Artificial Intelligence (AI) for a Dominant US Navy (USN)

Leading the Way with Data for Mission Readiness of the Future

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This above photo is work of a sailor or employee of the US Navy. The appearance of U.S. Department of Defense (DoD) visual info does not imply or constitute DoD endorsement.

OVERVIEW

AI Technologies, Inc. is pleased to submit this White Paper, which explains and validates the benefits of employing Artificial Intelligence (AI) in conjunction with Lean Six Sigma (LSS), to the United States Navy (USN) for consideration in its ongoing modernization planning efforts to shape and deploy a more dominant Naval Aviation Enterprise (NAE) of the future. The opinions and recommendations within affect, but are not necessarily limited to, the ongoing planning and execution focus for modernizing and improving performance of the three primary FRC depots of the Naval Air Systems Command (NAVAIR).

NAVAIR is in excellent position to reinforce its standing as the US Armed Forces service exemplar for leveraging cutting-edge science, technology, and process solutions to achieve greater warfighter capabilities, operational efficiencies and turnaround, mission readiness and outcomes. It is suggested NAVAIR would benefit from a near-term AI LSS pilot project (i.e. Proof of Concept) at either FRC SE or FRC SW. Both sites are logical choices for consideration due in large part to the similarities of core logistics and sustainment processes (fab and machining), suppliers and customers shared with Kessington Aerospace, a precision manufacturer of machined parts for commercial and military jet engines and landing gears. An ongoing AI Proof of Concept at Kessington Aerospace continues to validate that AI, when deployed using all data collected (i.e. Big Data) and executed upon a firm foundation of LSS practices, is principally responsible for increasing on-time delivery from 52% to >90%. In addition, AI + LSS reduced overall costs by 23% and improved operating profits from -3% to >20% in less than 18 months.

Lean was developed by Toyota in the 1980s for application within its high volume, repetitive manufacturing environments. In the years since Lean has been deployed successfully outside high volume, repetitive environments due to artful application of the Pareto Principle, which asserts that 80% of effects (output or results) are determined by 20% of causes (input or costs). These 20% were dubbed the "Vital Few" and, by contrast, the remaining 80% (e.g. low volume parts) were referred to as the "Irrelevant Many". Thus, historical use of Lean methods has focused largely on the "Vital Few" and, while achieving notable reductions in scrap, rework, cycle time, and operating costs, have typically left any 80% "Irrelevant Many" opportunities behind.

Today's computing speeds are orders of magnitude faster than in the 1980s, due to advances in semiconductors and parallel processing by millions of servers residing in Cloud Computing (i.e. Amazon). These technological advancements have ushered in a new age … the age of Artificial Intelligence (AI). AI makes it possible to rapidly discover patterns of waste and disablers of higher productivity, business and mission success that were previously hidden within the unused "Dark Data" of the so-called "Irrelevant Many".

In the case study to follow, you will learn how Kessington Aerospace discovered that their "Irrelevant Many" part numbers, in fact, accounted for 75% of the total setup waste in their factory. Toyota's traditional Lean setup reduction methods were simply not cost effective in attacking such a large quantity of part numbers only repeated a few times per year. In other words, brute force application of Lean methods and tools alone to these low volume parts would yield a poor ROI.

Kessington's success to date has been due in part to the Lean discipline and fundamentals (e.g. Pull Systems, Setup Reduction, etc.) engrained in its culture … much as LSS paved the way and informed the development and deployment of NAVAIR AIRSpeed and today's continued advancement of continuous process improvement (CPI).

This White Paper will reinforce the utility and power AI offers NAVAIR for achieving greater levels of cost-wise mission readiness and for improving industrial facilities capabilities and capacity to not only increase current performance but to support the next generation of aircraft and engines. It is also intended to reinforce a sense of urgency and the challenge facing America's continued force projection dominance.

The National Artificial Intelligence R&D Strategic Plan states that *"AI can create smarter, faster, cheaper production processes that can increase worker productivity, improve product quality, and lower costs."* That said, the Council on Foreign Relations believes the *"made in China 2025 strategy to dominate worldwide manufacturing is a real existential threat to U.S. technological leadership."* The threat to Naval Aviation is very real!

AI can equip the NAVAIR depots with breakthrough capabilities and a most formidable weapon for attacking and eliminating costly waste by using AI in conjunction with LSS to achieve results simply not possible using Lean alone. NAVAIR led the way across the Naval Aviation Enterprise (NAE) in deploying LSS and AIRSpeed as an enabler for achieving greater levels performance. NAVAIR can again lead the way for AI across the DoD and American industry.

US NAVAL AVIATION: DOMINATING the FUTURE

The AI Proof of Concept effort at Kessington Aerospace, owned by Michael L. George and located in Elkhart, IN, proves conclusively that Artificial Intelligence (AI), when deployed judiciously upon a firm foundation of LSS methods and tools, has increased on-time delivery (up from 52% to >90%), reduced overall costs (down 23%), and increased operating profits (up from -3% to >20% in less than 18 months).

A dominant Naval Aviation Enterprise (NAE) of the future will be comprised of faster, leaner, more capable business and production processes yielding increasingly higher levels of readiness for tasking and mission success. The same challenge and opportunity exist for all DoD aviation, including Air Force and Army. With increasing design complexity and greater performance expectations for today's Navy weapons systems comes greater potential that the shortage of even a single part can be the difference between in-service (operational) and out of service (grounded). We contend the outcomes realized and knowledge gleaned from a successful AI LSS Proof of Concept will meaningfully inform depot equipment and components baselining and subsequent facilities modernization plans.

AI Case Study: Kessington Aerospace, Elkhart, IN

Situation:

Kessington Aerospace produces high precision machined parts for jet engines (GE LEAP and PW 1000 and F135) and landing gear (Boeing 737, Air Bus A320, Air Force B-1, and B-52). Past use of Lean Six Sigma (LSS) tools and methods has been instrumental in discovering ways to reduce operating costs and to enable acceptable on-time delivery for the business' higher volume parts. The three most important tools include the following:

1. Pull systems, which place a cap (or limit) on the amount of work-in-process (WIP) hours at each machine or group of similar machines
2. Setup reduction, because setup time is generally the largest single source of waste in any manufacturing process, and
3. Quality counter-measures to reduce scrap to less than 2%

Pull systems affect all parts moving through the factory, while items 2 and 3 above are generally applied only to the so-called "Vital Few" … representing 19% of all part numbers and delivering 80% of the business' overall revenue. The remaining 81% of part numbers delivering 20% of revenue were dismissed as the "Irrelevant Many" … not worth the investment of finite CPI resources. Over time, however, it was determined these same low volume part numbers were primarily responsible for most late shipments to Kessington's customers. The notion of maintaining a higher finished goods inventory for so many different low volume part numbers was cost prohibitive. Management realized something different was needed to realize the required improvements to manufacturing cycle times. But, where to start? Fortunately, the business had collected and maintained massive quantities of historical manufacturing data in their ERP system … available for analyses in the past but deemed too cumbersome and impractical to use (commonly classified as "Dark Data") with LSS methods.

AI Case Study: Kessington Aerospace, Elkhart, IN

Actions:

Kessington mobilized its improvement resources, including several key shop floor supervisors who bought in to the concepts after attending a two-day overview demonstrating the ways AI could make a significant difference. Key members of our Kessington team are shown in the figure below:

The Kessington AI LB Lathe team: (from left) Nick, Intern from Notre Dame; Randy, Supervisor LB-II Lathes; Setup Consultant John Smith, AI LSS Inc.; Steve, LB supervisor; Pull System consultant Dan Blackwell, AI LSS, Inc. Not shown include Tim Frenzel, Data miner with AI LSS, Inc. and about a dozen operators of the 120 total

This team used the historical surplus of data ("Big Data") that had been captured for all part numbers to discover hidden waste. Utilizing Artificial Intelligence (AI) Kessington discovered some very enlightening and previously hidden patterns in the data. It turned out the so-called "Irrelevant Many" were responsible for 75% of total factory setup time … consuming as much time in setup (non-value add time) as in value-add machining! This discovery was a critical root cause responsible for driving higher manufacturing costs and unacceptably lower on-time delivery rates of 52% for its customers. The "Irrelevant Many" were proven not so irrelevant after all when it came to on-time delivery requirements for Kessington's customers.

AI Case Study: Kessington Aerospace, Elkhart, IN

Actions (Cont.):

Traditional LSS rapid setup reduction methods require labor intensive Engineering observation of tooling setup for each part number, which translates as higher costs with poor payback for low repetition part numbers. By contrast, consider the sample solution outlined below for our Kessington setup problem as just one concrete AI-enabled improvement example:

- A part number A job order is about to finish up at the LB lathe … 50 job orders are in WIP behind the LB lathe
- AI (our Neural Network) computes all possible sequences for machining the next four batches of different part numbers sharing common (or near common) geometry and tooling
- The Neural Network considers all 230,000 possibilities (50! / (46!4!)) and identifies the sequence with the lowest setup time in less than a minute … impossible with computing speeds of Circa 2000 when LSS was first developed
- Running these four part numbers' jobs minimizes total setup time while still meeting customer on-time delivery needs based on simulation
- The total number of tool changes is significantly reduced … lowering the probability of defects and scrap and improving C_{pk} (a key process capability quality metric)

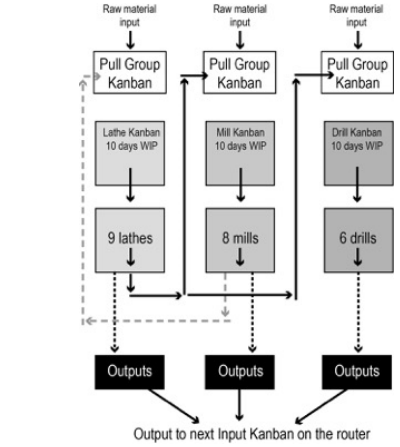
If an LSS pull system exists, it must be modified into an AI LSS pull system. Traditional LSS pull systems flow is Machine to Machine, while AI pull systems flow is from Pull Group Kanban to Pull Group Kanban (see figure below)

Redesign LSS Pull System to AI LSS Pull System

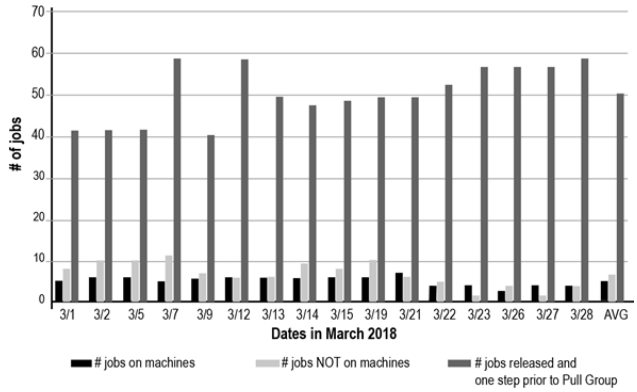
(Factory is Divided into Similar Machines, Lathes, Mills, etc.)

- The AI Pull Modification to LSS:

Machine AI Pull Group to Machine, not Machine to Machine



- Each AI Pull Group has about 50 jobs



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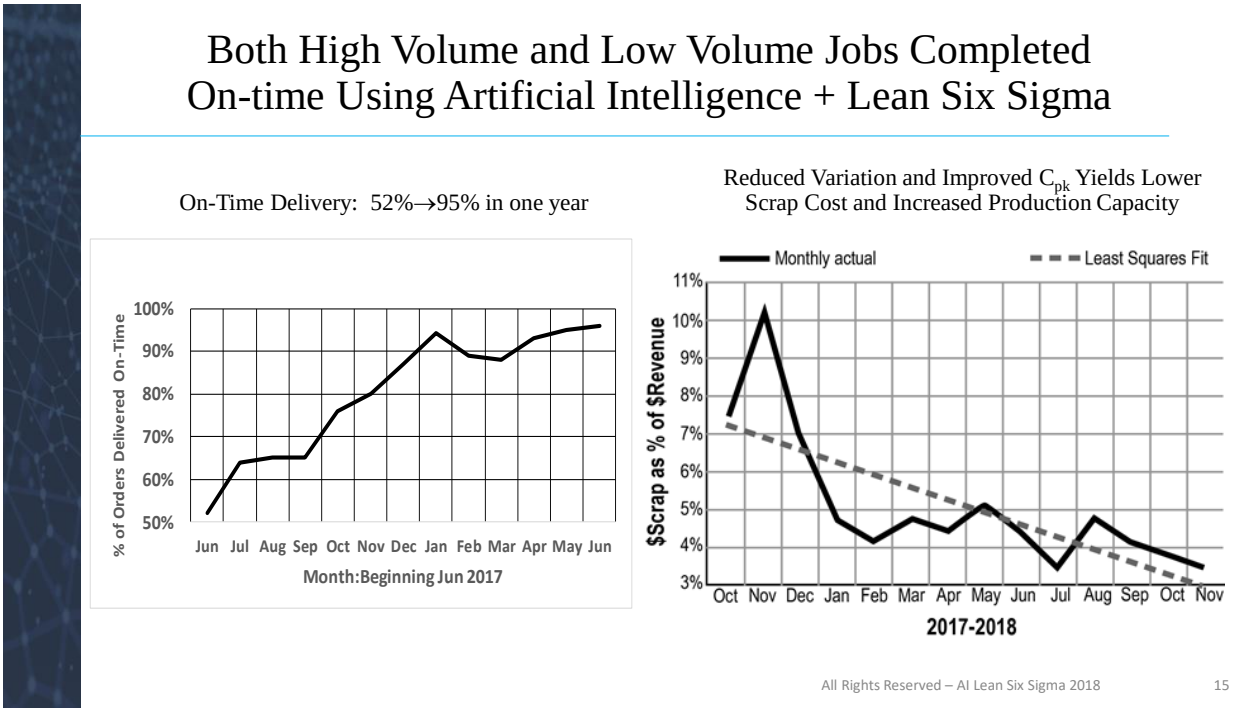
AI Case Study: Kessington Aerospace, Elkhart, IN

Results:

As shared previously, on-time delivery improved from 52% to >90%, overall costs were reduced by 23%, and operating profits improved from -3% to >20% in less than 18 months. Scrap was also reduced from 8% to 3%. Overall improved performance at Kessington Aerospace is also depicted in the graphs below:



SUMMARY / NEXT STEPS

Consider the following:

CEO of Intel (Wall Street Journal, October 24, 2017):

"Almost every company you can think of, every application, is going to be affected by Artificial Intelligence. You are going to be using Artificial Intelligence, or you're going to be outpaced by people who are… You'd be surprised at how many companies have access to the data but don't put the investment in place (to use it). Companies must use AI or else"

China's Artificial Intelligence (AI) Plan published in 2017

"The rapid development of artificial intelligence will profoundly change human society and life and change the world. To seize the major strategic opportunity for the development of AI....the plan of the CCPCC (Chinese Communist Party Central Committee) has been formulated.

As stated earlier, the threat is real … but so is the opportunity! The Kessington Aerospace case study proves that Artificial Intelligence (AI) can and should be implemented in combination with fundamental CPI/LSS methods and tools. Production capacity, process capability, manufacturing cycle time and costs, on-time delivery and readiness levels … all are key metrics upon which the use of Big Data, AI and LSS can have a profoundly material improvement. AI Technologies, Inc. strongly urges NAVAIR to identify a suitable Proof of Concept FRC depot site where manufacturing and fabrication activities are routinely executed to support maintenance, repair, overhaul and/or sustainment demands. It is suggested FRC SE or FRC SW be assessed for fit, due in large part to the similarities of core sustainment and logistics processes (fab and machining), suppliers and customers shared with Kessington Aerospace.

Specific quantifiable goals expected from an 18-month Proof of Concept include the following:

- Capacity increase of 20% with no manpower increase
- Cycle time reduction of 30%, and
- On-time delivery-to-promise date: >90% with no increase in inventory

AI will serve as a targeting mechanism and a means for identifying new, fertile areas for improvement, for discovering wastes not seen and not known before. AI will reveal new sources for replenishing CPI project portfolios and for guiding improvement initiatives into operational and/or transactional spaces where meaningful research and development and/or organized project identification and selection efforts can be conducted.

Finally, a key outcome of the proposed Proof of Concept will be a methodology and road map for replicating results across the other FRCs, maintenance and repair depot sites … providing for an even greater ROI and resultant increase in desirable process consistency and standardization. Further, it is indeed possible that results achieved will yield relevant insights into application of AI for other NAVAIR non-manufacturing Corporate Operations, Supply Chain and Procurement, Project Management, and Product Development processes.

The cost of this proposed project is TBD, pending results of an initial site visit and project scope assessment. Our considerable experience working within the DoD suggests a first-year payback of 10X the cost of Continuous Improvement (CI) funds invested is not an unreasonable expectation.