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White Paper

Digital shipyard sounds great but what is it?

The technologies making it possible.

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There has been plenty of hype around "digital shipyard" recently especially after the announcement of Australia's second mega shipbuilding program, SEA5000. Both BAE Systems and Naval Group will now look at gearing themselves up to leverage the power of the fourth industrial revolution, aka Industry 4.0.

So what does digital shipyard actually mean? Well if the name is anything to go by you would be safe to bet that it involves the latest evolution of cyber "digital" technologies. But what exactly are those technologies and how are they going to help BAE Systems and Naval Group build platforms that float (and sink)?

To answer that let's first take a quick look at what Industry 4.0 is all about. As you can see from Figure 1, the evolution of industry technology can loosely be categorised into four distinct groups:

Industry 1.0 - circa 1784, mechanisation and the first industrial use of steam power

Industry 2.0 - circa 1870, production in mass using assembly line and electricity

Industry 3.0 - circa 1969, introduction of computing, electronics and automation

Industry 4.0 - circa now, cyber physical systems and connected devices (IoT)

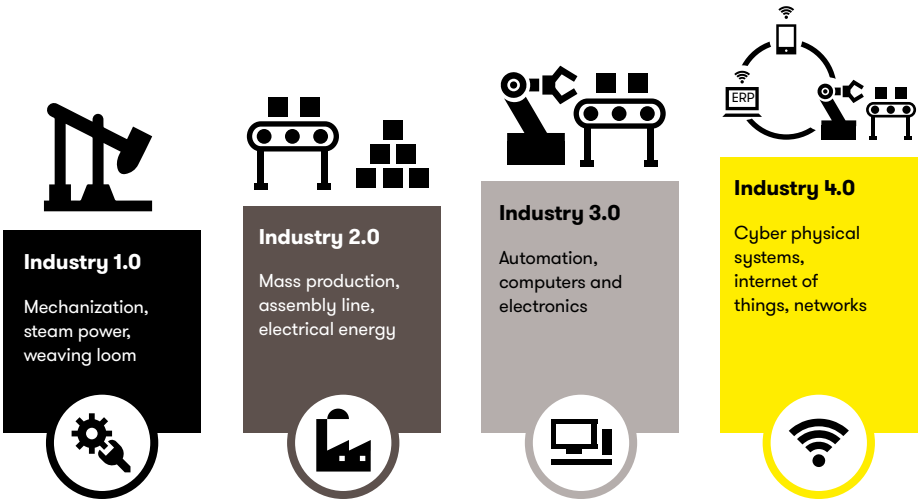

Figure 1. The evolution of industrial technologies from Industry 1.0 to 4.0

Of these four industrial categories it's the latest evolution that underpins the group of capabilities that enables digital shipyard. So that brings us to the two significant capabilities within the Industry 4.0 category, "cyber physical systems" (CPS) and "The Internet of Things" (IoT).

CPS merges physical and software components together and makes the end product highly connected to the internet and its users. Robots, autonomous vehicles, smart grids and other such complex systems are examples of CPS.

IoT is the collection of connected smart devices that require no human to human or human to computer interaction. These devices can range from watches to fridges to phones to weather sensors. They can communicate with each other, exchange information and work collaboratively to complete tasks and feed information back to human operators.

There are a number of technologies that I would consider digital shipyard enablers. Some of these fit neatly under the Industry 4.0 umbrella whereas others are either recent or emerging technologies. And although there are numerous technologies that could be considered enablers for a digital shipyard, in this article I am going to concentrate on thirteen that have emerged or evolved considerably over the past 5 years. Let's kick off by painting a "digital value chain" vision for shipbuilding as seen in Figure 2.

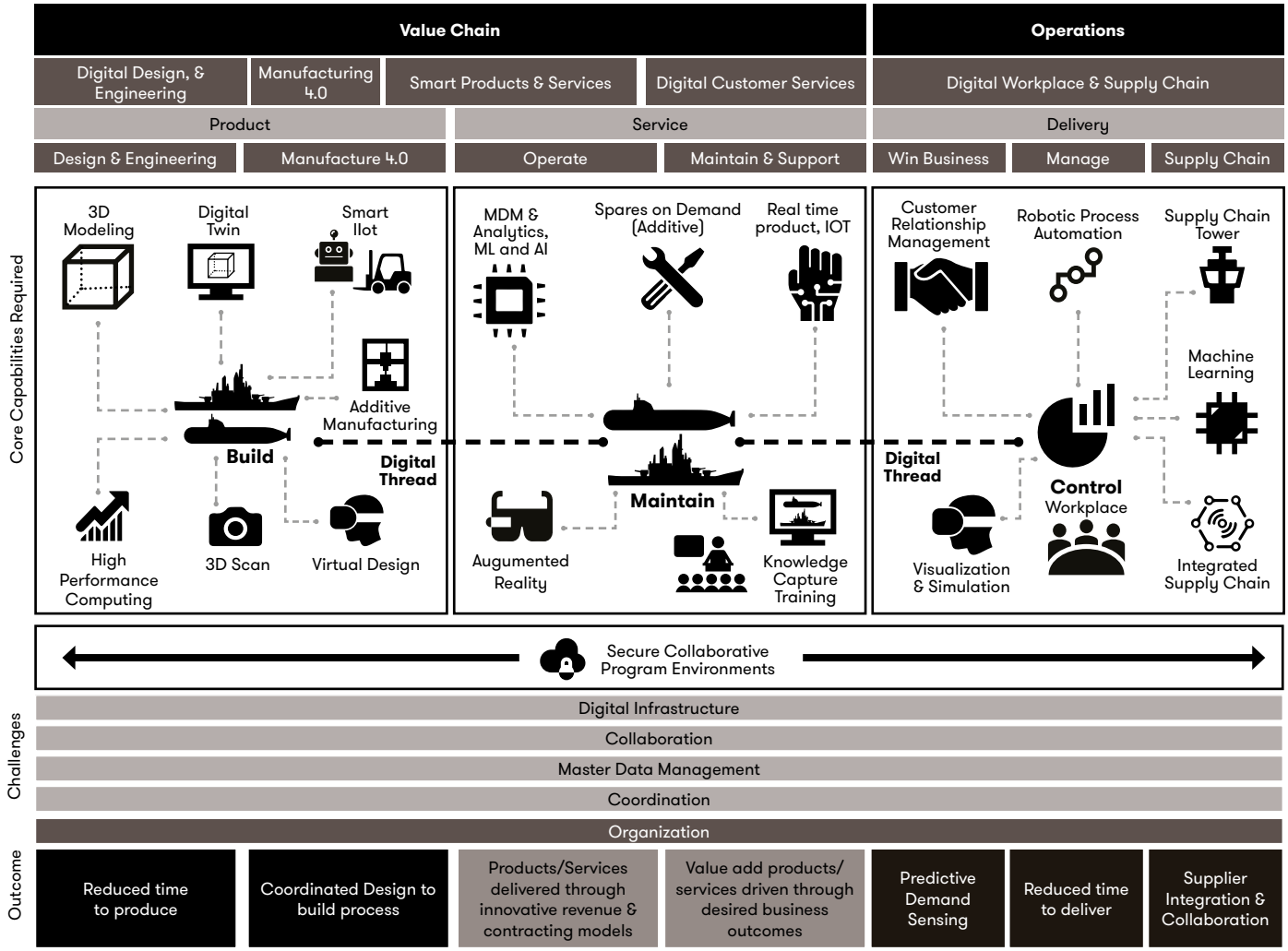

Figure 2. DXC's digital shipyard value chain vision*

This vision aims at applying specific technologies to specific phases of a shipbuilding lifecycle. The three phases being product (build), service (maintain) and delivery (control). The idea is that these technologies will help drive the identified outcomes

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Used effectively these technologies will not only reduce the time to delivery but will also improve safety and the end quality of the platform. The cumulative efficiency of these technologies when used in collaboration with each other in a manufacturing environment can dramatically reduce the time-to-market of the platform. Claims of up to a 43% reduction in time-to-market have been made. That's a staggering claim.

So, let's take a look at the technologies and understand why they are important for a digital shipyard and how they can live up to the hype.

3D modelling

3D modelling is not a new technology in fact it dates back to the 60s. What has however changed significantly over the last ten years, is the cost of high performance computing. This has led to a significant uptake in 3D design across manufacturing. Shipbuilding organisations have been using 3D modelling for a number of years bringing in the third dimension to existing 2D designs. Recent developments in 3D scanning technologies has also led to the creation of 3D models of already built platforms. Instead of retrospectively creating 3D designs from 2D versions, laser scanning can quickly build 3D models with minimal human intervention.

Why is 3D modelling important for a digital shipyard?

It is not just because 3D models look pretty. They also provide the ability to simulate across 3 dimensions how certain activities might or might not be achieved with a certain design or modification. For example, if torpedoes are to be stored in a compartment it is hard to tell with a 2D model if they can easily be transported in and out of that compartment. With a 3D model the simulation can easily determine how those torpedoes will be manipulated in and out of the entry point to the room. In turn that can determine if the entry point needs to be widened or if the compartment needs to be redesigned.

Digital twin

The concept of digital twin is to literally duplicate a physical twin digitally. For example, a physical diesel engine can have a digital twin in the form of a digital 3D model. The digital twin is able to simulate the physical dynamics and characteristics of its physical twin so that potential problems can be predicted and simulated in a safe environment before the engine is even built.

Why is digital twin important for a digital shipyard?

Due to the sheer size of a ship, a digital twin can dramatically reduce the time and effort of its subsequent physical build. Problems that would traditionally be identified once the ship is being built can be identified digitally before even a single line of weld is laid. Potential design faults can be identified through digital simulation of the twin and removed prior to build. For example, the following issues can be addressed digitally through simulation:

- Evacuation routes
- Line of site in the bridge
- Removal of machinery and equipment
- Fire suppression
- Compartment sealing in the event of hull breach
- Transportation and storage of vehicles and supplies

Industrial Internet of Things (IIoT)

The Industrial Internet of Things (IIoT) harnesses the power of the Internet of Things (IoT) to enhance industry specific tasks. In the case of digital shipyard, the majority of these tasks relate to manufacturing. IoT is a term used to describe a collection of connected devices that can work in unison by communicating with each other to share and process information. For example, a weather sensor on your roof can detect a rapid drop in barometric pressure. It can then communicate that to your wrist watch which can in turn show you a message that the weather is about to change. IIoT can amplify that power by leveraging machine learning and big data technologies to utilise sensor data to expedite decision making.

Why is IIoT important for a digital shipyard?

In manufacturing environments such as shipyards, the use of tools and equipment is critical. Metrics such as time on tools, yield, quality, throughput, schedule, downtime, capacity utilisation and others measure operational efficiency and effectivity. Traditionally, bottlenecks that negatively impact those metrics are hard to identify. However, with the use of network connected sensors on tools and machinery, operational inefficiencies can be identified. For example, it is possible to determine how much weld is successfully laid for each square metre of sheet metal using sensors in the welding equipment.

From a safety perspective, sensors can be embedded in wearable accessories such as watches and helmets. This can measure the wearer's heart rate, their height above ground level or the number of steps they have made. Their heart rate and temperature can also be monitored if for example they were operating in a confined space. An IIoT enabled helmet could determine if the worker was wearing their helmet in a PPE mandatory environment. On a similar safety theme, IIoT enabled card readers could be attached to equipment such as cranes to validate that the user has the right certifications to use the machinery.

Additive manufacturing

Additive manufacturing is best known as 3D printing. It provides the capability to print parts, jigs, templates and pretty much anything that can be digitally modelled and loaded onto the printer. These printers have been around for some time however new advancements in technology has meant that plastic is no longer the only medium that can be used. It has also resulted in much larger printers to create larger components. Historically 3D printers were only good for printing plastic components and therefore not that useful for platforms like ships. However, there are a number of additive manufacturing platforms that can now create metallic parts in order to be useful for shipbuilding applications. Once such technology rams particles of metal together at high velocity in order to create the fusion required to create the part.

Why is additive manufacturing important for a digital shipyard?

Additive manufacturing is very useful in both the build and support phases of a ship's lifecycle. Instead of having to order parts when they are damaged they can simply be printed in-situ reducing the turnaround time for the repair. Obviously, there are certain parts that would not be a candidate for additive manufacturing due to their size however complexity is rarely an issue for this technology. So long as a digital twin of the part is on hand, for example a CAD model, the part can be easily and quickly manufactured via this technology.

Virtual design

Virtual design leverages virtual reality technology to provide an immersive design environment. Outputs from both 3D design and 3D scan can create a lifelike clone of a platform that an individual can step into and navigate around using a VR headset.

Why is virtual design important for a digital shipyard?

Due to the immersive qualities of VR, virtual design provides a heightened level of environmental understanding of the platform before it is built. Instead of trying to visualise what an area on that platform might look like from a paper or computer-based image, virtual design provides a truly immersive view where you can actually walk around the platform and simulate tasks. In addition to viewing the platform you can also move design elements whilst in the landscape. With this capability the user can change the location of equipment, doors, structures and pretty much anything in the design using their hands.

Recent advancements in the capabilities that underpin VR have now made it possible to do peer reviewing and design of platforms whilst in geographically dispersed locations. For example, an engineer based in Sydney could join a peer review VR session with an engineer in Adelaide and an SME who might be based somewhere in the US. This has taken design collaboration to amazing new heights and has reduced the design phase significantly.

3D scan

3D scanning is a technology that creates a digital environment based on a mapping to a physical version. Essentially it creates a digital twin or clone. There are a number of sub technologies that enable this capability however modern scanners usually use a combination of optics and laser using triangulation and time-of-flight to map out the physical environment. Time-of-flight determines distance using an algorithm involving the known speed of a laser, speed of light. As this is extremely accurate, the digital output is also very reliable.

Why is 3D scan so important for a digital shipyard?

3D scan can provide a number of benefits. The two most significant in a shipbuilding scenario are “retrospective modelling” and “dimensional control”.

Retrospective modelling is a means to quickly build a 3D design based on an existing physical platform. For example, a compartment of a ship can be scanned, turned into a digital twin and then used for engineering change or other tasks. Effectively this bypasses the need for a draftsman to create the model from 2D diagrams.

Dimensional control is achieved by scanning the built platform and then making sure that the dimensions in the scanned image are the same as what was designed. If the dimensions are not the same, then you know there is an issue with the build.

High performance computing (HPC)

High performance computing (HPC) is literally that, computing on a big scale. Often called “big compute”, HPC typically uses server-side computing resources instead of relying on laptops or desktops. HPC is particularly valuable when undergoing complex scenario simulation or powering high end graphic requirements often used in digital design and virtual reality. Emerging and evolving technologies like artificial intelligence (AI) are also beneficiaries of HPC as with AI, the more compute you can throw at it the quicker and smarter it becomes.

Why is HPC so important for a digital shipyard?

The entire concept of digital shipyard aims to address operational efficiency and effectivity, so things can get done safer, faster and smarter. HPC is all about faster as it provides more computing power in order to get things done quicker. What you could do in a day on a desktop can be done in minutes through HPC. This has a dramatic impact on cost and schedule and therefore has an easy to define tangible benefit to shipyard operations during design, build and service.

Augmented reality (AR)

Augmented reality (AR) blends the real and virtual worlds together. As compared to virtual reality (VR) where you can't see the physical world when you are immersed, AR has the benefit of providing a digital overlay to the real world. Therefore, someone wearing an AR headset can quite easily walk around and not bang into things. That is particularly important when you are walking around a complex platform like a ship.

Why is AR so important for a digital shipyard?

Historically when a shipbuilder wanted to go work on or service an area of a ship, they would print out a 2D drawing in the office, board the ship with it and get to work. However as was often the case they would need more drawings and would therefore need to go back to the office, print more drawings and re-board the ship. This was quite inefficient. Of course, with the advent of wi-fi and other communication protocols, taking laptops and portable printers onboard is now possible. The next leap in this capability is to remove the reliance on drawings, laptops and printers completely using AR. AR headsets can be preloaded with drawings and even connect directly to PLM and other systems to bring up schematics, videos and other media on demand. The individual can then place a drawing in their virtual landscape which fixes it to their physical landscape without holding a thing. Maintenance activities can be significantly simplified by bringing up step by step routines in video to guide the technician. AR will dramatically simplify and speed up the build and maintenance phases of a ship's lifecycle.

Master data management (MDM)

Master data management (MDM) is underpinned by a set of technologies that makes it possible to have a single view on all the data across an enterprise. Typically, a shipbuilding organisation will have data in a number of systems such as PLM, ERP, MRP, records management, document management, file servers and other locations. MDM aims to have a single reference point for all that data. So instead of having to search through different repositories and applications for a set of related data, MDM joins that data together and brings it into a central location. The data does not have to all reside in that central location however it is accessible from that single location through links. It could be thought of as a Google for your enterprise's data.

Why is MDM so important for a digital shipyard?

As with the majority of digital shipyard technologies, MDM aims to simplify tasks and reduce the time it takes to complete tasks. MDM in a shipbuilding context will make the searching and retrieval of information, ie "discovery," significantly faster. So instead of an engineer having to swivel chair through various systems and subsystems for information pertaining to their task, a simple interface will find data across those locations for them. This can reduce the time it takes to find the right data exponentially. The capability also upholds the security controls of the systems and locations so although a user can see the data exists they might not necessarily have access to the data.

Artificial intelligence (AI) and machine learning (ML)

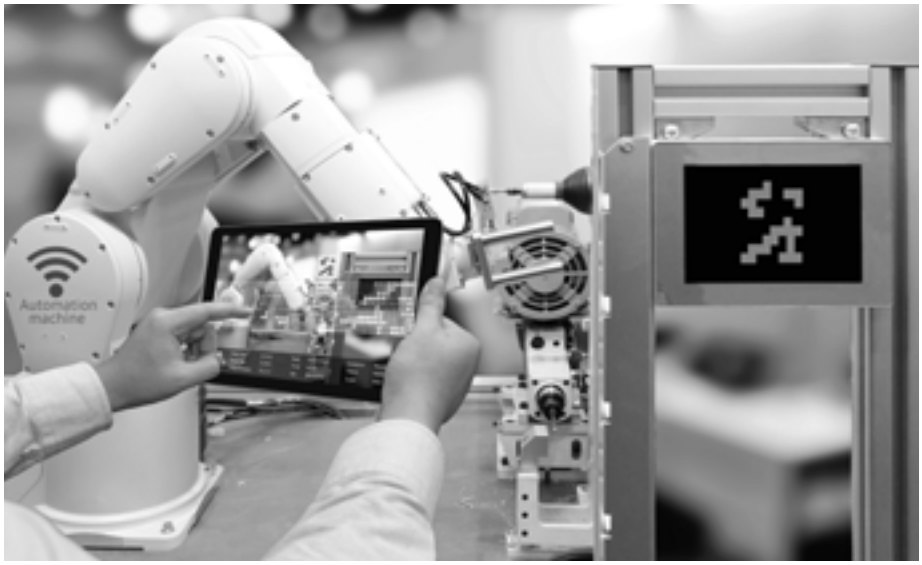
Artificial intelligence (AI) and machine learning (ML) are closely associated with each other. AI is something that has been developing over several decades and is the science of making machines smart enough to carry on with tasks by themselves. Machine learning is slightly newer as a concept and is based around the concept of giving machines access to data and letting them learn for themselves without humans telling them how to learn.

So, what makes something "smart"? A general definition of "smart" as it applies to technology is any computer system able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Why is machine learning and artificial intelligence so important for a digital shipyard?

There are many use cases for AI/ML in a shipbuilding environment. So, let's explore two:

1. There is often a need to determine how equipment and machinery would best fit into a ship compartment. A "smart" application can be fed the parameters for that environment such as the compartment design, the materials used, cost constraints, manufacturing methods and other design goals. The application would then go away and run thousands of different scenarios to find the optimal layout based on those design goals. That's AI. The next evolution of that use case would be to let the "machine" go and find the data itself, learn from experience and optimal layouts and actually find the best design itself. That's ML.
2. As previously mentioned, "digital twinning" a platform can provide valuable information around how certain designs would and wouldn't work. It is actually AI that powers that simulation to determine what could go wrong with a certain design should for example the ocean get rough and waves be over a certain height. That is AI but could lead into ML by just running the smart application over the design data as it's being created. So instead of waiting for the design to be completed and then running an AI simulation app over the top of it, ML can watch as you design and interrupt by suggesting "this design will create considerable roll when in rough waters and waves over 8 metres". It learns as you design.



Robotic process automation (RPA)

Robotic process automation (RPA) is essentially the application of artificial intelligence (AI) to processes. A software robot or 'bot' can interpret how a human interacts with a computer process which it can then understand, break down and repeat by itself. It also considers the multiple pathways a human might take based on certain events or parameters and incorporate them into its learning. A process whereby a human service desk operator fixes something on a PC can be learnt and replicated by a bot removing the requirement for a human to do it.

Why is robotic process automation so important for a digital shipyard?

Like in most working environments there are a number of tasks or processes that humans do that would be classified as repetitive, monotonous and inefficient. This is where RPA excels. Examples include:

- Setting all the font styles and sizes in a technical publication or design document to be the same
- Fetching data from different reports and merging them into one
- Adding information into the title blocks of a bulk set of drawings

RPA is focused at getting bots to do that repetitive work and free up significant time for humans to concentrate on more value add work. They could be considered your digital personal assistants.

Supply Chain Tower (SCT)

Supply chain tower (SCT) is another emerging technology that has been made possible through artificial intelligence. SCT moves beyond traditional supply chain whereby an organisation has a list of known vendors and suppliers they deal with. SCT uses the power of cross network intelligence to help accelerate decision making, identify providers of quality services and parts and reduce cost. For example, your SCT will work in the background after learning that you regularly purchase a specific part and find you other local vendors who are selling that part cheaper. Of course, it is not always about cost so SCT uses AI to research the reputation of identified suppliers and all without you having to lift a finger.

Why is supply chain tower so important for a digital shipyard?

SCT takes away a lot of the effort in having to find cost effective alternatives to current supply chain purchases. For example:

Your SCT identifies that you are procuring a large quantity of stainless steel bolts which accounts for 7% or your current spend. Without being prompted it traverses other supply chain networks and identifies that there are twelve other in-country manufacturers of the same sized bolts (form and fit). It then determines that three of those manufacturers sell the bolts for as much as 23% cheaper than what you are buying them for. It then actively researches those three manufacturers using a number of resources including social media, information from industry bodies and search engines. The research identifies that one of those manufacturers has a bad safety record however the other two come up green. Without you even realising what your SCT was doing it sends you a report suggesting that if you use one of those two manufacturers as an alternative to the one you are currently using you could save up to 3.4 million dollars over the life of your shipbuilding program. Pretty neat hey?

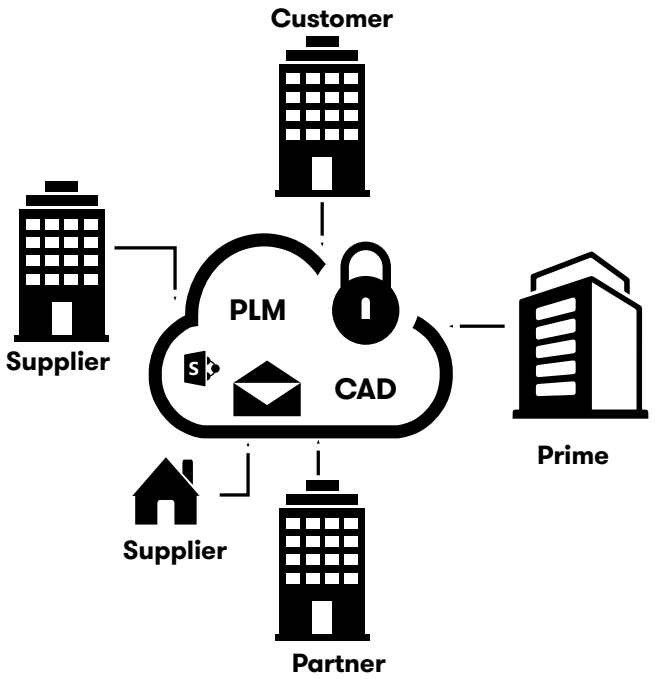
Secure collaboration

Often is the case that certain organisations are a little slow at adopting new technology. Of course, this has both pros and cons as although new tech can be very powerful you also don't want to be too close to the edge in case it just isn't ready. Collaboration in organisations however is something that is a little slow to advance, and for no apparent reason. Organisations still use antiquated collaboration platforms like email and snail mail to do some of their supply chain activities and share information. Not only is this ineffective for the purposes of true collaboration it's also inherently insecure. Secure collaborative program environments aim to remove the need to send information across "boundaries" by centralising those collaboration activities inside a single boundary. Not only does that dramatically change the collaboration value proposition it also fixes the concern around data leaks.

Why are secure collaborative program environments so important for a digital shipyard?

These environments are completely integrated and therefore all the data resides in a secure, containerised platform. This removes the need to collaborate across email, web portals and other antiquated and usually insecure platforms. The environments are data centric, so creation and management of information happens within a single secure space. Applications reside within the environment to remove the requirement of having to upload/download data from a desktop. The user simply enters the virtual environment and uses the applications within it to collaborate and do the tasks they need to do. Security is applied and managed across the environment providing users access to only the data they need.

The net result as seen in the diagram is a multipurpose environment where customers, partners and suppliers enter to collaborate and transact on the activities of a project. It fosters a culture of "one team" and removes working boundaries. Not only does it dramatically improve collaboration on a program it also keeps sensitive data secure which is paramount for any organisation.



Get it right and these digital technologies will provide a monumental step change in the efficiency, effectivity and therefore profit of a shipyard.

Conclusion

So there you have it. Thirteen capabilities that can successfully propel a shipyard into the digital age. However, don't fool yourself that it is as easy as inserting a CD, clicking on install and buying some licences. These capabilities are complex, require subject matter experts to implement and that's only after the hard yards have been done to determine how, and if, they would integrate into a specific environment. Interoperability and security are two other key considerations as without either of them things will not go well. Ninety percent of the hard work for a successful digital shipyard is in the planning, move too fast and it will create a lot of subsequent rework. Shipbuilding organisations should not feel like they have to solve all the problems themselves as there are a number of technology organisations out there who can help you make the journey easier. Some of these organisations, such as DXC, have global operations and have already helped implement digital shipyards in Europe and the US.

Like with all complex capabilities, my advice is to avoid "big bang" at all cost. Start small, introduce one capability at a time and fail fast in order to succeed fast. There are also foundation services that need to be considered before implementing some of these capabilities such as wifi without which will make it very hard to go digital. It would be like buying a car without a steering wheel. However, get it right and these digital technologies will provide a monumental step change in the efficiency, effectivity and therefore profit of a shipyard.

About the author

Bernard Ash is the Chief Technologist for Aerospace and Defence at DXC Technology in Australia and New Zealand. With over 15 years' experience in the industry, Bernard helps aerospace and defence clients manage their digital transformation.

*A special thanks to Ged Cunliffe and Chris Lennon for the digital value chain vision in Figure 2.

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