Maintenance & Readiness:
A Widening Gap in the DoD

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WHITE PAPER

Executive Summary

As of late there's been a great deal of justifiable concern by the Department of Defense (DoD) regarding equipment readiness, particularly with larger weapon systems that include aircraft, ships and land vehicles. At a Navy conference in 2017, a keynote speaker summed up the situation using a sobering comparison. From his perspective as a former U.S. Air Force officer and national security advisor, he likened naval aviation's current readiness to the period of time that immediately followed the attack on Pearl Harbor in 1941.

In response to this alarming state of preparedness, the DoD is spending a great deal of time and money exploring and implementing improvements. Along with a host of other initiatives, these include:

- Enhancing operations using "Big Data" analytics
- Eliminating siloed manufacturing data with a Digital Thread and Digital Twin
- Improving parts availability through additive manufacturing (3D printing)
- Digitizing technical maintenance data

Of particular interest by the DoD is how Artificial Intelligence (AI) may be used to help better plan maintenance and the use of resources (people, equipment, parts, materials, etc.) to support repairs. Given how rich the U.S. military is with historical maintenance data, the opportunity to leverage machine learning to optimize operations using this data is both intriguing and timely. Another focus area with a direct benefit to equipment readiness solutions is undeniably the most consequential: the maintainer. Ensuring maintainers have the right type of training and information to do their jobs quickly and correctly is paramount.

This paper provides a brief overview of the knowledge-based challenges facing today's maintenance leadership and maintainers, along with recommendations for changes that can have an immediate and positive impact on equipment readiness. This document will discuss a collaborative approach to improve the speed, accuracy, cost and safety of equipment repair and maintenance within the DoD. The vision this collaboration has taken is in the form of a *Maintenance Knowledge Framework*, or MKF.

Given the intentionally brief nature of this document, supporting studies or other types of detailed analysis will not be included. Instead, this paper will focus on four primary aspects of the DoD "knowledge infrastructure" that are readily understood and cause for little debate. By addressing troublesome issues that are not only generally agreed to by the maintenance community, but which can be solved using tools and strategies already being used inside and outside the DoD, it is hoped this paper will provide an impetus for transformational changes that are within reach.

Introduction

Equipment modernization, maintenance and repair in the DoD is ripe with opportunity for change, particularly when it comes to strategizing how knowledge will be harnessed and shared in the future. The advances in communication technology now make it possible for even most middle school and high school-age children in this country to carry a device in their pocket that provides immediate access to visually rich information about most anything, using smart

technology that caters to their immediate and anticipated needs. Yet, developing a consistent and effective approach to advance repairs and scheduled maintenance is a challenge.

This seemingly impenetrable wall has four architects. The first is lack of an inclusive strategy for using new technology to optimize maintenance planning and repair. The second is little to no equipment-specific training. The third is text-based instruction manuals that are inaccurate and highly susceptible to misinterpretation. The fourth is lack of an effective strategy for capturing, preserving and sharing the experiential knowledge of maintainers.

Architect #1: New Technology

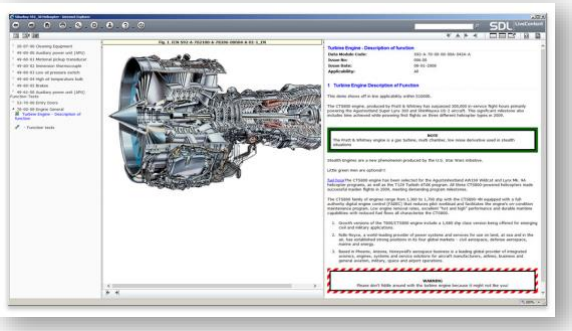
At the very top of future technology "must haves" is AI, and for good reason. It has already found its way into many of our experiences as consumers because of its speed and accuracy in interpreting the world around it. However, its use in the military remains relatively limited or, in the minds of many, still conceptual. Top military leaders are aware of the operational and strategic advantages AI can offer. They are also cognizant of the ability for much smaller nations (potential wartime foes) to adopt this technology at a relatively low cost, and the national security implications this poses.

Architect #2: Training

It would be financially unfeasible for the military to try and teach all of its maintainers at the equipment system level for every system they support. The rare exceptions include circumstances where a significant degree of complexity begs for formal instruction, such as the calibration of thermal optics gear, for example. So, when it comes to the majority of repairs or maintenance that maintainers will perform, they will do so without formal training. As a result, they have to rely heavily on their technical manuals and day-to-day experience to become proficient. Given that technical manuals will continue to serve as the starting point for acquired knowledge by sailors in the foreseeable future, this brings us to the third impediment: text-based instructions.

Architect #3: Technical Instructions

In years past, over-the-shoulder mentoring by senior technicians and maintenance manuals in paper form served as the primary learning approaches for the maintenance community. Efforts to improve manuals have resulted in interactive, digitized documents used mostly on ruggedized laptop computers. These new tech pubs are intended to be more portable, as well as easier and cheaper to update for tech data managers. However, benefits to the maintainer have been negligible, because these new electronic manuals have remained text-based, and have not benefitted from the rapid shift to visual-based learning that today's technology handily supports. In a world where the "how to" for almost anything you'd like to do can be accessed on the internet (e.g.,



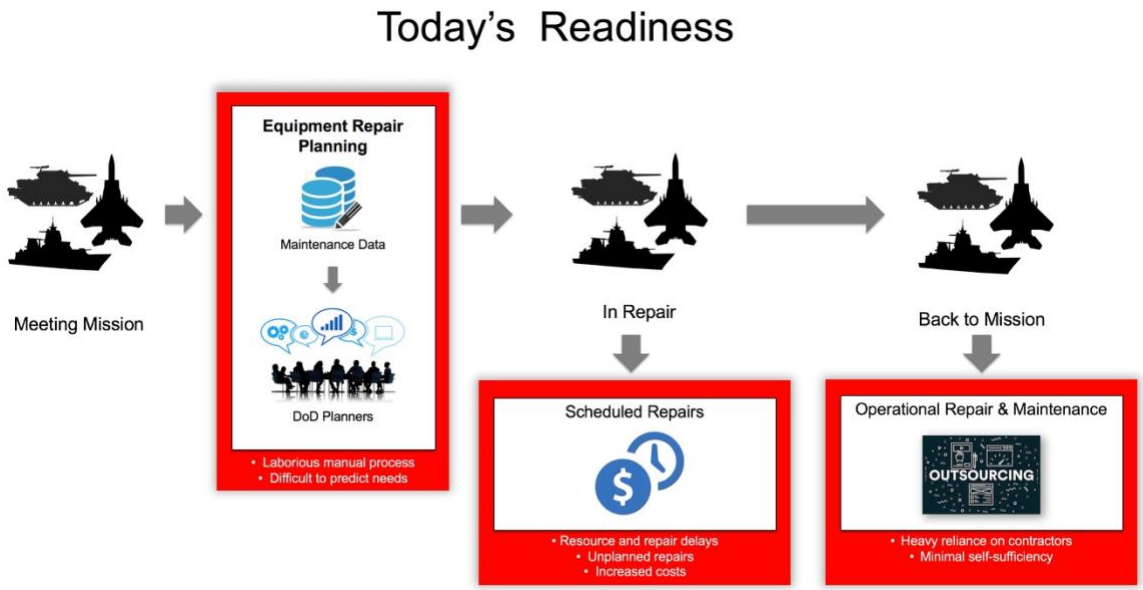
YouTube videos), the U.S. military remains frozen by policies and regulations that remain adversely comfortable with sentences and paragraphs, which attempt to explain rather than show.

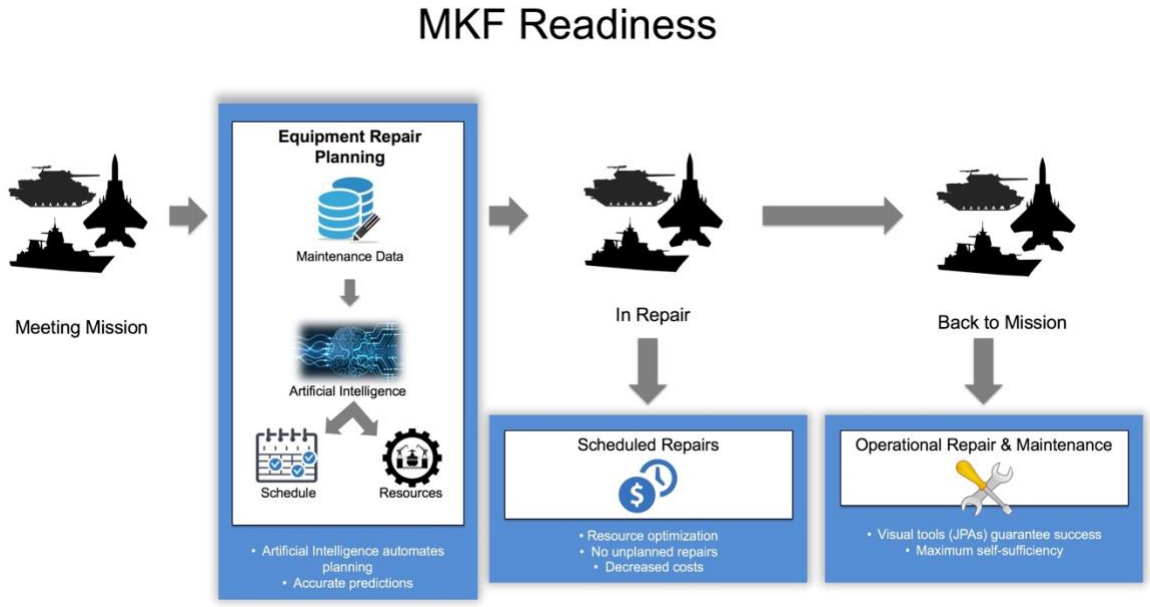
Architect #4: Knowledge Preservation

DoD maintainers gain a great deal of experiential knowledge during their day-to-day activities and various duty stations. Unfortunately, this knowledge – oftentimes related to equipment repair techniques and procedures that don't find their way into training or technical manuals – is not shared in a significant way with other maintainers doing similar work outside their command. A system or strategy does not yet exist that can capture the information and share it in a meaningful way across a wide network of other DoD users. The result is a repeated process throughout the DoD of learning and relearning, which is further exasperated by the frequency of duty station rotations, reductions in military staffing, and attrition. Given the complexity of much of the equipment used within the DoD, the lack of a knowledge capture strategy can and does have dire consequences. As an example, the Navy experienced more than $565 million in aircraft damage and the deaths of two pilots over a two-year period due to a lack of knowledge by Navy maintainers about proper landing gear rigging procedures on the F/18 aircraft. Though this particular issue is an extreme example, it is among thousands in the DoD maintenance community that occur every year.

DoD's Readiness Scenarios

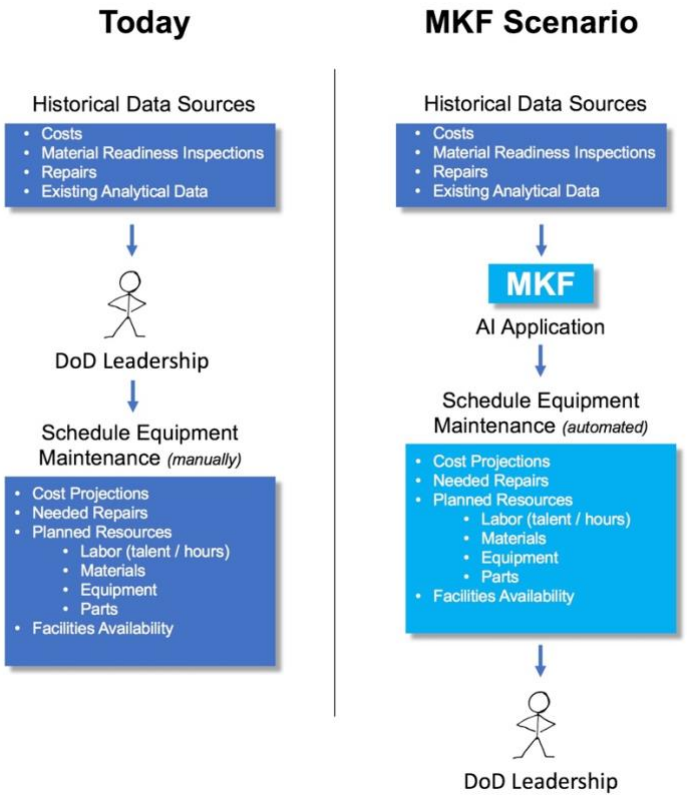
The current and potential DoD equipment modernization, maintenance and repair paradigm is illustrated in the following graphics:



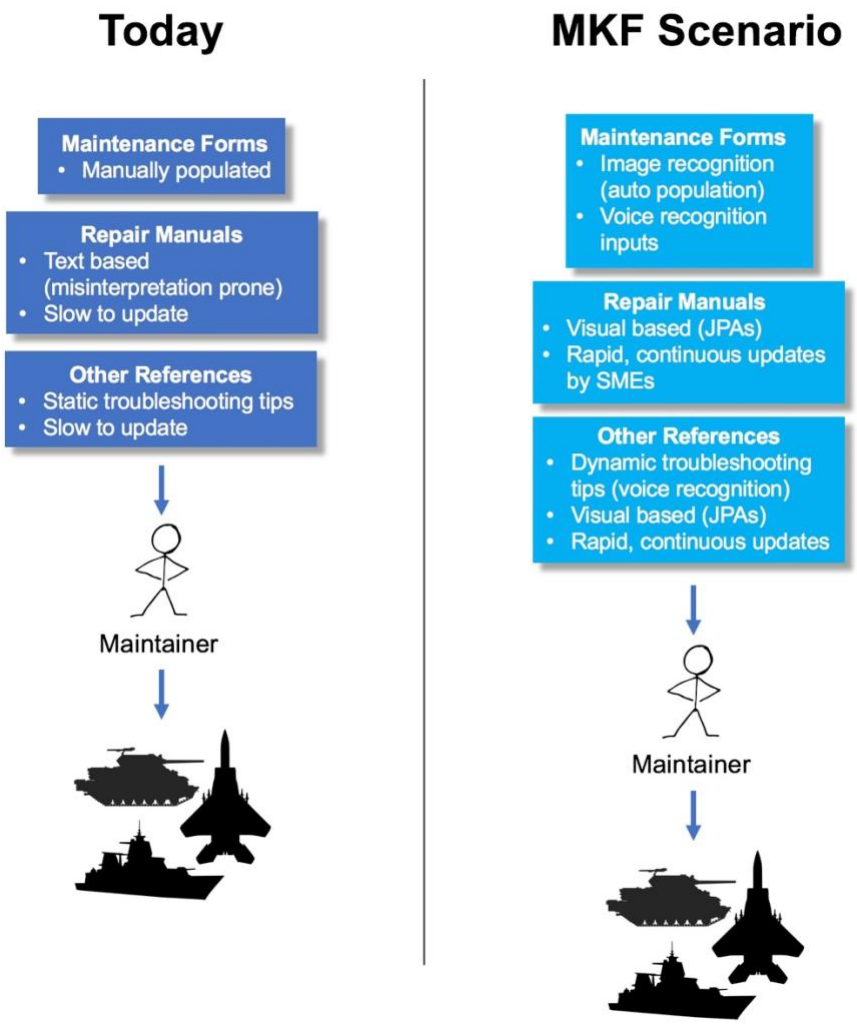


Modernization and Repair Planning

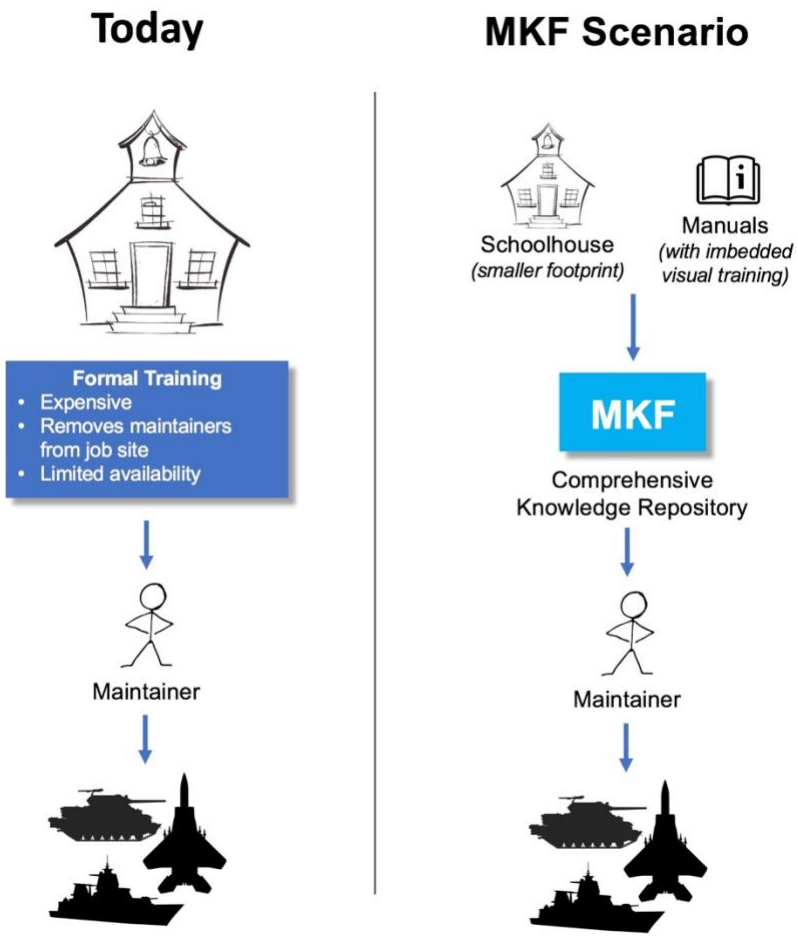
The logistics to support repair work is a complex, difficult undertaking. Leadership needs a systemized approach that can leverage historical data to predict repairs well in advance, and optimize resourcing (budget, tools, materials, supplies, labor, etc.) to reduce costs and delays.



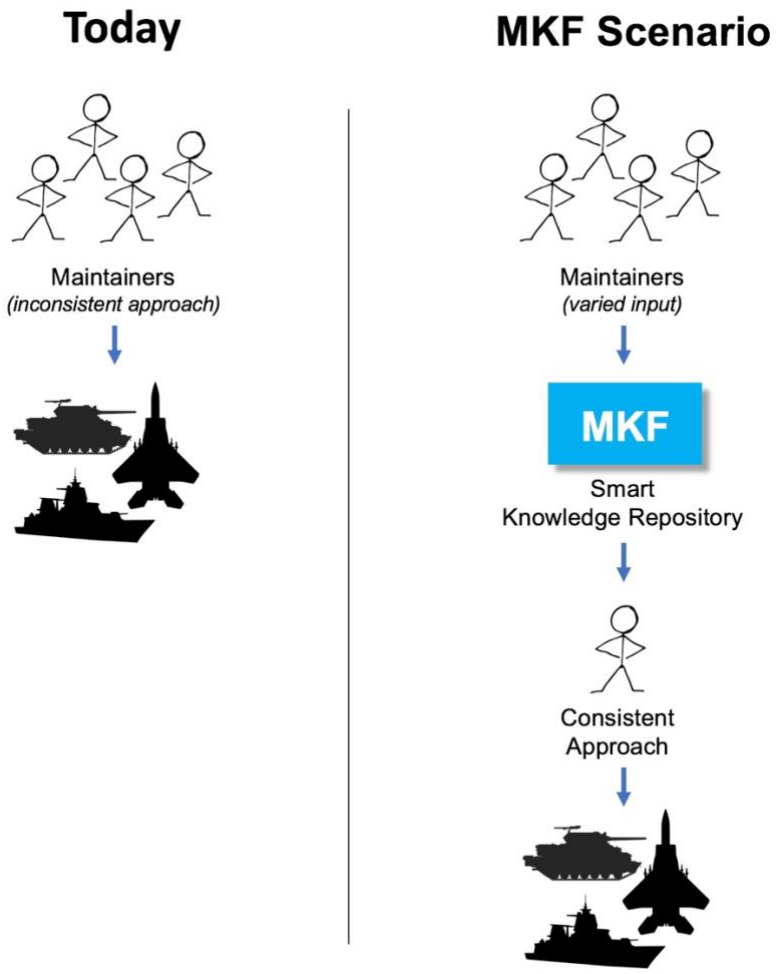
Technical Data
Current technical data (in the form of work orders, repair instructions, troubleshooting guides, etc.) is text based and used to perform all work. Written documentation is laborious to use (e.g., filling out data fields on maintenance forms), oftentimes in need of revision, and subject to misinterpretation by maintainers. Modernization of technical data and how it is used is needed to help optimize maintenance.



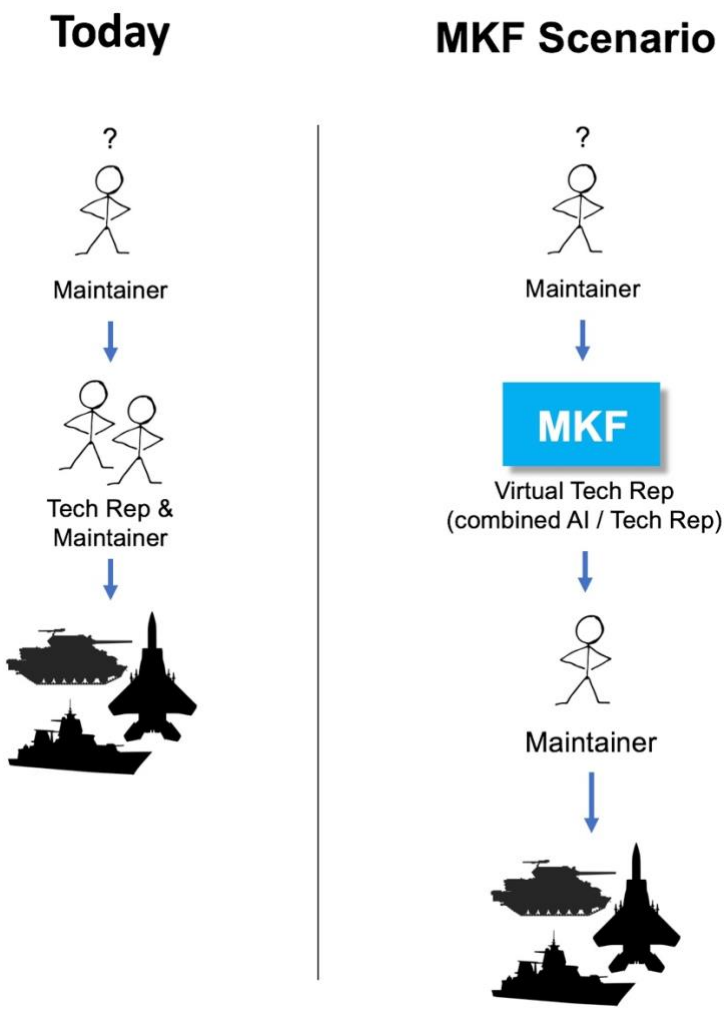
Training (see next page)
Maintenance training for DoD military personnel and civilians is too costly to provide for every need, especially across such a wide variety of equipment and sophisticated operating systems. With the understanding that most learning takes place on the job, the MKF offers an opportunity to expand the reach of formal classroom training and skills certification, by integrating learning and metric tools at the job site.



<u>Knowledge Capture</u> (see next page)
Maintainers gain a great deal of experiential knowledge while performing maintenance. Unfortunately, this knowledge – oftentimes related to equipment repair techniques and procedures that don't find their way into training or technical manuals – is not shared in a significant way with other maintainers doing similar work. A system or strategy does not yet exist to capture this experiential information and share it in a meaningful way across a wide network of DoD users.



<u>Expert Assistance</u> (see next page)
Providing advanced technical assistance when repairs exceed the capabilities of those performing the work, has historically meant relying on expensive technical representative support, along with travel costs to geographically dispersed locations. A functional MKF could provide virtual assistance (and distance tech rep support if needed) that could not only be more economical, but also more powerful in the accumulated knowledge that could be made available instantly.



A Single Solution

While each challenge area (new technology, training, technical instructions and knowledge preservation) has a distinct role within the maintenance community, it's also true that they should, together, contribute to the same goal: enabling planners and maintainers to be as efficient as possible. All four knowledge sources are critical to addressing the challenges faced by planners and maintainers, and it's traditionally assumed that each would need to be improved individually, with their own unique set of management, funding and tailored solutions.

It isn't necessary to think of improvement solutions in individual terms. In fact, each of the improvement areas being discussed should be addressed collectively and treated as a collaborative opportunity to demonstrate how traditionally disjointed efforts can be, and should be, united in their functions to serve a common goal.

What would this effort look like? It would be the right match of government and commercial resources, with each bringing their own

particular qualifications and technology to the effort. Industry expertise collaborating now on the *Maintenance Knowledge Framework* include:

- Amazon
- Dr. Steven Spear (*The High-Velocity Edge*)
- AVA Studios (AVA)

Development Team

The *Maintenance Knowledge Framework* has a very focused goal, which is to provide maintenance planners and maintainers with the right type of information when they need it. The anticipated result will be, quite simply, an unparalleled improvement to DoD equipment readiness.

Providing this information in a way that takes advantage of tailored and tested business practices and technology will mean assembling the right team of expertise from the very start. Each team member will contribute their part of a solution that must be designed to have the right fit and function. The solution also must be scalable, so that it can quickly respond to the inevitable and constant need for change, as well as new technologies that might become available in the future. This expertise is represented by:

1. Team Member: ***Amazon***

- **Role:** ***Artificial Intelligence & Image Recognition***

- **Description:**

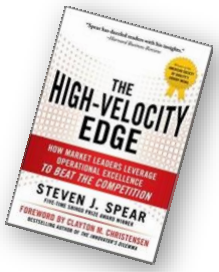
    - Artificial Intelligence: Businesses and government organizations face an increasingly complex operating environment. This is especially true in the DoD, where systems and equipment are supported by volumes of technical data that simply can't be understood fast enough or well enough by traditional methods. Amazon will enable the DoD to use machine learning-based systems to interpret new information and historical maintenance data to optimize ship repair and resource planning. The system will also learn from each maintainer, across a broad spectrum of support operations. Through day-to-day online communication among maintainers, Amazon's capture, interpretation and sharing strategy will build a collective intelligence that never atrophies, and which is immediately available when needed.
    - Image Recognition: The DoD deploys hundreds of thousands of large and small weapon systems while performing its missions, and these systems are made up of millions of individual components. Distinguishing one component from another, especially given the precise nomenclature for items used in the DoD, challenges maintainers to know what part they are looking at, and which specific technical instructions govern that part's operation, repair or maintenance. Amazon's "Rekognition" will make it possible for maintainers to point a smart device at any component and, through image recognition, "know" what it's seeing and gain immediate access to information needed to support it. This could include,

for example, assisted data population of maintenance repair forms or troubleshooting assistance.

- **Qualifications:** Founded in 1994, Amazon is the world's biggest Internet retailer, as well as the largest provider of cloud infrastructure services. The company is a recognized leader in business logistics innovation and results-based technology application, with a clear vision of building exceptional efficiencies in not only its every-day operations, but also the speed of information access that technology brings to its customers.

Contact: Balaji Iyer (balaiyer@amazon.com)

2. Team Member: ***Dr. Steven Spear***



- **Role:** ***High-Velocity Learning***

- **Description:** Many top leaders inside the DoD consider High-Velocity Learning (HVL) a critical element to meeting their mission now and well into the future. One member of the MKF team includes Dr. Steven Spear, the author of *The High-Velocity Edge: How Market Leaders Leverage Operational Excellence to Beat the Competition*. In his integral role, Dr. Spear will oversee each phase of the MKF development to ensure that the result both embodies HVL and defines a new and repeatable standard for the DoD's maintenance community, leveraging innovative technology and strategies to be showcased by the MKF.

- **Qualifications:** Dr. Steven Spear is a Senior Lecturer at the Massachusetts Institute of Technology (MIT), and a well-recognized expert on how select organizations develop the internal capability for high-speed, sustained improvement and innovation. He has won numerous excellence awards for his book and published articles; and holds an AB in economics from Princeton University, an MS in management, an MS in mechanical engineering from MIT, and a doctorate from the Harvard Business School.

Contact: Dr. Steven Spear (steve@thehighvelocityedge.com)

3. Team Member: ***AVA Studios***

- **Role:** ***Task "Visualization"***

- **Description:** The Navy was the first DoD agency, in 2004, to acknowledge a dramatic need for change to technical manuals being used to perform maintenance. Widespread misinterpretation of written procedures had proven excessively burdensome in regard to safety, cost and equipment readiness, so the Naval Air Systems Command introduced job performance aids (JPAs) to address the problem. Staff at AVA Studios have been the leading provider of JPAs to the U.S. military and their supporting commercial vendors since 2004, and will use this experience to imbed a visual "how to" component to the MKF initiative. JPAs will clearly demonstrate how even the most complex procedures are performed, step by step, to ensure speed, consistency and accuracy in maintenance operations.

- **Qualifications:** AVA Studios staff were the first producers of JPAs for the U.S military, and are the recognized leader of JPA production within the DoD and commercial industry. Along with authoring current JPA military specifications and standards, AVA Studios' credentials include a software portal that has automated multimedia programming and removed the geographical limitations of widely-dispersed collaborating members. Through the use of its online JPA development platform, production time has been reduced from months to weeks or days (24 hours in some situations), and production costs have been minimized.

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Summary

There is an undeniable paradigm change in information capture, interpretation and sharing that has been taking place. As general consumers, the transition away from text-based instruction to image-rich, "smart" content is not just readily accepted, but expected. Technology in the form of artificial intelligence, augmented learning, virtual reality, machine learning, etc., are quickly replacing laborious manual processes. At the same time, devices and software applications grow increasingly more powerful and less expensive.