As the U.S. Navy continues to advance and become more integrated, our success relies on the balancing of the intricate interdependencies woven into the fabric of our Service. The underlying support structure that allows our Fleet units to perform their duties in support of U.S. national interests rely on the innovation and hard work of our uniformed and civilian personnel up and down the supply chain. That is why the

Kurdian is the director of engineering and product support at Naval Supply Systems Command-Weapon Systems Support in Philadelphia and Mechanicsburg, Pennsylvania. He is an Acquisition Professional and E-ZC Naval Flight Officer and has a masters degree in Aeronautical Engineering from the Naval Postgraduate School and MBAs from Cornell University and Queens University of Canada. He is the co-chair of the America Makes Working Group for Additive Manufacturing Qualification and Certification. He is a published author and an entrepreneur and co-founder of Prosiren Inc., a watersports apparel company.
strategic deployment of additive manufacturing (AM) machines throughout the supply chain, coupled with the right business model, is an imperative need in order to fully achieve the benefits of this technology.

The research and development communities within the Systems Commands (SYSCOMs), Office of Naval Research, together with private industry and other organizations, are leading a charge of rapid technological maturation. With the right operations plan that requires changes to our business decision modeling and the tools used to manage the supply chain, including Navy Enterprise Resource Planning (ERP), the Navy will be able to take full advantage of these technological advances. This is why the Naval Supply Systems Command (NAVSUP) will play a significant role in planning to leverage AM’s full potential.

**Business Case Analysis**

Once SYSCOMs have identified parts that can be produced by AM to a specified level of technical performance and within tolerances, a business case analysis (BCA) must be performed before a determination is made to build and supply via AM. For example, printing a wrench is technically easy from an AM perspective, but the cost and time to make that part by using AM, coupled with limited throughput, would not be cost effective, as the wrench is a ubiquitous item and cheap to mass produce. However, a more complex part with low inventory demand could be an excellent candidate. A cooperative effort
Cost Savings

Other Considerations

Systems Support (NAVSUP WSS), in cooperation with Penn State Applied Research Laboratory’s development of an AM Supply Chain Modeling and Simulation tool, an AM feasibility assessment was performed for 150 H-53 components. A BCA model could be tested on those items.

With reduction or elimination of the requirement to stock an item, at the very least at the wholesale level, the introduction of a direct to manufacture demand signal leads to a paradigm shift in Supply Chain Management (SCM) philosophy. To date, decisions to reorder have been based on predictive demand, force deployment, or in reaction to unplanned stockouts or significant fluctuations in demand. We could apply the concept of just-in-time (JiT) inventory to noncommercial items with low demand, greatly reducing or even eliminating the need to maintain a level of wholesale and possibly retail inventory.

JiT Inventory

Currently, when a demand signal is introduced to the system, this requisition goes through the ERP front-end processor before getting routed. The ERP Sourcing Module will then determine whether an order needs to be filled, killed or backordered. A second module captures data refreshing demand forecasts quarterly. Finally, a buy/repair module determines whether a new order from the vendor is necessary and informs the planner. The algorithms which drive the logic reside within each ERP module and dictate how much inventory needs to be kept on the shelf at the wholesale and
retail level and when to reorder. However, the lead time for manufacture is still a significant factor in inventory planning. Naval Aviation is suffering due to critical high-priority back-ordered parts that have grounded a significant number of our aircraft. Similarly, ship Casualty Reports of back-ordered extremely low-demand items reduce a ship’s mission capability and take 1 to 3 years to fill.

One key advantage of AM is the potential for drastically reducing lead time to manufacture to possibly a mere 24 hours followed by some time to post-process if necessary. So the Logistics Information Technology business systems that manage the Navy’s SCM will need to be configured to take full advantage of JiT.

ERP considers Administrative Lead Time (ALT) and Procurement Lead Time (PLT) when deciding whether to re-order. ALT is the time to put out a contract or purchase order to a vendor, and PLT is the time between award and/or obligation and first delivery. AM could reduce that time significantly if the right contract vehicles were in place, the business logic appropriately modified, and AM machines were strategically deployed at the critical points in the supply chain.

For example, PoM has never been a real consideration in making a business decision in Navy Supply, since we usually are limited to one vendor, or more rarely two vendors, approved and/or on contract to make a part or subassembly; the system doesn’t care where the part originates (PLT much greater than shipping time or T<sub>S</sub>). Once the digital AM thread is established and secure, demand signals for a new subset of AM producible parts should be routed to a location most geographically suited to manufacture and ship that part based on T<sub>S</sub> plus the capacity to post-process the part or downstream of the PoM. A systems monitor would be alerted as to the build order, plus the part’s destination, and would prepare the shipping container and materials in advance of completion.

**Updated Process Flow**

A future order flow for ERP incorporating AM could follow the diagram in Figure 1. This flow currently is limited to certain type model series (Table 2), and does not include aircraft expected shipping date. The ERP Module records the demand. Finally, AM feedstock, in the form of powders or polymers, is continuously assessed within ERP across the entirety of the supply chain to ensure sufficient stock is available.

To maintain proper cost accounting, this evolution should result in a series of invoices that direct the appropriate financial resources or charges levied as necessary. This flow should be more or less the same as it is now when a Fleet Readiness Center completes work on a Depot Level Repairable and either sends it to a Fleet unit or back to a system stock point, but it must become more automated. The receiving unit pays a burdened rate for the AM-produced part, including materials, shipping, royalties and all other apportioned costs.

A variation on the updated process flow introduces the complexities of a hybrid model in cases when the machine is government owned and operated but a vendor retains data rights. In this case, NAVSUP WSS or the Defense Logistics Agency could pay the vendor a license fee after the part is manufactured. Establishing a long-term contract with a vendor specifying such fees for a specified item would eliminate the need for individual purchase orders, avoiding the time and cost associated with cutting that document. Vendors simply would be notified when an order for one of these parts comes through and then again when the part is made. The government could then on an agreed-upon

<table>
<thead>
<tr>
<th>Aircraft Supported by NAVSUP WSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/A-18 A-D</td>
</tr>
<tr>
<td>E-2C</td>
</tr>
<tr>
<td>H-1</td>
</tr>
<tr>
<td>P-3</td>
</tr>
<tr>
<td>C-130</td>
</tr>
<tr>
<td>F/A-18 E/F</td>
</tr>
<tr>
<td>E-2D</td>
</tr>
<tr>
<td>H-53</td>
</tr>
<tr>
<td>P-8</td>
</tr>
<tr>
<td>AV-8</td>
</tr>
<tr>
<td>EA-18G</td>
</tr>
<tr>
<td>C-2A</td>
</tr>
<tr>
<td>H-60</td>
</tr>
<tr>
<td>V-22</td>
</tr>
<tr>
<td>EA-6B</td>
</tr>
</tbody>
</table>

We could apply the concept of just-in-time inventory (JiT) to noncommercial items with low demand, greatly reducing or even eliminating the need to maintain a level of wholesale and possibly retail inventory.
periodic basis pay the vendor what is owed, and ERP would record everything. This shares some similarities with current contractual constructs for Performance-Based Logistics (PBL) efforts in which the government pays a vendor to maintain a level of readiness, not for individual procurement or repair orders.

The model becomes much simpler when the order goes directly to a vendor. Once a vendor has a working machine and sufficient feedstock, each government purchase order should look the same. A long-term Indefinite Delivery Indefinite Quantity (IDIQ) construct would be used, delineating a single base price for manufacture and shipping while allowing for small annual increases due to inflation.

**Constraints**

As laid out, there are several major areas throughout the supply chain that will require changes or upgrades prior to implementation, running the gamut from technical, algorithmic, logical, to legal and contractual. They should not be insurmountable, but identification of all the constraints is critical to successful AM integration into SCM.

For example, IDIQ contracts and ERP compliance require that we identify which items we intend to buy and approximate quantities over the ordering period. AM makes the process more open-ended, although quantities for expected demand should not vary significantly, at least in the short run; AM is only supplanting a previous method of manufacture for a part, not increasing the draw. The government generally is required to state ahead of time the minimum number of parts it agrees to purchase over the life of the contract, and the vendor needs to agree to the turnaround times, which would be significantly shorter than those of traditional manufacturing.

Delivery Orders (DOs) can take months to organize and award, pricing may vary based on tiered pricing tables, and a DO is not awarded until all the funds for full execution of that DO are in place and ready for obligation. In the proposed model provided, an overarching purchase contract would need to exist under which the government agrees to pay a vendor each time a part is ordered, whether it’s “customer direct” to the vendor each time a part is made, or a license fee when the part is manufactured organically, with each DO cut automatically without human intervention. ERP does have
provisions for PBLs, but not necessarily a “pay for XX quantity of and unknown mix items at the end of period YY” outside of that construct. The government would award a contract based on a pre-determined amount of parts. Plus, that is very difficult to do outside of a cost type—PBL construct. At the end of each fiscal year, the contract could be reconciled based on the number of parts ordered as compared with how much was initially obligated. If demand significantly exceeds expectations, ERP would notify the contracting agency so that additional funds could be obligated if so desired.

As for licensing and royalty contracts, this has not been implemented on the proposed scale before. Although very rarely used, Federal Acquisition Regulation 31.109 covers the negotiation of Advance Agreements, while 31.205 discusses how to handle the cost element, and 27.202 goes to the specifics of reporting, adjudication and the Notice of Government at a licensee. The government and vendor should negotiate a fee that is a fair percentage of the AM production cost for that particular part. The first set of these contracts should be done with great care, as that negotiated percentage could set precedent for all future similar contracts.

**Summary**

Once issues of qualification and certification are overcome for a sufficient population of parts, AM has the potential to improve the Navy’s SCM and response in several ways:

- Shorter lead times
- Greater capacity to absorb positive and negative demand shocks
- Lower inventory carry costs
- Exact and near-real time correlation between supply and demand
- Reduced backorders

As with any new technology, understanding AM’s benefits, capabilities and limitations will be crucial to successful implementation. Both the government and our vendors will have to change mindsets, process and procedures to achieve AM efficiencies. Failing to adjust business practices and acquisition rules to AM’s unique aspects will result in our missing out on the revolutionary advantages the technology offers us to keep our ships sailing and our planes flying.

*The author can be contacted at armen.kurdian@navy.mil.*

---

**Where Can You Get the Latest on the Better Buying Power Initiatives?**

- **BBP Gateway** ([http://bbp.dau.mil/](http://bbp.dau.mil/)) is your source for the latest information, guidance and directives on Better Buying Power in defense acquisition

- **BBP Public Site** ([https://acc.dau.mil/bbp](https://acc.dau.mil/bbp)) is your forum to share BBP knowledge and experience