore what are acceptable activities for future technology and where we are still uncomfortable ceding control to a machine or piece of code.

Then, as was mentioned previously in this article, imagination must be let loose. We must journey to the edge of the impossible and let loose the shackles of societal convention to think about what we want technology to actually do for us. Consider this the "inverse" problem. Technology does not have to be constrained to only automating today's processes or performing incremental improvement on today's capabilities; instead, it has the potential to be game-changing—if only we can imagine it. However, before we can truly develop a comprehensive game plan for future S&T investments, we need to understand what we want that S&T to be able to produce.

AI IS A JOURNEY OF DECADES WITH AN UNTOLD FUTURE

"So, the history of the steam engine is actually the history of a technology that evolved over a 100-year cycle from its first rudimentary stationary form built to evacuate water out of mines...to becoming a mobile train, to developing into a railway system, to re-defining our concept of time, to influencing how utilities were distributed across the nation. Today's AI is like yester-year's steam engine. When it becomes a system (and not a piece of technology), that will be exciting. Because all the technology that you're imagining is still stuck on it being inside a computer and so people are failing to grasp it because they are so mesmerized by the impossibility. But the **world that is coming is infinitely more complicated** because what will happen when AI is no longer bound inside the object or talking to each other?"

–Dr. Genevieve Bell[13]

Whether you consume your news from the television or the internet, there is a seemingly endless discussion about Artificial Intelligence (AI) and how it will save the day. Vendors are

hawking it in their products to increase your productivity, and for-profit universities are offering degrees in it so that you can weather this new coming age of intelligence as your old job will be replaced by machines and software. When faced with a future changing at an ever-increasing rate, it is easy to get caught up in the rip current and just accept that AI will be ready to save us and make it all better (or that the great AI borg will consume us all, and that resistance is futile). At present, AI applications often echo history when snake oil was sold as a cure-all elixir for many kinds of physiological problems in the 18th and 19th Centuries. Unfortunately, we now know that this panacea failed to solve the health problems that it was marketed against and, in fact, just worsened many of these health problems as individuals failed to use other means to combat their ills. So, can we really expect AI to solve all our problems in the future?

The answer is maybe, but probably not at the timeline that current vendors proclaim. AI is not new: it was a concept first coined in 1955 by John McCarthy roughly as, the goal of AI is to develop machines that behave as though they were intelligent.[14] It is now 60+ years after the original work, and we are still unsure of when AI will really arrive. A much more elegant definition of AI is from Elaine Rich: "AI is the study of how to make computers do things at which, at the moment, people are better."[15] This manifested in 1955 when Arthur Samuel (IBM) developed a learning algorithm that could play checkers better than its developer to 2016 when AlphaGo beat one of the world's best Go players. AI science takes time and remains an elusive reality compared to Dick Tracy's watch and flying cars (for some reason, Maxwell Smart's shoe phone never seemed to penetrate the market). Therefore, to imagine that AI will be here tomorrow to solve our world challenges is a bit too optimistic. However, we also can't just ignore it until it gets here because of the profound impacts on society and life. To quote the Space Balls,[16] "when will then be now?" Perhaps when a robot can improvise Gershwin tunes on a violin alongside human jazz players, that might be a vital clue. When said robot creates novel things never done on a violin in the same situation, one can probably be certain.

Though the steam engine took decades to manifest, it still had profound impacts around the globe: from developing the concept of standard time (and time zones), determining how major transportation and communication infrastructure would be employed within the US (thereby creating have and have not zones). None of these global effects were imagined by the creators of the steam engine. Similarly, it is hard to picture the potential effects that AI will have on humankind. This yields the difficult problem of preparing to use a technology (and respond to an adversary's use of this technology) without knowing what this technology can do and when it will be available. Therefore, we must continue to invest in both the science and the technology that support the development of AI systems (as outlined in the upcoming OUSD (R&E) roadmap) and acknowledge that DoD must diversify its portfolio of technological solutions to best support the military. Even when the general AI arrives, it will probably create new problems/challenges that we cannot begin to fathom today.

HUMAN-MACHINE TEAMING

> "...humans have been having conflicts for multiple millennia. Looking ahead, what do we still not know about human nature that could trip us up in the next future? My guess right now is, **we still don't fully understand how human nature will respond to ubiquitous advanced technologies**, which are fundamentally alien to how evolution has shaped our behaviors as a species."
>
> *–Dr. David Bray*

It seems that an unstated assumption within DoD is a take on "if we build it, they will come"[17] —namely, that if we build the S&T capability, then it will be helpful and used by humans. Imagine an early caveman being introduced to the wheel (an alien thing and beyond their normal comprehension of the world's capabilities). How many iterations of this technology were necessary until he became comfortable with it? How many iterations of use were necessary until he found the best way to use it? So, it seems that many are assuming that if new cyber capabilities are built, they will be instantly valued, useful, and comfortable within a military context.

Yet, there is still a great need for thinking and researching the best way for humans to team up with machines to build a productive partnership. These concepts must be included in developing future cyber capabilities that operators will need and want to use. Indeed, one can think of it as creating a symbiotic relationship with technology—to enable it to be more like an R2-D2 to our Luke (favored over the clunky Boolean-dependent C3PO from Star Wars).

Research shows that humans need three things to trust an entity (whether that is trusting another human being or a machine): that the entity is benevolent, competent, and operates with integrity.[18][19] If those features can be included in the design, then a pathway is created for a human to trust the capability. Because if you think that they are benevolent, you will probably form a friendship with them. If you think they are competent, you will treat them as an expert system. If you believe they have integrity, you are not worried about what they will do with your data or information. To effectively team, the entities must trust each other.

Additionally, until now (in human history), there have been very few technologies that extend humans' cognitive capabilities and their ability to operate at a scale beyond their physical reach. Humans are good at building tools that are mechanical and adapting to them. But aside from books and possibly some psychedelic drugs, altering one's mental state is new to us. A typical conversation with the various SMEs that Valence talked to would include a warning to proceed a little bit cautiously with human-machine teaming. Namely because a lot of what we see right now with domestic polarization in the US, Europe, and elsewhere clearly demonstrates inept understanding of the impact of today's tools on our cognitive abilities, let alone be able to comprehend the potential impact of tomorrow's capabilities.

So, building trust in cyber capabilities and envisioning how teaming will occur with operators must be a vital component of the scientific research and application development from the initial

design phase of the capabilities. Developing this understanding of how humans will respond to technology might be the difference between success and failure in the future, given that, now more than ever, we will look to technology for answers about our most vexing problems.

CLIMATE AS A RAVISHING AFFECT

> "DoD is not a capitalist enterprise; It is effectively a non-profit—it uses the money given to get the job done that it has been assigned to do without worrying about whether it will make a profit in the end. So, it is an exemplary organization: highly competent, good esprit de corps, really good wage parity, and working on protecting the country... **DoD is the largest non-profit in the world.**"
>
> *–Kim Stanley Robinson*[20]

In a thought-provoking conversation with Kim Stanley Robinson right after the release of his new book "The Ministry for the Future", he challenged our understanding of what the DoD actually is. To not just think of the organization as employing almost 3 million service members and civilians to defend the nation, but to think of the organization as the largest non-profit in the world. Considering that the DoD is not constrained by a need to make money and its "shareholders" are the American people, we can lead the world in a hopeful new direction. Making the world a safer place makes America a safer place.

As the previous generation of DoD leaders faced the quasi-existential threat of the Russians pouring through the Fulda Gap, today and tomorrow's leaders face an actual existential threat of climate change. It will radically change how the DoD envisions military operations and prepare for them across the DOTMLPF-P[21] spectrum. Climate change threatens to compromise cities/regions/countries and inflict severe and irreversible harm to almost every aspect of society, creating failed states and increased sources of conflict across the globe. A whole-of-world approach is needed but at least the US can start with a whole-of-government approach and be the moral leader in this space. The DoD is uniquely positioned to do so within the US government due to its resources, authorities, influence, partnerships, and sheer size. The real challenges are those of foresight and wisdom, which are required to mobilize the will of the American people to understand that situations of suffering beyond our borders are incubators of tomorrow's wars, some of which will involve our armed forces. There could be no better spokesperson than the DoD regarding the net cost of such failed circumstances and how to avoid them.

Some elements within the DoD S&T/R&D community are already working towards solutions that directly address the most pressing drivers of climate change. The DoD uses a tremendous amount of energy. While this number has been dropping since 1975,[22] the Department still uses more energy than any other single entity on the planet. To combat this reliance on fossil fuels and reduce the military's carbon footprint, the Services initiated several projects to increase efficiency. For example, the Navy's Geothermal Program Office (EXWC PW68) is a

leader in geothermal resource care and exploration within the DoD. They explore, develop, and maintain geothermal energy production sites for the Navy and the DoD. Similarly, the other service components have long-standing research programs that could positively affect climate change if their successes were embraced and incorporated on a national scale. In recognition of the impact of climate change on national security[23] and the need for results, the DoD Climate Action Team stood up earlier this year to translate thoughts into action.[24]

As the threat looms nearer and more significantly, the window of opportunity for humanity to respond is quickly disappearing, and the necessity of intervention from the DoD becomes greater. The DoD cannot remain solely focused on purchasing the next generation of aircraft if, within a decade, we might not have the fuel to fly them anymore.

MILITARY CULTURE IS AN UNSOLVED PROBLEM

> "Therefore, perhaps the question is not what is the future but what are our sacred cows? Those things that we won't get rid of. Those organizational and/or political roadblocks that are going to keep us from adopting well or innovating or changing. And that requires soul searching for people."
>
> *–P.W. Singer*[25]

Both the US and its nation-state adversaries have the problem of relying on decades of military culture to make decisions about the future. However, the US should rely more on what basic science tells us, and the answer will probably be in the middle. Therefore, as we craft the roadmap to the future, it will be a significant problem to also get the narrative correct so that we can start to overcome the inertia of military culture that might hinder the development of capabilities that will save future lives on the battlefield or spare us from battle altogether.

It is not just about choosing the right cyber capabilities to invest in over the next two decades, but also about how we choose to use them once they arrive. The worry is that we will be like the British in the 1920s. Then, it was not about whether you used the tank and the airplane in battle, but about how you used them. The British invented the tank and the aircraft carrier. They conducted phenomenal wargames to test the technology's best employment within operations but did not choose the best employment concept because of their own military culture. Military history is rife with examples of failing to implement new technology correctly because the current culture could not imagine doing things differently and actively worked against embracing new ideas. Therefore, even if the DoD develops a perfect roadmap to investing in S&T capabilities over the next couple of decades, if they fail to overcome the long-standing inertia of military culture, that failure might hinder the use of capabilities that will save future lives on the battlefield. This holds especially true in that broader DoD does has not recognized that Cyber and IW will represent how most fighting will unfold in the future, and that there is a more logical conclusion to be drawn that JDAMs will probably not be needed as we shift our gaze to Indo-PACOM.

The influence of US military culture is also seen in the argument of quantity versus quality—especially as it plays into technology. A significant risk to the DoD is that the combination of military culture and the defense economy has been quality-focus dominant for the past 75 years. The irony is that this is the opposite of what we did in World War II to win; the US made durable, high-utility systems (akin to Jeeps) but now make exquisite, fragile systems similar to Ferraris. But as we look at autonomous robotics (in the air, sea, and land) and swarming tactics, Ferraris do not seem to be the way to go. The fear is that even if the most innovative military planners and technologists determine that swarms would be better to accomplish anticipated military objectives, it is unclear whether the Pentagon could ever convince itself to purchase enough to make it profitable for the defense contractors to offer. The contractors will most likely peddle the Pentagon on the amazingness of six big, expensive platforms. Then the generals will be surrounded by contractors explaining how effective the big ones are, and there will be no marketplace offering the small ones which meet our tactical needs. Therefore, reworking the military and defense sector culture might be a key component to realizing and embracing our future S&T needs.

Ultimately, the sacred cows are the military's unconscious bias(es), which are based on decades of experience in a risk-averse model. If the DoD refuses to picture a future where they will have to change, they will be caught by surprise and at a devastating disadvantage if the adversaries can let go of their sacred cows.

WHAT IF WE DO NOT INVEST IN SCIENCE AND TECHNOLOGY?

A recent example of the cost of second-rate technology on the battlefield is the 43-day Nagorno-Karabakh war. This was a short and largely unacknowledged part of a decades-old Caucasus conflict that unfolded in late 2020 in a region fought over by Armenia and Azerbaijan (the territory is internationally recognized as part of Azerbaijan). Armenia suffered a crushing defeat against the Turkish-backed Azerbaijanis, who made massive investments in Turkish and Israeli unmanned aerial vehicle technology in the years leading up to the war. Armenia showed up to fight with old tactics and Cold War-era field weapons (tanks and artillery pieces).

Blending well-crafted deception tactics and integrated systems, Azerbaijanis used decoys (old An-2 biplanes retrofitted with remote piloting capability, thought to have been acquired from Ukraine) to lure out Armenia's mobile air defenses in a kind of pilotless Wild Weasel suppression of enemy air defense (SEAD) campaign. The actual UAV fleet, Turkish Bayraktar TB2, and Anka-S combat drones loitered at higher vantage points and observed the defense positions, swarming the Armenians and issuing a sweeping, punishing defeat over nearly 180 separate battles. According to a Turkish analyst from the Istanbul-based Center for Economics and Foreign Policy Studies (EDAM), what was showcased by Azerbaijan on the battlefields of the Karabakh region extended from Turkish-provided doctrine published on robotic warfare and concepts of operations.

The Azerbaijanis adopted other tactics from Turkish, Russian, and US playbooks, including the use of small agile field forces akin to Special Operations contingents and small bands of advanced operational nodes dubbed "saboteur groups," somewhat like the curious case of "little green men" present during Russia's 2014 aggression in Crimea. The combination of battlefield losses, air superiority provided by highly integrated and capable UAVs, fissures created by the saboteur groups that helped ensure target fixes, and the use of laser targeting technology made for a case of overwhelming force that resulted in Azerbaijan's successful takeover of large parts of the Karabakh region before a cease-fire was declared.

The Nagorno-Karabakh story is one of successful systems and tactics integration, and of timely and effective investments in S&T. Moreover, what is known about Azerbaijan's investment in these technologies includes the rapid acquisition of these and other systems in 2018, meaning that the intense and very rapid planning and engineering over two years put them in place to utterly dominate a comparatively stone-age rival. Extrapolating on this a little further, what this conflict should teach us is that the kill chain is much broader than typically referred. Comprising S&T, R&D, build and development, implementation, and fielding, and beyond, these are matters which must be honed and compressed to gain and maintain the cascading advantages advanced technology can provide.

CONCLUSION

Now more than ever, we must expect the unexpected. And so, writing about the future has become a crucial exercise that allows us to consider what we will need to confront in terms of threats, not only as it pertains to the future of the United States, but to a world favoring Western, Democratic values. Whereas conflicts of the recent past have been the ones easiest to assess, the DoD will be pushed to acknowledge that planning for and fighting according to lessons learned of previous wars is a losing business model, and there will be less tolerance for lack of foresight as our interconnected, technological world offers us the ability to do predictive analysis. Easy as that is to accept, what must come next is a changed way of thinking across the DoD that is insistent on sensing the causes of conflict and understanding how adversaries will engage, across physical and metaphysical domains alike, and amid the stressors and pressures of ultimate pacing threats such as climate change and the cascading challenges which will result. The pace of such matters is staggering, and the rates of change in norms and aspects of conflict will continue to vex planners and decision-makers. But, if we tune into the thoughts and curiosities of those who live in this particular head-space – the futurists, technology forecasters, and science fiction writers – we can ground ourselves in important elements critical to understanding these abstract challenges. Namely, that the future is local, that we can and should seek to invent the future as we desire, and that deliberate prevention of a world we wish for others not to inherit should be thought of as within our span of control. We need only commit ourselves to the required levels of cooperation, understanding, of course, that our species has not yet proven its ability to do that quite yet.

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