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Military readiness

How emerging technologies can transform defense capabilities

Part of a Deloitte series on Industry 4.0, digital manufacturing enterprises, and digital supply networks

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About the Deloitte Center for Government Insights

The Deloitte Center for Government Insights shares inspiring stories of government innovation, looking at what's behind the adoption of new technologies and management practices. We produce cutting-edge research that guides public officials without burying them in jargon and minutiae, crystalizing essential insights in an easy-to-absorb format. Through research, forums, and immersive workshops, our goal is to provide public officials, policy professionals, and members of the media with fresh insights that advance an understanding of what is possible in government transformation.

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In the digital era, organizations can increasingly leverage data specific to their core mission to improve performance. Deloitte's Mission Analytics offering applies contemporary data science approaches, largely in the context of existing client technology architectures, to deliver insight on current performance or to make important operational predictions. Robust open-source tools enable teams to work quickly with minimal technology resourcing for many projects. In other projects, teams configure and use leading statistical analytical packages to create results with robust enterprise support. Either way, organizations can leverage mission analytics to put their data to work and gain useful insights. Please reach out to any of the contacts listed in this article for more information.

What readiness means in defense

FROM PERICLES TO Patton, military leaders have likely always wondered if they had enough soldiers, spears, or tanks in fighting condition. In today's environment of proliferating threats, military readiness is once again in the spotlight. US Secretary of Defense Jim Mattis has made readiness a priority, while across the Atlantic, British, German, and French defense leaders are also formulating plans to increase the low availability of combat aircraft, ground vehicles, ships, and personnel.[1] As militaries across the globe look to maximize the value of every dollar in their budgets, it seems time to reframe the debate on readiness with a new lens that leverages technologies, data science, cloud computing, and artificial intelligence (AI) capabilities unavailable just a few years ago.

Readiness can inspire quite a lot of contention[2]. Readiness has been conceptualized as both operational (a unit-level measure) and organizational (a strategic perspective). The concept of the full readiness spectrum reconciles this contention, by incorporating both the operational and strategic lenses of readiness into a comprehensive view. At the narrowest level, readiness is the training and health of a unit and the maintenance status of its equipment. At its most expansive, readiness is "the ability of military forces to fight and meet the demands of assigned missions."[3] The full readiness spectrum spans from this most narrow point all the way through the most expansive, providing decision-makers not only with high-level views needed for strategic decisions, but also the detail needed to make tactical improvements. Thinking about this full readiness spectrum sparks an important set of questions: Ready for what? Ready by when? Ready with what combination of forces?[4]

Readiness ultimately rests on one core question: Are we prepared to win the next fight? No single question might better define a military's mission than whether it can muster sufficient forces, anywhere, at any time to defeat an adversary. But it is also a difficult question to answer: It hinges on a huge number of inputs and assessments that span from the tactical to the strategic ends of the spectrum, each of which can be challenging to gather and analyze. To help simplify the problem, this core question can be broken into three questions that decision-makers should understand:

- **What capabilities are needed for expected missions?** What are the capabilities, assets, and enablers that allow militaries to execute a planned mission directive? Also known as force structure, this is the starting point for readiness. For if leaders want to determine how "healthy" or able forces are to execute missions, the nature of those missions matters greatly.

- **What is the status of those capabilities?** What is the current state of the personnel, weapons systems, and supporting infrastructure needed for mission execution? In other words, a measure of how "healthy" a force is relative to the missions likely to be assigned to it.

- **How to allocate the next dollar to improve those capabilities?** How should militaries invest in maintenance, modernization, or training to realize the greatest possible improvement per dollar? Often seen as a budgeting or planning issue, this question is fundamentally informed by readiness—where you need to invest is generally determined by where the force is healthy and where it does not meet requirements.

Current readiness reporting systems often struggle to fully address each of these characteristics, but a new approach built on emerging technologies, including sensors, wearables, autonomics, and machine learning, can provide defense organizations with greater insight across the full readiness spectrum than they have ever had. Together, these technologies are enabling a shift in how industries operate. That shift, called Industry 4.0, is already enabling the private sector to prototype rapidly, build products faster, optimize operations, improve maintenance, and manage smarter supply chains. But to understand the full value these technologies bring to readiness, we first examine some challenges in the current system.

Stop reporting, start knowing

CURRENT APPROACHES TO readiness measurement limit the visibility senior leaders have into the real-time, ground-truth status of their forces. That's because readiness in its current form does not always accurately depict the true state of forces—instead, it's a model. Current readiness metrics attempt to *represent* the state of the forces relying on a set of proxy inputs, but this system has two inherent weaknesses: First, reporting systems are fundamentally backward-looking; second, they provide decision-makers with only high-level summaries, not underlying data.

The current system, in effect, documents the results of resource decisions made months or even years prior, and by summarizing all the data together, tends to lose critical information about the root causes of readiness problems. In a reporting-based readiness system such as that used by the US Department of Defense, only net status reports—not the authoritative data sources—are forwarded to leadership.[5] The result is that leaders are sometimes making decisions based on information that is only as deep as a single slide deck. What is needed is a system that can provide broad trends to support the decision-making of senior leaders but still retain the granularity of the underlying data.

Truly digital organizations recognize this, and they rely less and less on reporting alone to evaluate projects, performance, and maintenance.[6] Instead, they use real-time data streams taken from real-world measurements. Every employee check-in, every rotation of a connected turbine, and every heartbeat sensed by a wearable device can generate meaningful data. Individuals can be compared with others and with their own histories. This new wealth of data means organizations can spend less time developing models of the world and start looking directly at the real world.

Getting to "know"

A NEW APPROACH to readiness based on real-world data may seem almost impossible to implement. After all, finding the location and status of every piece of equipment and every service member seems a nearly insurmountable challenge. However, this large task can be made simpler by breaking it up into smaller and more manageable problems where existing solutions can help. In fact, portions of such a solution are already at work in many commercial companies using Industry 4.0. (See the sidebar "What is Industry 4.0?")

The core of Industry 4.0 involves using digital information about the physical world to improve decisions and actions taken in the physical world. With more accurate information about the physical world, organizations can make better decisions, faster.

No company faces the same daily challenges as the military, so merely importing solutions wholesale from the commercial world will never work. However, the core issue of readiness is similar in nature to the business challenges faced by many companies. Therefore, the approaches and technologies of industry, when recombined in new ways, can help to solve similar challenges for the military. In this way, a manufacturing company struggling with efficiency could look very much like a military organization struggling to determine its readiness. Both need to know the location of their assets, the condition of key components, and whether the current status of equipment can meet the current demand from orders. To put that in the terms of the three readiness questions, both militaries and companies need to *know the need, know the assets,* and *know the best action* to take. For the military, this means that the three questions of readiness each require information of a certain type:

- *What capabilities are needed for expected missions* requires that we *know the need*, which means correlating mission parameters to the force requirements and capabilities needed to execute.

- *What is the status of those capabilities* requires that we *know the assets*, meaning a real-time, on-the-ground picture of the status of the Joint Force down to the individual tank, aircraft, and service member.

- *How to allocate the next dollar to improve those capabilities* requires that we combine those data streams so that leaders can *know the best action.* Correlating force requirements for likely missions with the real-time picture of available people, systems, and infrastructure allows leaders to understand where shortfalls may exist and where additional funding could be most effective.

Each of these information needs can be addressed by different solutions, some of which are already at work in commercial plants and warehouses around the world (see figure 2).

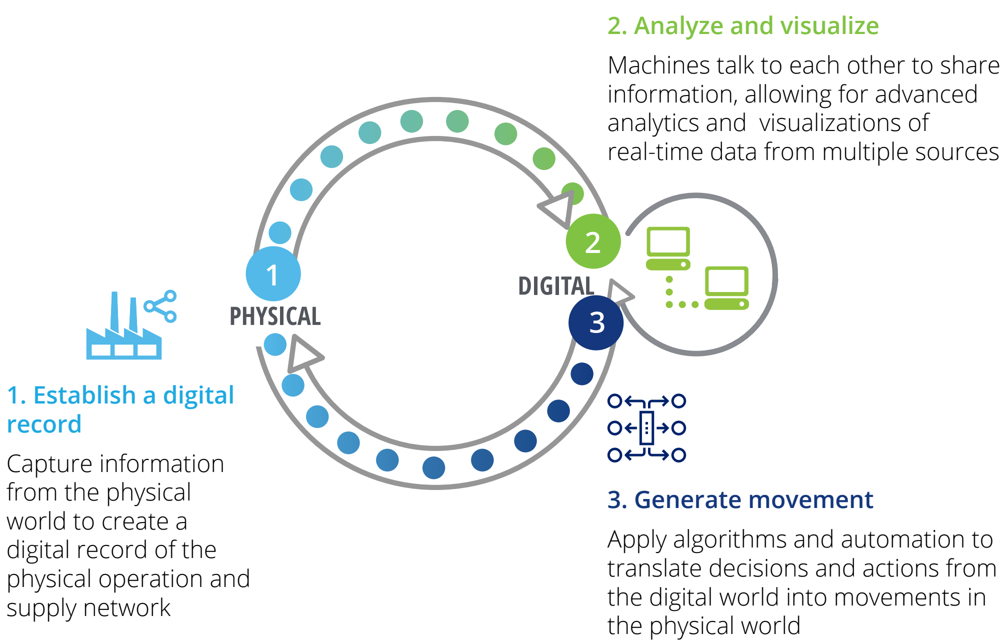
WHAT IS INDUSTRY 4.0?

The concept of Industry 4.0 extends digital connectivity into the physical world. Industry 4.0 technologies combine digital information from many different physical and digital sources and locations, including the Internet of Things (IoT) and analytics, additive manufacturing, robotics, high-performance computing, artificial intelligence and cognitive technologies, advanced materials, and augmented reality. These data sources come together to improve operations in an ongoing cycle known as the physical-to-digital-to-physical (PDP) loop (figure 1).

Throughout this cycle, real-time access to data and intelligence is driven by the continuous and cyclical flow of information and actions between the physical and digital worlds. Many organizations already have some portions of the PDP loop in place, namely, the physical-to-digital (sensors providing data about key assets), and digital-to-digital (digital analytics tools) processes. However, it is the leap from digital back to physical—from connected, digital technologies to action in the physical world—that constitutes the essence of Industry 4.0.[7]

FIGURE 1

The Industry 4.0 physical-digital-physical loop



For further information, read *Forces of change: Industry 4.0*[8] and *Industry 4.0 and manufacturing ecosystems: Exploring the world of connected enterprises*[9].

Source: Deloitte Center for Integrated Research.

FIGURE 2

Readiness questions can be answered by Industry 4.0 solutions

Readiness is all about: Are we prepared to win the next fight?
That question implies three questions itself:

Questions	**What capabilities are needed for expected missions?**	**What is the status of those capabilities?**	**How to allocate dollars to most effectively improve those capabilities?**
Information needs	**Know the need** What capabilities are required for different mixes of missions the joint force is likely to undertake	**Know the assets** The status, location, and capabilities of all equipment, personnel, and infrastructure	**Know a common picture** Combining the need and asset assessments shows the gap between needed and available capabilities
Solutions	Machine learning associates historical missions with the forces required	Industry 4.0 provides a real-time, sensor-driven picture of personnel, equipment, and infrastructure availability	Machine learning programs can examine those gaps and determine the most effective path to increase the needed capability

A more effective, lethal, and affordable force

Source: Deloitte analysis.

Know the need

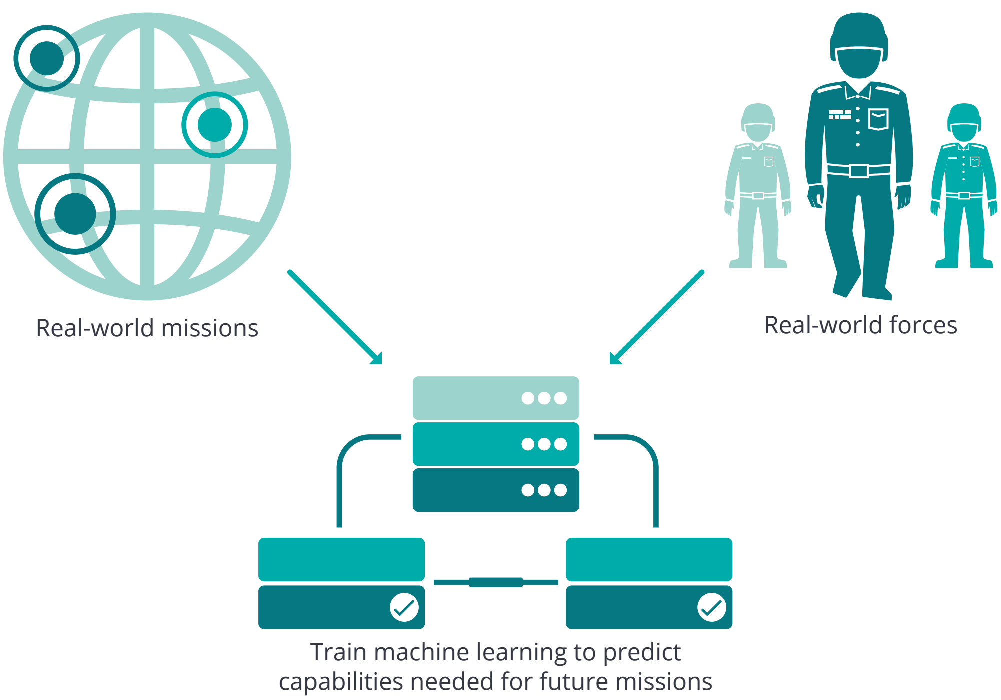
Knowing what capabilities are needed for a mission may seem to be the simplest of all readiness issues for the military. After all, the units and capabilities needed for key missions are typically set out long in advance in strategic plans at every level of command. But there can be a large difference between military operations as planned and military operations as successfully executed. After all, as the old adage goes, "No plan survives first contact." Therefore, to truly understand how ready a force is to execute a mission, militaries should not only look at what the plan calls for but also what has been done in the past in real-world missions.

This is much more than just looking at the order of battle or lists of units. Rather, it is about understanding how different parameters of a mission place demands on the forces that will execute that mission. Everything from the task, to the terrain, to the weather, to the particular enemy being faced can change the makeup and skills needed to execute that mission. Operating at high altitude? You will need more helicopters due to reduced load in the thin air. Tasked with a foreign internal defense mission? You will need junior personnel with local language skills. The huge variety of different factors make predicting future force requirements exceedingly difficult.

Here, machine learning can step in to provide an answer and ease the workload. Today, machine learning is all around us performing tasks from recognizing hand-written digits to recognizing patterns of credit card fraud. A machine learning tool using neural networks or another approach can be trained to associate the various mission parameters (e.g. task, enemy size, terrain, weather, time, and so on) with the size and capabilities of the force needed to accomplish them. (To read more about how machine learning can help planning an operation, see the sidebar "Industry 4.0 in the real world: Machine learning in supply chains.") Over time, the neural network will become trained enough to anticipate the need for wholly new mission parameters it has never seen before. In other words, the machine learning tool will be able to reliably suggest the required capabilities for future missions. But most importantly, these suggestions will not be based on assumptions or best guesses; they will be based on hard-won lessons from real-world missions (see figure 3).

FIGURE 3

Neural network machine learning can be trained to match force requirements to different mission parameters



Source: Deloitte analysis.

INDUSTRY 4.0 IN THE REAL WORLD: MACHINE LEARNING IN SUPPLY CHAINS

Restaurants may seem like a familiar, simple business, but many feature complex supply chains with planning and actions reminiscent of military operations.[10] Ingredients must be delivered regularly so that they are fresh, but all of that depends on the rate of use, which depends on how often customers order different dishes—something outside the control of the restaurant. Traditionally, this was done manually by tallying up how much of each ingredient had been used and guessing when it would need to be reordered. This could lead to over-ordering and waste, or ordering too late and not being able to fulfill customers' orders.

One restaurant chain decided that there was a better way to manage its supply chain. The restaurant chain used machine learning and AI tools to analyze point-of-sale data. Soon, the system was able to "learn" how much of each ingredient was used for each type of order. Rather than forcing planners to predict based on the information they had on hand at the moment, the restaurant chain used a seamless flow of real-time data to begin to sense, anticipate, and even forecast demand. This improved forecast accuracy by 25 percent, reduced the workload on staff, and achieved a 99 percent in-stock rate for each restaurant.[11] Even more importantly, the benefits cascaded down the supply chain, with every supplier being able to better plan. The result was less waste, timelier deliveries, and the right dish on the customer's plate—every time.

Better knowledge, better predictions, and better performance: a lesson equally applicable in the restaurant as it is to the military. In fact, the US Navy is using similar machine learning tools to prioritize and route the huge volumes of message traffic that ships and submarines receive.[12]

Know the assets

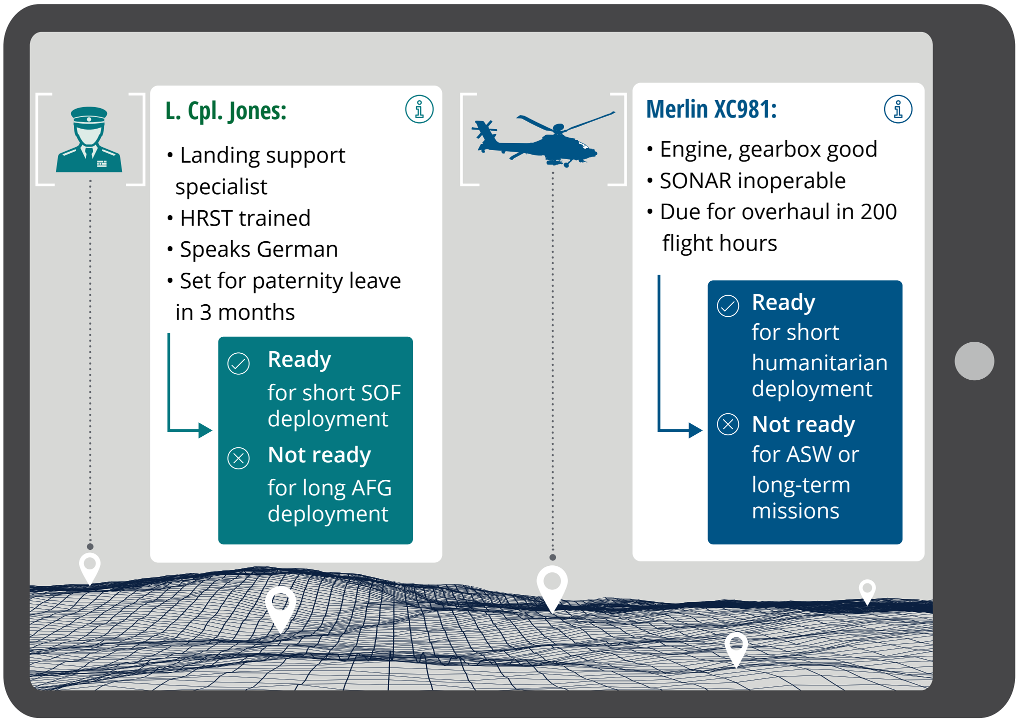
While a complete picture of real-world mission needs can ease planning, the right capabilities still need to be available to carry out those plans. This challenge goes far beyond any patch chart or doctrinal table of organization. It gets at the heart of the factors that make military units successful. Some of those, like having the right equipment, are easy to see and measure, while others, like having local knowledge or experienced leadership, can be more difficult to observe. A real-world, real-time picture of the location and status of personnel, equipment, and infrastructure down to the individual level can help address this challenge.

After all, it doesn't matter if a unit is designated with a regional specialty in West Africa; it matters if the squad leader can speak French. In fact, this more granular picture of capabilities can supercharge the benefits from task organization that the military already enjoys. Today, task organization tends to exist only at the unit level, blending different units with different capabilities to create a task force tailored to a mission. However, with a more granular picture of the equipment, personnel, and infrastructure, commanders could combine individuals with the right skills and experience with equipment in the right place at the right time to create more capable formations in shorter time. Rather than just seeing red or green stoplight charts, a commander could see that a helicopter may not be ready for its squadron's upcoming combat deployment due to inoperable radar warning system, but could support a disaster relief mission with a different unit.

Similarly, an individual soldier may seem "non-deployable" due to upcoming paternity leave, but a

FIGURE 4

Industry 4.0 can provide real-world, real-time information about the status and location of personnel, equipment, and infrastructure



Source: Deloitte analysis.

more detailed picture of his skills and availability may show that his language skills may make him an ideal fit for a short-term deployment to support a foreign exercise (see figure 4). This more granular picture requires real-time information about the status of equipment, personnel, and infrastructure:

- **Equipment.** Sensors already monitor many performance parameters of many major weapons systems. By combining this data with the location of the equipment in a common data platform, military planners can begin to see a more detailed and accurate picture of what assets are available and what they can realistically do. Imagine the case of snow plows at military airfields. Simply knowing how many snow plows a unit has is useful, but not as important as knowing which ones are down for maintenance or even where snow is expected. If commanders can see all of those different types of information in one place, they can adjust to the situation, sending working snow plows from a base not expecting snow to one that is about to experience a blizzard—keeping the runways clear and allowing for more jets in the air.

- **Personnel.** The military already has significant amounts of data about the capabilities and qualifications of its personnel. Collating this data with mission requirements could give a richer picture of the often invisible factors that affect readiness. Seeing which soldiers are deployable, healthy, and mission-trained is a key component of knowing what a unit can accomplish. With detailed knowledge about each individual, commanders can see beyond what is in the "morning report" of attendance and put together the right team with the right skills for any mission.

INDUSTRY 4.0 IN THE REAL WORLD: IOT AND PREDICTIVE MAINTENANCE

The challenge with traditional maintenance strategies is that it can be difficult to predict what will happen with a given machine. Therefore, companies typically must stock a wide variety of different spares to be prepared for any failure. However, IoT-based sensors and predictive maintenance algorithms can offer a more efficient solution by providing insight into the condition and status inside each piece of machinery.[15]

Italian train operator Trenitalia was looking for exactly such a solution when it faced performance penalties for schedule delays created by unexpected maintenance on its trains.[16] To address the problem, Trenitalia added hundreds of onboard sensors on 1,500 locomotives. Data from those sensors was then transmitted to private cloud storage in near-real time, where diagnostic analytics provided advance warning of the failure of parts such as brake pads. With such data, Trenitalia was able to maximize the brake pads' useful life while reducing unexpected failures. With these sensors and predictive maintenance algorithms, Trenitalia was able to decrease downtime by 5–8 percent and reduce its annual maintenance spend by an estimated 8–10 percent, saving about $100 million per year.[17]

While the maintenance demands of a commercial business with relatively predictable schedules are different than the hard-wearing, anytime, anywhere demands on military platforms, the same predictive maintenance techniques are already being used by some militaries around the globe.[18] For example, the US Army is using predictive maintenance on a portion of its fleet of Stryker combat vehicles using more than 5 billion data points from onboard sensors.[19]

Technologies such as augmented reality can extend this data advantage even further by allowing the perfect expert for any situation to be virtually present. For example, some airlines are already using augmented reality to connect maintenance personnel at small airports with experts so that they can make complicated fixes immediately instead of waiting for experts to fly in and creating costly delays.[13] For the military, this could mean that if you know the capabilities of each service member, critically needed knowledge about anything from repairing a broken landing gear in the field to translating Nepalese can be only a headset away.

- **Infrastructure.** No airplane can take off without a runway, and no ship can berth without an open port. Sensors embedded in tarmac can give the status of a runway while smart buoys can tell port managers which berths are open for what size ships at any moment. Real-time knowledge of the status of critical infrastructure can be just as vital to mission success as having the right troops and the right equipment.

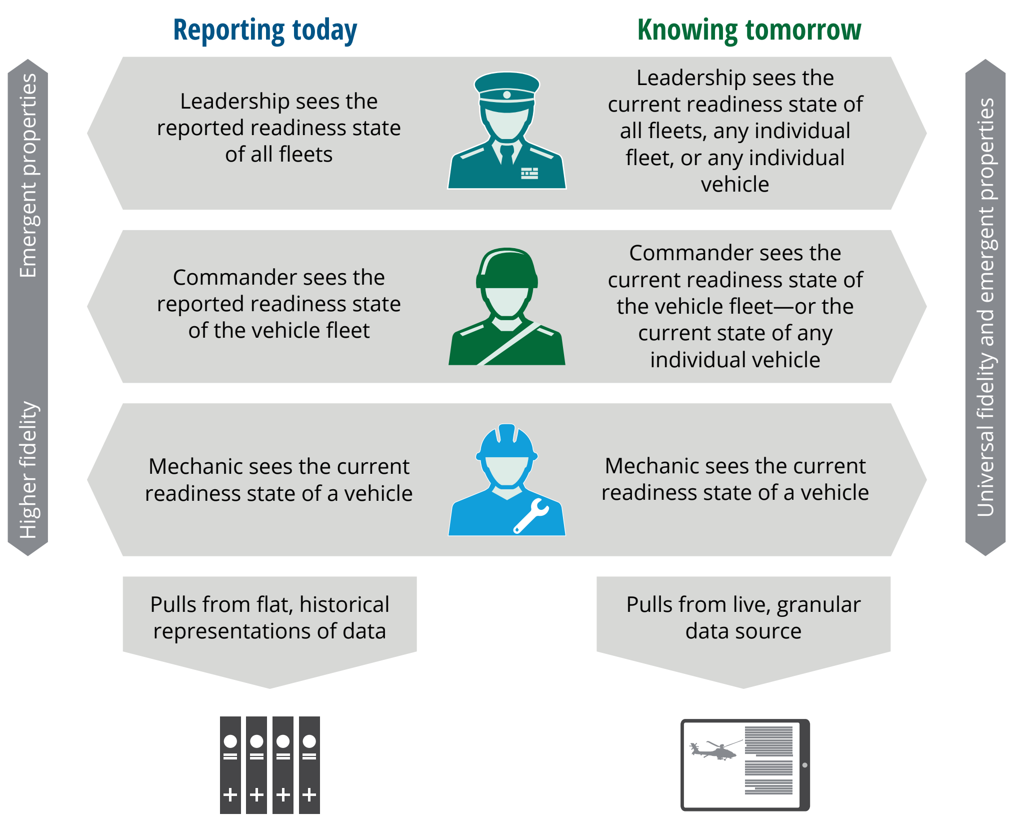
The local mechanics can see the state of their tanks, the commanders can see the state of all their tanks, and service leadership can see the state of all ground forces or the state of individual tanks.

Simply gathering this data is not the end, however. Different forms and types of data should be stored in such a way that they can be analyzed together to allow both the vehicle-level mechanic and the corps-level general to discover insights relevant to them. This capability typically requires some form of big data storage that can support parallel and cross-cutting analysis—which may be neither as new nor as daunting as the technical jargon may seem. Predictive maintenance and IoT solutions in both commercial industry and the military have been using similar data stores for years, many of which are even open source.[14] (To read more about how IoT and predictive maintenance are already helping organizations, see the sidebar "Industry 4.0 in the real world: IoT and predictive maintenance.")

Having real-world, real-time information about equipment, infrastructure, and personnel would not only provide leaders with better information to support their decisions, but it could also support decisions up and down the chain of command: The local mechanics can see the state of their tanks, the commanders can see the state of all their tanks, and service leadership can see the state of all ground forces *or* the state of individual tanks. The unfiltered data allows leaders to zoom in and out, encountering both the granularity and the broad, emergent trends of their readiness posture (see figure 5).

FIGURE 5

Supporting different conclusions with real-world, real-time data



Source: Deloitte analysis.

Know the best action

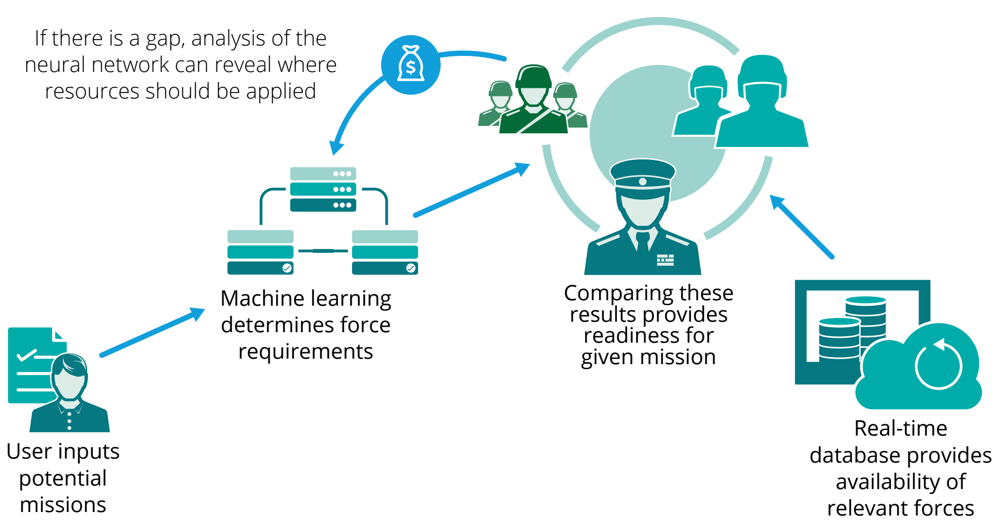
With a real-world picture of mission needs and a real-time picture of available capabilities, militaries can evaluate their preparedness in detail, potentially for the first time. But that is not the end of the story. Even more important is the question of how to improve that preparedness. When there is inevitably a gap between required and available capabilities, planners need to know where future investments should be directed to remedy that gap. Is the problem a lack of specially certified personnel, a shortage in a type of aircraft, or even a need to have more qualified units in an insertion technique?

What is typically needed is some sort of enterprise decision support capability. Luckily, machine learning techniques can again be applied here to answer those questions and ultimately ensure that the joint force is more capable, lethal, and affordable than before. By combining the real-world and real-time pictures of force capabilities, planners can create what is essentially a "digital twin" of the force.[20] This digital, data-driven picture of the force allows leaders to conduct detailed scenario planning. They can test the force against different types of missions and combinations of missions in ways that would be impossible to recreate in real life. Moreover, by seeing how the force stacks up against these various mission requirements, planners can understand where gaps in capability exist and where the next dollar of investment should be spent to best fill those capability gaps—whether through additional capacity, greater training, or new materiel (see figure 6).

Take the readiness of an F/A-18D squadron as an example. If the squadron is experiencing readiness problems because of maintenance issues, solutions could range from decreasing operating tempo to increasing maintenance personnel, to expanding depot-level maintenance capabilities, to replacing the aircraft with a newer type. Today, planners would simply have to decide among these various solutions based on their understandings of the cost and efficacy of each. However, a machine learning tool applied to the "digital twin" of the force could draw on reams of data from history to highlight exactly which solution is likely to get the most jets in the air at the lowest cost. (To read more about how digital twins are being used by advanced organizations, see the sidebar "Industry 4.0 in the real world: Digital twin.")

FIGURE 6

Bringing it all together to determine the most efficacious investment areas



Source: Deloitte analysis.

INDUSTRY 4.0 IN THE REAL WORLD: DIGITAL TWIN

The collection of data and technologies described in figure 6 is what the industry would call a "digital twin." A digital twin is an evolving digital profile of a physical object *or* process that helps optimize business performance. Digital twins start with complex models of the object or process they wish to mirror and then update them over time with data streaming from the real-world thing as it operates.[21]

The digital twin can mirror a physical object such as a particular jet engine or an entire process such as what is happening on a factory floor. Most importantly, these twins are not just for show but can be tested in ways that their physical counterparts cannot. For example, Formula 1 racing teams have digital twins of both their cars and the tracks they race on. They use these twins to run complex simulations of race strategies, often with the drivers in the car, so that on race day, they know exactly what tires to use, when to stop, and all the other settings that will give them the best chance of a win.[22] Just like race teams, the military has long sought to prepare for the future with war-gaming and simulation. However, the ability to make those simulations more accurate via the use of a digital twin is a game changer and can produce a more lethal force at a lower cost than ever before thought possible.

The tools are already there

THE MOVE FROM a reporting-centric picture of readiness to one that hinges on real-time, real-world information would represent a large departure for almost all militaries. However, the good news is that it seems to be a feasible change. Not only are many of the core technologies already proven in the commercial world, militaries likely have much of the needed data already. A digital transformation such as this one can often begin with the data already on hand without any need for massive investment in new technology or a bulky new IT system.[23]

In fact, some parts of the military are doing just that already. The US Air Force recently began using data that had been generated for years by C-5, C-130J, and B-1 aircraft to feed predictive maintenance algorithms.[24] The same approach can be used for data that militaries already capture, from airfield statuses to daily personnel reports. All of this data has a value, and tapping that value is the key to understanding readiness in a new way.

Naturally, any transformation of a large bureaucracy can be challenging. However, hard-won lessons from other government and commercial modernization efforts can help smooth a military's transition to a real-world, real-time readiness picture:[25]

- **Start small.** Consider beginning with small-scope pilot projects focusing on either specific units or specific functions, and evaluate those pilots after a given period of time. Units built largely around one specific type of equipment, such as armor and aviation, or one function in one location, such as installation management, may be the best candidates for initial pilots.

- **Scale fast.** Based on the learnings from the pilot projects, consider modifying the programs to keep good features and eliminate ineffective ones. Then scale to larger formations and more functions.

- **Target resources.** As a picture develops of the state of assets and the demands placed on them, your investments should target the upgrades likely to make the greatest impact. Incorporating readiness data into the budgeting process can allow decision-makers to see in real time the returns of their readiness efforts.

At the end of the day, military advantage does not typically come from new technologies but rather from how technologies, processes, and people all work together.[26] Industry 4.0 for readiness is about redefining those relationships. Armed with a few key principles, decision-makers can implement a plan to unleash the data in their forces and enhance readiness. By distributing proven technologies in new configurations throughout the military, leaders could soon have a full, real-time, real-world picture of their forces that only a few years ago would have seemed like science fiction.

Endnotes

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