Safety stock is a term used by inventory specialists to describe a level of extra stock that is maintained below the cycle stock to buffer against stock outs. Safety stock (also called buffer stock) exists to counter uncertainties in supply and demand. Safety stock is defined as extra units of inventory carried as protection against possible stock outs.

Challenges

21st Century Logistics

Engine Safety Stock: An Opportunity to Avoid Over-Sparing Engines

In today's fiscally constrained environment, correct inventory management has become even more critical than in the past. In "Engine Safety Stock: An Opportunity to Avoid Over-Sparing Engines" Duane Anderson examines current engine safety stock processes and levels and makes a case for reducing stock levels.

Currently, the Air Force computes engine safety stocks in the Propulsion Requirements System (PRS), which computes a base safety-stock level (BSL) with a subcomponent including a war ready engine (WRE) target. The BSL forms the basis of many metrics upon which priorities are set and work around actions are undertaken if an engine *goes red* (below BSL/WRE target). The current process disregards the aircraft availability target of the aircraft and computes an 80 percent availability based both on demand variation and wartime flying hours. According to Anderson, this computation creates a glut of engine inventory compared to the aircraft availability (AA) target and commodity stock levels, especially for systems with low AA targets.

Anderson proposes a decrease in engine safety-stock levels and inductions by integrating the D200A item-level planning process, the AA planning process, and the engine planning process. Then, he suggests reclaiming lost assets and developing a burn down plan for engines that are clearly overstocked once the systems are more closely integrated.

War ready engines are safety stock, and the current process, Anderson notes, results in an overabundance of this safety stock with little effect on actual aircraft availability and mission capability. Not only are the targets very high compared to the variability of engine demand, but the Air Force often overproduces beyond the WRE target. Engine availability targets need to be balanced with aircraft availability, otherwise there is negative impact on actual mission capability.

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Engine Safety Stock: An Opportunity to Avoid Over-Sparing Engines

Duane Anderson, USAF

Inventory management is about two things: not running out, and not having too much. Our desire to not run out, along with uncertainties in demand and supplier lead times are why we have inventory in the first place. Essentially, inventory is a reserve system to prevent a stock out. However, as important as it is to prevent such a stock out, we also don't want to hold onto too much inventory because of holding costs. So how do you balance the two and what is the right amount? More importantly, when should you reorder in order to prevent a stock out?

—Charles Atkison

Introduction

Safety stock "is a term used to describe a level of stock that is maintained below the cycle stock to buffer against stock outs. Safety stock, or buffer stock, exists to counter uncertainties in supply and demand."[1] It is commonly defined as extra units of inventory carried as protection against possible stock outs. Safety stock or buffer stock is held to counter uncertainties in supply or demand.[2]

The Current Process

The Air Force computes engine safety stocks in a system called the Propulsion Requirements System (PRS), which computes a base safety-stock level (BSL) with a subcomponent including a war ready engine (WRE) target. The BSL forms the basis for many metrics upon which priorities are set and work-around actions are undertaken if an engine *goes red* (below BSL/WRE target). Engines are very expensive to buy or repair. The current process disregards the aircraft availability target of the aircraft and computes an 80 percent engine availability based both on demand variation and wartime flying hours. This computation creates a glut of engine inventory compared to the aircraft availability (AA) target and commodity stock levels, especially for systems with low AA targets.

Proposed Process

This article proposes a decrease in engine safety-stock levels and inductions by integrating the D200A item-level planning process, the AA planning process, and the engine planning process. It also proposes reclaiming assets and developing a burn down plan for engines that are clearly overstocked once the systems are more closely integrated.

War ready engines are safety stock, and the current process results in an overabundance of this safety stock with little effect on actual aircraft availability and mission capability. Not only are the targets very high compared to the variability of engine demand, but the Air Force often overproduces past the WRE target. Engine availability targets need to be balanced with aircraft availability, otherwise there is negative impact to actual mission capability.

Article Acronyms

AA – Aircraft Availability
AMARG – Aerospace Maintenance and Regeneration Group
BSL – Base Safety-Stock Level
EXPRESS – Execution and Prioritization of Repair Support System
LRU – Line Replaceable Units
MICAP – Mission Capable
PRS – Propulsion Requirements System
SRU – Shop Replaceable Units
WRE – War Ready Engine

Hypothetical Case

For example, let's look at an engine we will call the F-333, used in a single engine fighter. There are 160 planes in the fleet using the F-333 and the BSL target is 40. The actual BSL is 25, and thus 62.5 percent of the target—below target by 15 engines, and considered *red*.

Though the F-333 logistics personnel are *running around* expediting actions and incurring extra cost to correct the *red status*, the reality is that the aircraft using the F-333 are in very little danger of not being able to complete assigned missions because of the lack of WRE. There is actually a positive inventory position of 25 working engines. This equates to 16 percent safety stock, on a *red program*, assuming the aircraft has an availability rate of 100 percent for nonengine parts. If the availability target of the aircraft is 65 percent excluding engine parts, the safety stock is even higher, since the engines will not make the aircraft mission capable anyway. In this hypothetical case, if the WRE was 40, the simple safety stock percentage would be 25 percent. However, there are also spare line replaceable units (LRU) and shop replaceable units (SRU) (major components) that are not installed on engines, providing additional safety stock. Finally, there are perhaps half or more installed serviceable engines on the remaining 35 percent of the fleet (17 more engines). To quickly convey the type of cost savings if we integrated PRS with aircraft availability targets, the F-333 program could keep 25 spares and cost avoid repair of 33 engines in one inventory turn. The typical cost for an engine repair is between $1M and $3M, so this cost avoidance is significant.

Pipeline

In addition to savings from integrating AA to PRS, the PRS pipeline is also based on an 80 percent engine availability target. Engines are typically *onetime* buys at the beginning of programs, but as programs get older the pipeline and the AA target decrease. This provides an opportunity for reclamation of the spare unserviceable engines using temporary work orders to avoid costly new procurement. Using our hypothetical example, assume the F-333 used to have an AA target of 80 percent, and a calculated pipeline of 73 unserviceable engines. Now, having dropped somewhat, the pipeline is only 40 engines. This leaves 33 possible engines available for reclamation, each of which could easily avoid $1M in piece-part buys or even repairs.

Real World Case—F-101 Engine[3]

The F-101 engine was red, since its major command-negotiated WRE requirement is 28 and the program only had 25 WREs. Four engines go on each aircraft, and the active fleet size is 66 (264 engines). Thus, the negotiated requirement basically equates to 11 percent safety stock (66 aircraft divided by 6 sets of 4 engines). In addition to the active inventory, there are approximately 40 F-101s at the Aerospace Maintenance and Regeneration Group (AMARG) that can be utilized as risk mitigation, as well as over 230 serviceable installs. At the time of this study, the F-101 had 121 other spare engines, many of which could be broken down to provide LRU and SRU safety stock, as well as spare LRUs and SRUs.

This information is shown to illustrate that the F-101 engine is over-safety stocked. There is virtually no effect on the mission if the WRE is at 25 or 12 due to the speed of lateral support and how quickly an engine can be put on or taken off a wing (estimated 40 to 80 hours or $3,200 dollars per engine). Even if the BSL was to drop to 9 (10 percent of the BSL target of 87), the worst case scenario would be to use mothballed engines from AMARG, which although difficult (because of policy), is more than possible, or to take an engine from one aircraft and put it on another aircraft.

The aircraft availability goal of the B-1 is 58.5 percent, thus illustrating the effect of the delta between PRS (80 percent plus) and the AA (58.5 percent). The cost of repairing an F-101 engine (or any other engine) simply to create unnecessary safety stock is astronomical. Incidentally, as of February 2009, further research shows the F-101 is still listed as red, but actually has a BSL of 87, and 87 serviceable spares.

Using a recognized commercial method of creating BSL using historical variation is required. Minimum and maximum policy would drive planners to hit the target within a defined percentage, but they would be discouraged from going too far over or under the decreased environment. Engine programs have already adopted parts of this *too green* philosophy, but the tie-in to actual production does not appear to be lowering the amount of WRE. Further, the metric does not appear to be strong enough to change the existing mindset. Nevertheless, this new process, called WRE *banding*, has been a success, but does not directly impact many of the associated problems.

Repair Issues

Another object of concern is how engines are driven into production. Production schedules of full-up engines are generally negotiated. A program might plan to produce 20 engines at depot in 1 fiscal year. They do this regardless of the health position of the aircraft or the engine. Although the terminology is blunt, the current system *buggy-whips* engines. Engines are not driven by the Execution and Prioritization of Repair Support System (EXPRESS), and thus the piece-parts required for repair are also suboptimally prioritized. For example, programs that are green have MICAPs [mission capable] for piece-parts that have a higher priority in EXPRESS than programs that are below AA targets. This issue has been discussed with EXPRESS subject matter expert Mr Steve Roberts, and he confirms EXPRESS does have the capability to account for this situation. The users have simply chosen not to turn it on.

Expected Benefits

A significant cost avoidance (at least $1B over 3 years) can be realized over time by reducing long inventory turn times.

Lean methodology, as outlined in such notable books as *The Toyota Way, Lean Thinking*, and *Streamlined: 14 Principles* clearly outline the benefits of adjusting for variation in demand by capacity rather than inventory. Extra inventory may include shelved assets for programs that have additional safety stock at locations such as the AMARG. While there is a cost to reconfigure AMARG engines up to current configuration, it is much cheaper to modify the engine than to expend the unit repair cost of the engine.

To illustrate, at a micro level, the cost avoidance on another engine, a single HPT rotor on the F-110-129 engine has a unit repair cost of $137,000. For this single LRU, the cost avoidance for a reduction of 12 LRUs (major component) would result in a $1.65M cost avoidance. A simple look at D200 shows the Air Force continues to repair LRUs and SRUs even when engines are 10 to 20 percent over target.

The B-1 and F-101 programs were used as an examples, since they are supposedly red. Other engine programs are even worse. For example, the F-110-100 recently had an authorization of 75 serviceable, but had 131 serviceable assets on hand. Although the F-110-100 is undergoing a Service Life Extension program, this type of overproduction results in uneven support to the warfighter and a waste of money without benefit to the customer or to the mission.

Put in very simple Lean and Theory of Constraints terms, 125 percent engine availability plus 60 percent aircraft availability equals 60 percent weapon system availability and 65 percent engine waste.

Notes

1. Definition of safety stock, *Wikipedia*, [Online] Available: http://en.wikipedia.org/wiki/Safety_stock#cite_note-0.
2. Safety stock discussion, *supplychaincasestudies*, [Online] Available: http://supplychaincasestudies.com/resources_knowledge.html.
3. 26 September 2008 data used.

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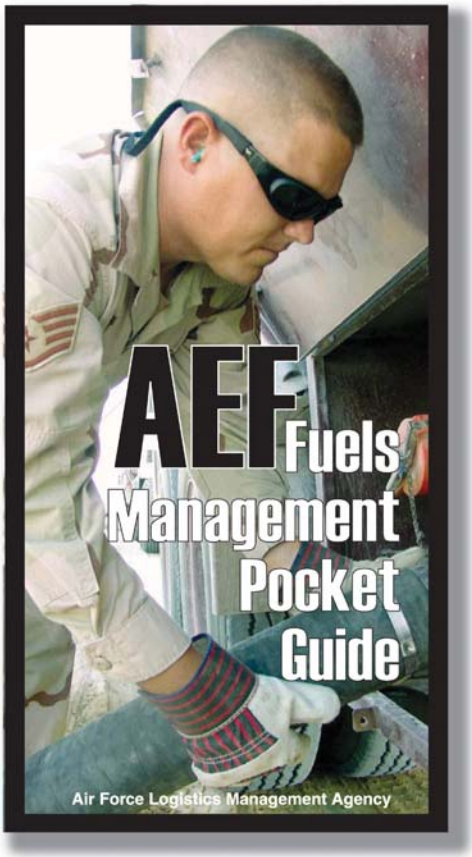

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