C-130 PROGRAMMED DEPOT MAINTENANCE PROCESSES

GRADUATE RESEARCH PROJECT

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Abstract

The C-130 is a tactical airlifter and has been in steady use for decades in austere deployed locations. The inspection program to ensure its sustainment has faced increasing workload requirements due to structural issues related to heavy use and aging materials. The most in-depth inspection is the Programmed Depot Maintenance (PDM) inspection and is accomplished at two Air Logistics Centers (ALCs). In recent yers, both centers have experienced increased maintenance time and decreased on-time production rates, with Due Date Performance (DDP) rates as low as 30%. This negatively impacts aircraft availability and mission capability. Another challenge facing the ALCs is the ongoing transition to High Velocity Maintenance (HVM), which is intended to improve aircraft availability to meet mission requirements.

This study utilizes a simulation model to assess the impact of adding dock spaces and the impact of prioritizing one aircraft variant over other variants. The model represents the expectation for the entire PDM inspection process based on technical data inspection requirements for the C-130 fleet. Data was generated using expected (scheduled) flow times for major sub-processes from induction into the inspection process through the functional test flight and the return to home station. Simulation results indicate several problems with the current production strategies, including the negative impact of prioritization on the overall due date performance for all C-130 variants.

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Heather D. Cooley

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I. Introduction

Overview

C-130 airlift aircraft have been in service for over 40 years. The depots which are responsible for their sustainment are currently struggling to manage the increased workloads due to aging aircraft and high operations tempo. The combination of aging materials and high operations tempo have combined to affect the structural components of the aircraft, requiring unplanned repairs during the most in-depth inspection required—the Programmed Depot Maintenance (PDM) inspection. For most of the C-130 fleet, the PDM inspection is accomplished by the Air Logistics Centers (ALC) an is normally accomplished every 69 months. Due to the extensive inspections and work required, each aircraft may be down for over 6 months before being returned to the owning unit. The ALCs measure this inspection process using a Due Date Performance (DDP) metric. This metric identifies the capability of the Air Logistics Centers (ALC) to return an aircraft to the owning unit in accordance with the contracted inspection time. Currently, the ALCs are returning less than 40% of the aircraft on time back to the owning unit. This delay increases the number of aircraft down for maintenance and negatively impacts aircraft availability.

In order to improve aircraft availability, the High Velocity Maintenance (HVM) concept is being implemented to replace the current PDM process for heavy maintenance inspection and repairs. The transition of the PDM process to the HVM process will take place over several years through attrition. The C-130 fleet, constrained by mission requirements and age-related structural issues, is the pilot program for this transition.

This study will identify the impact of additional dock spaces and prioritization on the inspection process using discrete simulation software.

Background

Ongoing mission requirements and age-related structural issues constrain the C-130 fleet. C-130s are maintained and operated by active duty, reserve and guard units. The mix of varieties and owning units complicates the planning processes required to maintain and sustain the C-130 fleet. In addition, extensions or delays in the return to service heavily impact the units' mission capability. There is a growing concern about the long term implications of our aircraft fleets, including increased maintenance requirements and decreased aircraft availability. One of the challenges in addressing the problems of aging fleets is the availability of data. Ad hoc data collection across the depots has limited researchers' attempts to identify trends (Pyles, 2004). Constrained fleets require precise planning and clear communication between the inspection organizations and the owning organizations to meet mission requirements (Kim , Sheehy, & Lenhardt, 2006).

The amount of work to be accomplished and the expected completion date are established prior to the aircraft arrival at the inspection facility. This plan is established between the ALC and the owning Major Command (MAJCOM). The initial plan is established about 2 years out, then is revised approximately 90 days before the aircraft arrives at the repair facility. Once the aircraft is actually in the inspection dock, the maintenances team makes their initial assessment which may be used to adjust the scheduled out date (Richards, 2010).

The expected aircraft production for each depot is based on the aircraft inspection requirements, not necessarily on the maintenance capacity of the repair locations. This type of scheduling pushes the depots to set their flow rate based on the total number of inspections for the period, rather than the maintenance requirements of each aircraft or the repair capacity of maintenance organization. The squadron schedulers in the depots prioritize the aircraft based on input date, required maintenance and mission impact. For example, aircraft which belong to Air Force Special Operations Command (AFSOC) are pushed to the front of the line when they arrive. These aircraft receive priority due to the limited availability for some variants, as well as the critical nature of the AFSOC mission. Prioritizing these aircraft may push other aircraft back in their input dates or work schedules, which can affect the scheduled output date to the owning unit. Owning units may also request acceleration to reduce the total time spent at the depot (Romero, 2010).

According to the squadron schedulers at WR-ALC, they use several systems to input and track maintenance data, including database maintenance information systems and spreadsheet programs such as Excel (Guyer, 2010). A program called Roll Oriented Consolidated Information Tool (ROCIT) consolidates info from several data systems and enables analysis. GO-97 is used for PDM scheduling, and contains the data used to build the 90-day network plan for tasks. The schedulers load all aircraft and the information is linked to the network, which is what the various shops use to determine the daily work requirements. The network shows the end date based only on work scheduled against the aircraft and doesn’t account for unexpected work or facility constraints. There are also several Excel spreadsheets requiring manual updating, which can take an extensive amount of time and still not be up to date (Lancaster, 2010).

One of the many challenges in this type of work is that actual repair requirements for each aircraft may not be evident until the work actually begins. The C-130 is used as a tactical airlift aircraft and is exposed to heavy loads, austere conditions and minimal maintenance capability at some locations. Some repairs may be put off for months due to time or resource limitations at the deployed locations. The corrosion and age both impact the structural integrity of the aircraft, as well as the workload required in the PDM inspection. As the maintainers open the panels for inspection, the metal flakes off of the structural components and what looked like a solid support structure is actually chipping away. While the inspection plan is established months or years out, the maintainers may not have an accurate task list until they actually remove the aircraft panels and inspect the structure (Romero, 2010). This additional, and often extensive, work has a significant impact on resource management and budget allocation within the depot (Kinzie & Cooke, 1998). The extended downtime required to repair the damage significantly impacts the aircraft availability for operations and training (Loredo, Pyles, & Snyder, 2007).

The amount of unscheduled and unexpected maintenance increases the variance in the process. The schedulers have to plan with only part of the information about the workload on the aircraft. When work is found on an aircraft, the repair is added to the task list. But it difficult to determine the impact of these additional tasks to the final output date due to the extensive amount of work required for each aircraft. A small delay early in the inspection may not affect the final output date for a particular aircraft. Or a major delay on one aircraft could cause resource constraints for other aircraft and eventually delaying multiple deliveries. There are many other variables for all management levels to consider, including manning, shared resources and adequate training.

Management of the inspection process takes place across several levels. Site visit feedback from these managers indicated high levels of concern with the amount of work required and timeliness of completion on all aircraft. The managers' concerns included work-in-progress, experience levels of workers and unplanned repair requirements (Romero, 2010). The inspection work packages have increased over the last several years to accommodate the increased workload for the aging aircraft, but the work packages may not account for all the work required to return the aircraft to serviceable condition. The inspection work packages are currently under review to address the gap between the work packages and the actual work completed during the PDM inspection (Richards, 2010).

One of the challenges with adjusting the inspection work packages is the access to data regarding current processes within the depot. Without accurate data regarding the work completed and forecasts for the remaining work, it is difficult to identify the problems within the work packages. The current information sharing protocols do not provide accurate or matching completion estimates to the owning units. Completion estimates are determined based on the squadron schedulers' spreadsheet timelines. That information is updated in multiple information systems, but those systems may not have the same information. In addition, it is difficult to determine the impact of maintenance actions or decisions on the final completion date when changes occur.

All levels of supervision are focused on the daily actions and reactions, rather than looking ahead to plan changes or to prevent problems. The C-130 Branch Chief estimates 30-50% of his formal suspenses for information are due to requestor within hours. There is a need for a fleet management tool that will fit into ECSS and provide accurate information to all levels of users (Flattery, 2010). This type of system would allow all users to see the same information and display accurate details regarding changes or delays to aircraft. In the last few months, funding requirements have reduced the budget for ECSS so the implementation is delayed.

In order to improve aircraft availability, the Air Force is shifting from a PDM concept of inspection to an HVM concept of inspection. Aircraft currently go through the PDM inspection every 5-7 years and may be unavailable for over 6 months. The HVM concept of inspection has the aircraft down for major inspection more often, such as every 18 months. But the inspection periods are much shorter, in theory a few weeks. The transition will be implemented through attrition over several years. Incremental changes need to occur to transition the PDM process to the HVM, including improving variance across processes and increasing throughput for the depot production lines.

Problem Statement

The current inspection processes for the C-130 fleet are not meeting the mission requirements for aircraft availability and are negatively impacting operational units' mission capability. With ongoing funding and resources constraints, it is important to identify areas for improvement in the current inspection concept. In addition, the C-130 fleet is transitioning from a PDM concept of inspection to an HVM concept of inspection. The transition will take place through attrition, so there will be incremental steps within the inspection organization to incorporate the tenets of HVM. It is important to identify the most effective areas to address first with limited resources available. This research is important because an unpredictable depot production schedule decreases aircraft availability and prevents adequate planning.

Research Objectives/Questions/Hypotheses

The objective of this research is to apply a simulation model to the C-130 PDMs in the Warner-Robins Air Logistics Center C-130 Programmed Depot Maintenance production lines. The intent of the model is to identify the impact of additional resources to the current process and determine the impact of current business rules on throughput. These results may also highlight changes in instructions or management processes required for the transition to HVM. This research addresses the following questions:

1. What is the impact of additional resources on the average flow days for the inspection?
2. Are the current business practices for prioritizing aircraft detrimental to the overall goal of on-time completion of the inspection (DDP)?

Methodology

This research uses Arena© 10.0 for analysis of the proposed changes to the Programmed Depot Maintenance (PDM) inspection concept for C-130 aircraft at Warner-Robins ALC. Simulating a system of this complexity generally entails representing only the key characteristics and behaviors of the proposed system. This model addresses the inspection process from a "big picture" perspective, rather than a task-level approach.

Assumptions/Limitations

This study assumes the available baseline data is accurate regarding flow days for inspection completion. Access to maintenance data was problematic and this study uses

AMREP data attained from AFMC/A4VP for comparison. The models are built using the baseline data provided from the ROCIT program at WR-ALC. The models assume the tasks are completed consecutively, with each subsequent tasks beginning one day after the preceding task is completed.

The actual data recorded for each aircraft does not match the baseline data in distribution or deviation. In all of the tasks, the actual data recorded shows preceding actions close after subsequent actions are completed. Instead of consecutive tasks, the actual data shows overlapping tasks. Another limitation of the data is the limited data set. Data was available for 13 aircraft that have been completed recently; however, one of those aircraft was still in work at the time the study was completed. The baseline data for this aircraft is included in the model.

The approach of this study requires several assumptions about task completion and management processes. While other studies focus on a sub-process or work area of a PDM inspection utilizing task-level data, this study aggregates task completion into flow days. This does not account for time gains or losses related to daily production levels. The model assumes the daily production, or burn rate, is the the same for all aircraft variants across time.

Implications

This model is intended to identify areas of improvement for the current PDM inspection process as well as highlight areas to address in the ongoing transition to HVM inspection concept. Lessons learned with this simulation could benefit other production lines and aircraft fleets.

Summary

In this chapter, a brief background of the C-130 PDM process was presented along with implications for future inspection concepts. The focus of this research is on C-130 aircraft, but lessons may apply for other aircraft inspection processes. A brief discussion of assumptions and limitations was presented. Finally, the implications of the research results are discussed.

II. Literature Review

Overview

The literature review aims at presenting a series of studies that have already been accomplished about the subject and are related to the research problem. Aircraft PDM processes are complicated and data-intensive. While there is not much in the current literature regarding C-130 PDM, there are studies on major aircraft inspections in the C-5 and KC-135 fleets. These fleets tend to be more homogeneous than the C-130 fleet, which has several different models in use currently. The Theory of Constraints (TOC) has been used to address inspection processes in aircraft, as well as vehicle fleets.

Air Force Guidance

The ALCs in the Air Force Materiel Command are responsible for weapon system sustainment. Air Force Instruction 21-101, "Aircraft and Equipment Maintenance Management" states that regular maintenance and repair is necessary to keep Air Force aircraft at optimum availability (HQ USAF/LGMM, 2010). One of the major aircraft inspections which are accomplished at these centers is the PDM. The Air Force Technical Order (AFTO) 00-2504, " Depot Maintenance of Aerospace Vehicles and Training Equipment states that depot maintenance will be scheduled to allow for the programming of funds, material, personnel, facilities, and other resources (2010). Each type of aircraft has a specific list of tasks which are accomplished during this repair and overhaul process in accordance with (IAW) technical data particular to each airframe.

One of the main indicators for the squadron's production is their Due Date Performance (DDP). This metric indicates the depot's ability to complete the work on the aircraft by the agreed date. The Original Scheduled Out Date is established no later than the day the aircraft is placed in work and is calculated from Date in Work using the Negotiated Flow Days. Flow Days are calculated from the Date In Work. The Original Scheduled Out Date (baseline) will not be changed. Once the aircraft is inducted into the PDM, the repair activity will assess the aircraft before the Revised Scheduled Out Date is established. The assessment will be based on the repair processes, repair activity center capacity and/or contract requirements. The assessment period agreements are maintained by HQ AFMC/A4D and the completion date for the Assessment Period is recorded in the Aircraft Maintenance Production/Compression Report (AMREP) System. The Revised Scheduled Out Date is computed after the depot has completed its assessment of the aircraft and it reflects the changes driven by assessment period findings. The Revised Scheduled Out Date considers the level of effort required to complete the negotiated work package by the specific tail number and may also reflect additional work requested by the customer. The Air Logistics Center delivery performance is measured against the Revised Scheduled Out Date. Any changes made after the Assessment Period must be coordinated with the System Program Manager (SPM) and approved by the SPM, the owning command and ALC/Aircraft Sustainment Wing commander. Changes to the Revised Scheduled Out Date are only made when the scope of work has changed beyond the work specifications, which can include customer requested modifications, previously undiscovered defects (unplanned requirements) or SPM directed safety requirements. These additional days are added to the negotiated days to determine the new Revised Scheduled Out Date. No more than two changes are allowed: one1 during the assessment period and one after the assessment period. Changes to the delivery date will be reflected in the Forecast Out Date. The Due Date Performance (DDP) metric is used to measure aircraft produced in the month against operative schedule.

- Early: produced more than 5 days prior to Revised Scheduled Out Date
- On-time: produced on Revised Scheduled Out Date ± 5 days
- Late: produced more than 5 days after Revised Scheduled Out Date

The normal maintenance production schedule for depot maintenance is based on 8-hour, 5-day week, one-shift operation. Exceptions may occur for certain MDS that require multi-shift operations (HQ AFMC/A4DA, 2008). The depot maintainers are expected complete the inspections and repairs on 90% of their aircraft on-time, meaning within 5 days of the Revised Scheduled Out Date. This leaves 5 days of wiggle room for a 180-day expectation on aircraft with expected unplanned maintenance. Small problems found during the inspection or repairs have a ripple effect, delaying other work and perhaps eventually the final completion date (Johnson G. , 2010).

The 2009 DoD Inspector General (IG) Report identified several problems with the planning and scheduling processes for depot-level repairs on C-130s. The IG identified problems with timely completion of PDM, as well as non-compliance with extension request procedures. Due to these problems, the Air Force may have flown 36 C-130 aircraft beyond the scheduled PDM without an approved extension and 11 of those may have been flown more than 365 days. The C-130 System Program Office (SPO) uses the Program Management Configuration Control Aircraft Tracking (PM/CCAT) system to track the PDM cycle. Air Force units or Major Commands use a separate program, Automated Inspection Repair and Corrosion Aircraft Tracking (AIRCAT) system to enter technical assistance requests, such as PDM extension requests. These systems are not reconciled on a regular basis, according to the System Program Office (SPO). The IG concluded “the internal control weaknesses occurred because Air Force Materiel Command did not have procedures to comply with Federal and DoD regulations and Air Force Instructions”. One of the recommendations in this report is to improve the PDM scheduling processes through the System Program Office and the wings (Inspector General Department of Defense, 2009).

Tripp et al (2010) addressed potential higher-efficiency solution supporting split operations. This type of operation is more common now in our expeditionary deployment construct. Squadrons do not necessarily deploy as a whole but rotate portions of their manpower and aircraft into enduring locations. This requires substantial manning in both locations to maintain operations. Currently, the Air Force is not funding additional manpower spaces, so more efficient methods are required to support split operations. The authors found that consolidating inspections and backshop operations improves efficiency because it requires fewer people. The authors also found that these consolidations can improve the flow of aircraft through inspections. These consolidations can provide a good basis for integrating intermediate- and depot-level processes. (Tripp, McGarvey, Van Roo, Masters, & Sollinger, 2010)

Scully (2009) discussed HVM as a part of the broader AF campaign to improve aircraft availability by reducing the time spent at depots for overhaul and repair. From the AF leadership perspective, this concept will “revolutionize the way we overhaul our airplanes.” This concept includes training programs as well as process overhaul initiatives in order to integrate “lean” processes throughout the lifecycle of the aircraft. These processes are in response to the need for improved aircraft availability as well as addressing usage and aging issues seen in the aircraft fleets today. Workloads for major inspections have been increasing over the last several years, resulting in extended overhaul times for mission critical aircraft. The C-130 PDM at Warner-Robins ALC is a pilot program to assess the implementation of the concept. If successful, this will return over 50 C-130s to their operational wings. To meet this plan, the depots will need to improve their throughput for the aircraft drastically. One of the major requirements for this plan to succeed is the implementation of automated systems to help with accountability of resources, including parts and personnel (Scully, 2009).

Programmed Depot Maintenance (PDM) studies

Daniels (1998) examined the criteria for C-130 PDM inductions. He presented an alternative approach for scheduling this major inspection, based on aircraft variables rather than just the MDS. His model variables included aircraft age, total flying hours, average yearly flying hours, mission profile and operating location of the aircraft. These variables impact the affect the wear and tear on the aircraft. He collected data from the C-130 Service Life Database and from interviews. Rather than using the same interval for all aircraft, Daniels presents a tailored plan to address the specific needs of each aircraft. He also discussed the potential reduction of resources required to perform the PDM inspection, since some aircraft would have a longer interval between inspections (Daniels, 1998).

Srinivasan examined the project management functions of the C-5 depot lines at Warner-Robins Air Logistics Center in 2007. The authors identified three levels of complexity in depot repairs: known work, which is scheduled on every aircraft; anticipated work on some of the aircraft, which is difficult to predict; and unanticipated work that is due to damage and is unpredictable. They also identified another major challenge in depot repairs: limited resources. Every aircraft requires manpower, materials and equipment in order to complete the repairs and these resources may be needed to complete work on other aircraft. This competition affects scheduling and execution. Warner-Robins ALC implemented Critical Chain Path Management (CCPM) because lean principle utilization was insufficient to make all the changes necessary to the PDM lines. CCPM enabled mangers to "view each aircraft as a project, with a series of tasks and precedence requirements to be met". Critical Chain Project Management (CCPM) was implemented on the C-130 lines in 2005 (Srinivasan, Best, & Chandrasekaran, 2007). During a site visit in September 2010, the schedulers assigned to the C-130 PDM were not using the CCPM to manage the C-130 lines (Lancaster, 2010).

Paskin and Trevino used computational organizational modeling and simulation to deconstruct the flight controls repair process to identify efficient approaches for process improvements (Paskin, Trevino, Ferrer, & Dillard). Their work was with the KC-135 Programmed Depot Maintenance (PDM) at the Oklahoma Air Logistics Center at Tinker Air Force Base. Their focus was to assess the Horizontal-Vertical Repair Cell's leverage of communication across its functions and the information sharing between the assigned personnel. This work area faces "multiple complexities stemming from mission requirements, financial pressures, workforce reductions, aircraft age, and continuous demands to eradicate waste". The study team's objective was to provide decision makers with feasible alternatives for organizational change without impacting the organization. The study team collected data through observation and interviews. The models used in this study simulated one set of stabilizers moving through the repair process. The actual workload for the work area is up to six sets of stabilizers. The study team used a model to "identify problem areas that might increase repair duration, integration risk, cost and work backlog affecting decision bottlenecks". Their recommendations heavily emphasized cross-training the mechanics assigned to the cell in order to improve flexibility in the work area.

Levien (2009) also studied PDM processes and focused on the manning requirements. His study utilized Arena to model the impact of implementing cross-training for the mechanics assigned to the KC-135 PDM production line at Oklahoma City ALC (OC-ALC). He identified the limitation of modeling every task in the sample process. It would require months of full-time data gathering and effort. Levien used a sample of tasks to test methodology for this study. Due to the variety of applications for this concept, Levien established a methodology based on task completion to be applied to various work centers. During his study, he identified several problems with data integrity which made validation of the simulated data "very difficult, if not impossible" (Levien, 2010).

McFeely et al, studied a support shop within the depot repair processes. While this shop is much less complicated than the aircraft PDM production lines, he found similar concerns with resource management and prioritization. In this shop, the items are prioritized based on due date and severity of mission impact. The shop's overall goal is to meet every customer's due date requirement. However, the shop was loading tasks to the machines based on mission impact, not just the due date. So those items which had less mission impact, or did not have a sponsor checking up on the progress, tended to gain time waiting for processing. The expediting required to move the higher impact items up in the schedule disrupted the daily flow through the shop. Lower priority items tended to sit and gain time awaiting repair. The study team considered three machine loading rules and six sequencing rules. The team found that the selection of the loading rule had the most impact on the performance measures. By loading jobs to the machine with the lowest average work in progress (LAWIP), the mechanics could decrease average flow time and reduce the number of jobs in queue. The study team recommended increasing cross-training to add flexibility to the shop by delaying machine loading decisions as much as possible and increasing cross-training for technicians. The authors also recommended implementing new scheduling rules to improve flow time for all assets. Negotiating due dates with customers should also be considered when necessary, and should take place as early as possible to allow customers to adjust. The authors also recommended that the shop consider lot splitting, to push smaller quantities of items through the system faster. There may be times when a customer has several items for repair but only needs a few to be processed quickly. In the end, the shop utilized these recommendations and reduced flow days by 10% (McFeely, Simpson, & Simons, 1997)

Loredo et al (2007) developed a model to evaluate the combined (organic and contract) maintenance assets to accomplish PDM workloads. The PDM Capacity Assessment Tool (PDMCAT) forecasts the average number of aircraft that will be in PDM status each year over several decades. This forecast is based on relatively few categories of data: a forecast of future workloads, an estimate of the maximum labor application rate and an estimate of the depot capacity. This model enables researchers to rely only minimally on “inside” information from the facility managers. The detailed task level information changes constantly in these complex facilities and the specific workflows are seen as proprietary information. Both situations make data gathering difficult. The authors applied this model to the U.S. Air Force's capacity to support the KC-135 PDM. In this study, the authors found that the shapes of the availability and cost forecasts did not grow, which is contrary to assumptions in many studies. The authors recommend using this type of tool to estimate how changing workloads will affect budget and sustainability (Loredo, Pyles, & Snyder, 2007).

Discrete-Event Simulation Models

Johnson et al (2008) studied the C-5 Isochronal inspection process in terms of centralizing the inspections docks. The study team used Arena discrete simulation to show the impact of consolidating the inspections to fewer locations, as well as identifying the limitations of consolidation. The team found that throughput and precise scheduling were necessary to ensure three inspection locations would be enough to meet mission demands. If there were delays in the inspection, then the next aircraft to arrive could be delayed in starting. The current inspection takes about 18 days and the inspections must be reduced to about 14 days for this consolidation to work. Even then, the aircraft must be released for re-panel in order to get the next aircraft into the dock. The study team recommended working to reduce the inspection time required before consolidating the C-5 Isochronal inspections to only 3 locations (Johnson, Glasscock, Little, Muha, O'Malley, & Bennett, 2008).

Heiman (2009) extended the C-5 Isochronal study to address the dock scheduling method in order to minimize processing time and queuing time. Heiman addressed the High Velocity Isochronal Inspection within the AFSO-21 construct. Based on his simulation results, he recommended completing the dock consolidation at the earliest feasible date and maintaining reductions in inspection times to facilitate adequate production (Johnson, Heiman, Cooper, & Hill, 2010).

Levien (2009) used an Arena simulation model to consider cross-training technicians on the KC-135 PDM production lines. His model resulted in a methodology to build a similar model for other workcenters considering cross-training as a solution to improve flexibility (Levien, 2010).

Theory of Constraints

The Theory of Constraints (TOC) was invented by Dr. Eliyahu M. Goldratt and has been in use since the mid-1970s. Dr. Goldratt used scientific methods to create management concepts which applied scientific thinking to areas outside the sciences. These concepts have been used in industry, sports and conflict management (Newbold, 1998). The TOC explains how to improve the performance of a process with interdependent steps. In terms of project management, the idea of a critical path means that resources are constrained for a particular process and there is a certain order and timelines necessary for the process to be optimized (Elton & Roe, 1998). If the critical events are delayed, then the overall production will be delayed (Newbold, 1998). Project designs need to identify the potential sources of failure, then insert resources and buffers to ensure throughput (Elton & Roe, 1998). The TOC is based on five steps: identify the constraint, exploit the constraint, subordinate everything else to the constraint, elevate the constraint, identify additional constraints (Rand, 2000). Recent research has utilized these concepts to improve throughput and production for aircraft maintenance processes.

Srinivasan (2001) studied a Marine Corps Logistics Base to address apparent capacity shortages. The repair center was considering adding manning in order to address the forecasted shortage. Instead, the study team found that the policy constraints within the facility had more impact on the shortages than the actual physical limitations of the workers and facility. The repair center implemented a pull system for scheduling repairs, which revealed additional capacity. By using Theory of Constraints principles, the repair center was able to add capacity without adding cost.

The repair center previously utilized a push system for scheduling work, which scheduled jobs without regard for the work already in progress. This caused the system to back up as jobs waited for resources to become available. The center applied a Simplified-Drum-Buffer-Rope model to the scheduling process, which removed the policy constraint. The repair center also implemented Lean efforts for other processes in the center to improve throughput and enable more flexible response to customer requirements. These efforts also improved the workers' morale and improved working conditions (Srinivasan, Jones, & Miller, 2001?).

Mattioda (2002) used Microsoft Project to study the Isochronal Inspection process of C-130s assigned to Air Force Special Operations Command (AFSOC). He chose this process because it provided the best opportunity to increase aircraft availability by reducing the inspection duration. He modeled the Isochronal Inspection three ways: the existing inspection process, the inspection process with the task constraints removed and the inspection process with the task and resource constraints removed. He found that Critical Chain scheduling did not directly increase aircraft availability, but did identify potential for improvement if task and resource constraints are removed (Mattioda, 2002).

Design of Experiments

Callahan, Hubbard and Bacoski (2006) combined design of experiments (DOE) methods with simulation modeling to identify an optimal solution for a process flow problem. They used the DOE to vary simulation inputs and identify the interactions between factors in a batch processing firm. In this case, the researchers used a 2^k experimental design, with k representing the number of input factors being evaluated. This design is efficient since several factors can be varied in each simulation run. The authors used Analysis of Variance (ANOVA) to identify the significance of those interactions to the system as a whole. Once the significance of each factor is determined, the factors are compared to the output data to determine the effect of each factor on the output. Management decisions can then be made regarding the settings for each of the factors in the system considering the desired output (Callahan, Hubbard, & Bacoski, 2006).

Performance Measurement

Goldratt's "Critical Chain" implements discipline by the proper use of measurements. "Measurements should induce the parts to do what is good for the whole, and measurements should direct managers to those parts that need their attention." Relying on milestones instead of measurements diverts the managers' attention from what needs to be addressed (Elton & Roe, 1998).

McAneny (2009) addresses the Air Force's use of metrics in regards to the overall goal of aircraft availability. He states that "successful, valid, reliable, and continuous process improvement is only possible in an environment that tolerates, encourages, and promotes the public airing of dirty laundry". Metrics should tie worker involvement to customer value and enable quality, on-time production. Problems should be viewed as opportunities for improvement, not reason for blame. The challenge is finding objective metrics to put the output products in clear focus (McAneny, 2009).

Pendley, et al (2009) identified a disconnect between the metrics used at the wing level and the command level when looking at C-5 total not-mission capable maintenance performance. The study team found that wing level maintenance managers were making decisions to improve the on-time departure rate, while the AF senior leadership focuses on aircraft availability. The daily decisions to prioritize tasks and resources placed more importance on the short term goal of timely departures. In interviews, the maintenance group commanders indicated the operational effectiveness is more important. However, senior leaders are focused on improving strategic readiness. The study team found that the Home-Station Departure Logistics Rate (HSDLR) is not correlated to the total not-mission capable rate or to aircraft availability (Pendley, Thoele, Howe, Antoline, & Golden, 2009).

McFeely et al (1997) selected two primary measurements for their study: percentage of jobs tardy and mean tardiness of late jobs. They also considered the mean flow time of all jobs and priority penalty. The authors found that the shops prioritization methods before the study contradicted the shop’s goal to produce all orders in a timely manner. The shop’s decision to schedule jobs by priority rather than due date meant that some jobs were sacrificed for the sake of other jobs. By implementing new scheduling rules, the shop can improve production performance for all orders (McFeely, Simpson, & Simons, 1997).

High Velocity Maintenance (HVM)

Aircraft availability is a measure of a fleet capacity to meet mission demands. One key driver in improving aircraft availability is time spent in maintenance. The civilian aviation community obtains higher man-hour burn rates in their inspection processes, resulting in less time spent undergoing maintenance. HVM was outlined in FY 2007 to identify a method to move aircraft through military depots faster by increasing man-hours per day. A steering group and high performance team (HPT) were established to develop the concept. This team mapped out all current processes that support depot maintenance. The current PDM package will be divided into 4 smaller packages with shorter intervals between the inspections. Variability analysis performed by Georgia Tech and UT revealed these smaller packages will result in greater confidence in staying on schedule, which is an important planning factor for the depots and the owing commands (Robins AFB High Velocity Maintenance Team, 2010)

The C-130 was selected as pilot program since it is in high demand for operations around the world (Drohan, 2009). C-130 maintenance at Robins will transition to HVM over the next 7 years. The intent of this transition is to dramatically increase the aircraft availability by increasing velocity between inspections. Currently, aircraft spend an average of 164 days at Robins (Crenshaw, 2009). HVM experts hope to reduce downtime from 4-5 months to 39 days (Drohan).

HVM is patterned after same maintenance practice currently being used by major commercial airlines. The essence of HVM is to bring aircraft in for inspection every 18 months, rather than the every 5 to 6 years (Crenshaw, 2009). The purpose of high velocity maintenance is to have everything in place for the mechanics to perform their work without leaving to search for the things they need (Drohan, 2009).

Aircraft will be inspected before they are transported to Robins for maintenance. Maintainers will be better prepared because they will know what the planes need ahead of time. Aircraft often require numerous additional parts, which require time to source and install (Crenshaw, 2009). This new process will enable “task kits” to be built so replacement can be made without delay. This concept will also allow some work to be pushed to next inspection in 18 months, rather than accomplished immediately upon identification since the next inspection is 5 years out. HVM will also eliminate the need for isochronal inspections (currently accomplished every 15 months and puts plane out of service for 2-3 weeks) (Crenshaw, 2009)

Key tenets of future state include the need to reduce the variability of the maintenance requirement and knowing the condition of the equipment. Kitting, standard use of visual work for all tasks, disciplined processes, integrated planning and decision making and robust data collection are required to enable HVM (Robins AFB High Velocity Maintenance Team, 2010)

Summary of Literature Review

This body of literature helps to build a framework around this particular problem. Many of the management or process issues identified in the C-130 PDM inspection processes exist in other industrial maintenance areas. Also, the production issues, such as aging aircraft, manpower and constrained resources are found in other aircraft fleets. These studies of other fleets provide insight for the C-130 processes. While the PDM inspection process is very complicated, with thousands of tasks and hundreds of people, a simulation model can capture the overall effect of potential changes to the way managers prioritize resources and aircraft.   Many of the current studies focus on relatively smaller inspection process such as the isochronal inspection, or on sub-processes within the PDM inspection. One study looked at the PDM process as a whole. The RAND PDMCAT model uses relatively few data points, most of which are externally available, to produce forecasted workloads.   This study uses a similar perspective to develop a model which encompasses all of the maintenances and inspections processes within the PDM inspection.

III. Methodology

Introduction

The goal of this project is to identify bottlenecks in the 560 AMXS C-130 PDM production line at WR-ALC. This study uses discrete event simulation model (Rockwell Arena) based on models presented in Mattioda (2002), Johnson et al (2008), Heiman (2009) and Levien (2010). While most of these models use task times to estimate overall inspection time, the models in this study use an aggregated approach similar to the PDMCAT tool used to predict the number of aircraft in depot status over a period of time (Loredo, Pyles, & Snyder, 2007). The intent of this approach is to provide a relatively simple model which can provide a rapid assessment of potential changes.

Data Sources/Format

The data for the simulation models was generated using historical production data from the ROCIT database program at WR-ALC. The current C-130 business rules were used to build input assumptions for the model and are listed in Appendix D (Lancaster, 2010). The data provided by the data analysis section at WR-ALC is aggregated into 11 major sub-processes from defuel upon arrival to the functional test flight prior to departure.

Model descriptions

Simulation models are used in this study to replicate the current operating procedures for the PDM production line and determine the impact of altering the current business rules used to prioritize aircraft and resources. The data will be validated against historical AMREP data provided by AFMC/A4D.

Once the aircraft arrives at the PDM location, the aircraft awaits the intake inspection and pre-dock tasks. Each aircraft is defueled, wash, depainted and stripped prior to being towed into an inspection dock. Once a dock space is available, the aircraft is towed to the inspection dock. After the inspections and repairs are completed, the technicians complete the build-up task, reinstalling all components and panels. Then the aircraft is towed out of the inspection dock and prepared for departure through rigs and operational checks. The final step for each aircraft is a functional test flight by a certified aircrew. Once the aircraft has successfully completed the functional test, it is released for return to home stations.

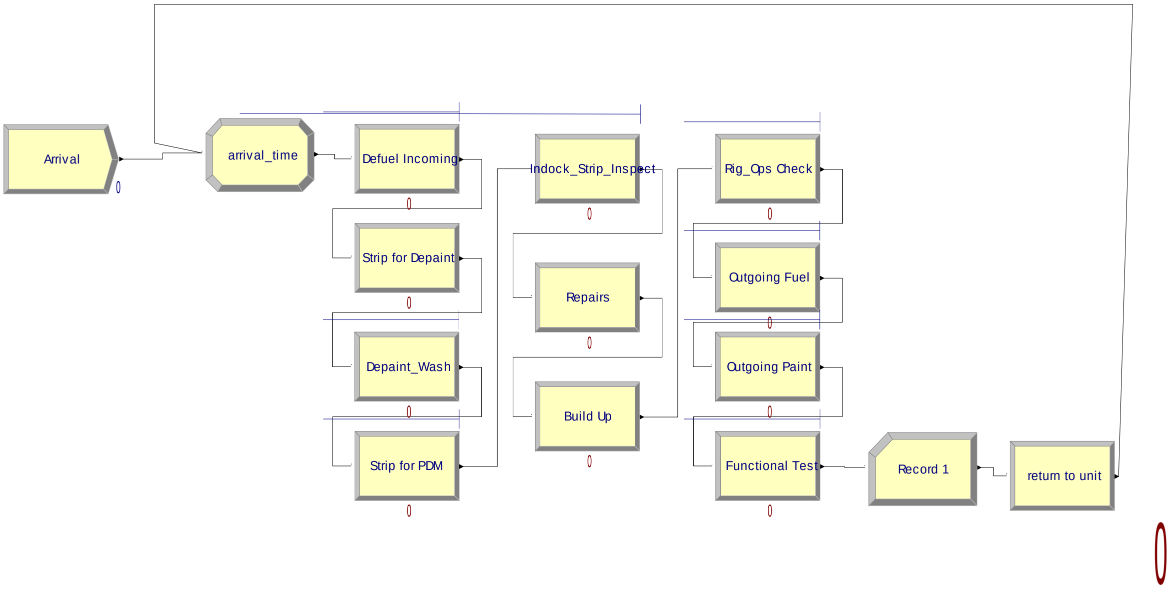


Figure 1: Baseline Model

Four scenarios will be used to address the research questions:

1. Baseline data from ROCIT program with 8 docks
2. Adjust priorities to see impact of prioritization of aircraft
3. Increase the number of available docks to 10 docks
4. Increase the number of available docks to 12 docks

There are 150 entities created in each of the models, simulating an aircraft input into PDM for inspection. The models are run for 7300 days (20 years) with a 3650 day warm-up period to cycle through a full rotation of the PDM requirements. The standard PDM interval for C-130s is 69 months and is simulated using a delay process in the models. This study uses five resources: docks, fuel repair parking spots, operational checks parking spots, paint barn docks and functional test parking spots and functional test aircrews.

Assumptions

This model accounts for the PDM production line at WR-ALC only. There are other PDM lines at OO-ALC and Singapore which may have different processes for repair, supply sourcing and data input. This model also assumes the baseline data entered in the Maintenance Information Systems is accurate. The PDM production lines share resources and sometimes personnel with other production lines depending on the ALC's priority. The baseline model includes 8 docks to represent the available workload. There are also two tents at the depot which can be used for PDM, PDM-transition or HVM which are not included in the model. This model assumes all personnel and resources are dedicated to the PDM production line during the simulation run. These models also assume the additional docks are manned at the same level as the current docks. This assumes the daily production rate (or burn rate) is the same across all aircraft and does not change over time.

One of the key tenets of the HVM transition is that the burn rate can be significantly increased by kitting parts and providing task support for the aircraft technicians. This change is not incorporated into these models.

Data Analysis

The results of the model will be compared and validated against AMREP data provided by the AFMC Data Analysis Branch. The AMREP data only provides overall flow days, not the flow days for the sub-processes. The results from the models will be compared using a paired t-test.

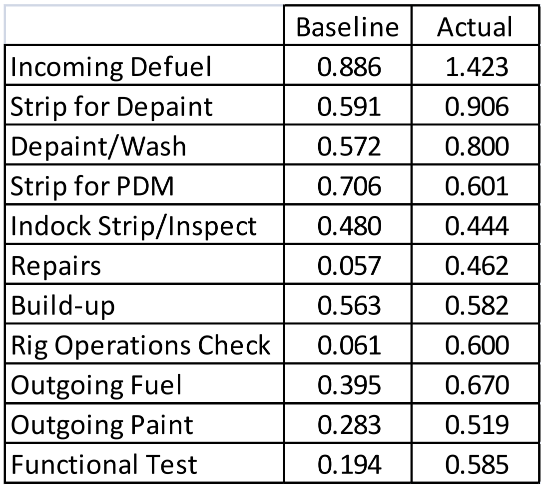
IV. Analysis

Input Analysis

The distributions of the processing times were determined using Arena's Input Analyzer. The flow days for the major sub-processes are based on historical data from the ROCIT database at Warner-Robins ALC. The estimated process time distributions for the baseline (scheduled) and actual data are located in Appendix A. Arena Input Analyzer provided the most likely distribution of the data based on square error and the Kolmogorove-Smirnov test p-value. The data was assessed in two sets: baseline and actual. The baseline data is the expectation or schedule for the 11 sub-processes in the PDM inspection process. The distributions for the baseline data did not provide Kolmogorove-Smirnov test p-value. The actual data is the dates recorded by the unit when the sub-process was started or completed on a particular aircraft. The p-values for the actual data set were all above 0.15, indicating a close fit to the distribution.

However, the dates indicated consecutive tasks rather than serial tasks. Since the specific flow days could not be determined from the available data, the actual data was not used in these models. Table 1 contains the Coefficient of Varation (CV) for the Baseline (Scheduled) and Actual data distributions. The CV is used in this case to compare the means of the distributions of the scheduled and actual flow days for the 11 sub-processes within the PDM inspection process. The actual flow days recorded for the inspection processes vary more from the distribution means than the expected (scheduled) flow days.

Table 1: Coefficient of Variation (CV) Flow Days



	Baseline	Actual
Incoming Defuel	0.886	1.423
Strip for Depaint	0.591	0.906
Depaint/Wash	0.572	0.800
Strip for PDM	0.706	0.601
Indock Strip/Inspect	0.480	0.444
Repairs	0.057	0.462
Build-up	0.563	0.582
Rig Operations Check	0.061	0.600
Outgoing Fuel	0.395	0.670
Outgoing Paint	0.283	0.519
Functional Test	0.194	0.585

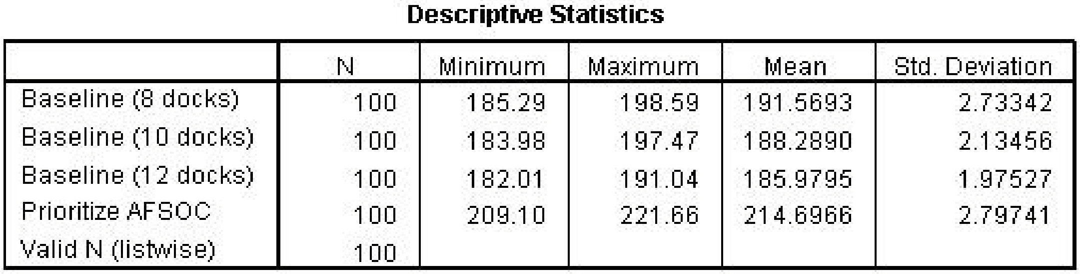
Simulation Results

Each entity in the simulations represents one aircraft induction and inspection. The means listed below in table 1 indicates the average total flow days of 100 replications for each of the experiments in this study, indicating the impact of additional dock spaces or prioritizing some of the inducted aircraft ahead of the others. The sub-process flow times are the same distribution for all variants

Model 1 represented PDM with 8 docks (Baseline 8 docks) and aircraft move through the model as they arrive (First in, First out). Then the resources were adjusted to identify the impact of adding two (Baseline 10 docks) or four additional docks (Baseline 12 docks). The docks in this model also represent the workforce or capability associated with a dock space, so each additional dock represents the physical location as well as the resources associated with each space. The 8-dock model produced an average of 191.5 flow days, the 10-dock model produced an average of 188.3 flow days and the 12-dock model produced an average of 186.0 flow days.

Model 2 represented the impact of prioritizing the AFSOC aircraft (Prioritize AFSOC) . There are 8 docks available in this model, similar to Model 1. As AFSOC aircraft arrive, they have a higher priority than the aircraft already at the depot and are moved the front of the line for induction and inspection. This resulted in an increase in mean flow days from the 8-dock model, with an average of 214.7 flow days for all aircraft variants.

Table 2: Simulation Results (Flow Days)



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Baseline (8 docks)	100	185.29	198.59	191.5693	2.73342
Baseline (10 docks)	100	183.98	197.47	188.2890	2.13456
Baseline (12 docks)	100	182.01	191.04	185.9795	1.97527
Prioritize AFSOC	100	209.10	221.66	214.6966	2.79741
Valid N (listwise)	100				

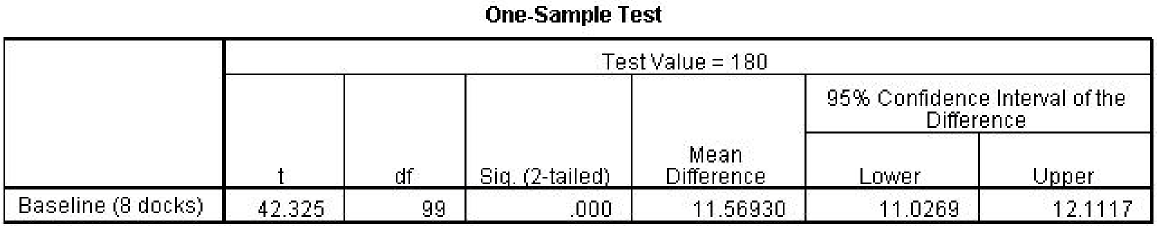
Verification

The results of these simulations were compared to the AMREP data provided by the AFMC Analysis Branch. The average flow days for the C-130 PDM over the last two fiscal years is 253 days. The baseline model with 8 docks was also compared to the published standard for the Duty Days Performance (DDP), which is 180 days. Due to aggregation of data, the variability of the processes and the unpredicated structural maintenance accomplished during the inspections, it is difficult to validate these results against the historical data. Other simulation studies identified similar challenges (Levien, 2010)

One Sample T-Test

The one-sample t-test compares the 8-dock baseline model to the 180-day expectation for the Duty Day Performance (DDP). The 8-dock model produced an average of 191.5 flow days. The results indicate the average flow days generated by the model is statistically different from 180 days.

Table 3: One-sample T-Test comparing baseline to DDP standard



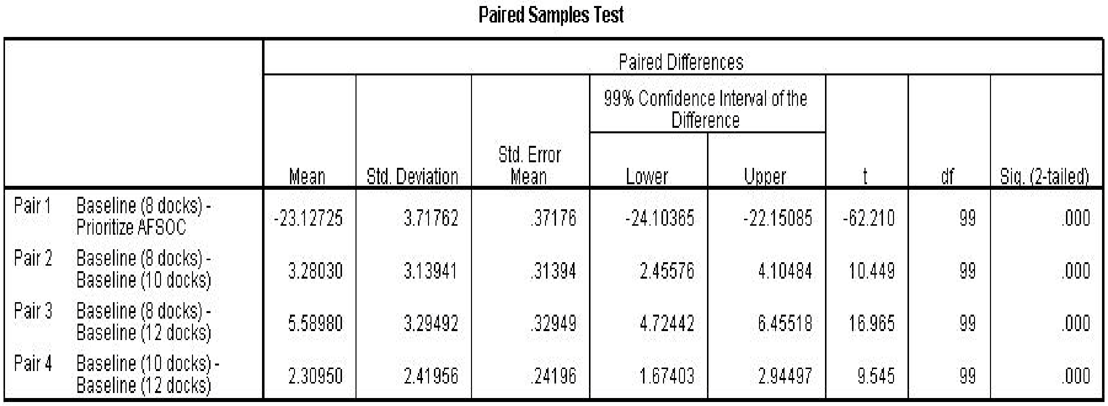
One-Sample Test

	Test Value = 180					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Baseline (8 docks)	42.325	99	.000	11.56930	11.0269	12.1117

Paired Sample Test

A paired sample t-test was used to compare the means of the simulations. The results of this test are listed below in Table 5. The results indicate the average flow days of the two tests (prioritize AFSOC aircraft and increase dock availability) are statistically significant. The confidence intervals for each of the four pairs listed in Table 5 do not include 0 and the significance values are less than 0.05 with a 99% confidence interval. The difference between the means is not due to chance, but is due to the changes in docks or prioritization. The difference between the mean flow days for the baseline model and the prioritization model is the largest, at 23.1 days. This indicates prioritizing one variant over the others increases the average flow days for all aircraft in the inspection pipeline.

Table 4: Significance of Paired T-Tests for additional docks spaces and prioritization



Paired Samples Test

		Paired Differences							
					99% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Baseline (8 docks) - Prioritize AFSOC	-23.12725	3.71762	.37176	-24.10365	-22.15085	-62.210	99	.000
Pair 2	Baseline (8 docks) - Baseline (10 docks)	3.28030	3.13941	.31394	2.45576	4.10484	10.449	99	.000
Pair 3	Baseline (8 docks) - Baseline (12 docks)	5.58980	3.29492	.32949	4.72442	6.45518	16.965	99	.000
Pair 4	Baseline (10 docks) - Baseline (12 docks)	2.30950	2.41956	.24196	1.67403	2.94497	9.545	99	.000

Figure 5 provides a visual representation of the mean differences between the results of the baseline model when additional docks spaces are added. The largest impact is by adding 4 docks (and associated resources), which results in reducing the average flow days by over 5 days.

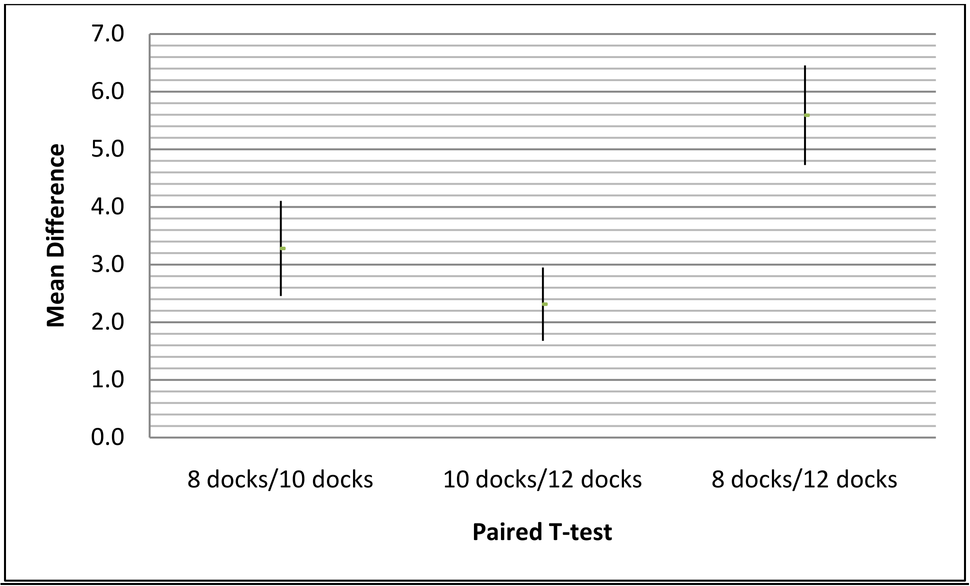


Figure 2: Stock chart for mean differences of additional dock spaces

V. Discussion

Answers to Research Questions

Question (1): What is the impact of additional docks spaces on the average flow days for the inspection process?

This study used work spaces available as the primary resource. Each dock space or parking space represents a physical location as well as the manpower associated with that location. This assumption was used in order to reduce the amount of data required to build the model. The results of the simulation show that increasing the number of docks (and associated resources) will reduce the average number of days required to complete the inspection (increase throughput). The average flow days from the simulations with additional docks approached the production standard of 180 days, while the model using 8 dock spaces averaged 191 flow days. This could indicate the available resources at the depot are not sufficient to meet the expectation driven by the requirements-based scheduling process. Since the model uses only 150 entities to represent the throughput of Warner-Robins ALC, the 2-5 days decrease noted in the Analysis section is optimistic for the addition of docks spaces. The current requirement for the Warner-Robins ALC is approximately 50 aircraft per year, which includes multiple variants and additional work requirements such as the Center Wingbox Repair (Romero, 2010).

Question (2): Are the current business practices for prioritizing aircraft detrimental to the overall goal of on-time return to the owning units?

The current business rules prioritize special operations aircraft ahead of all other variants. This practice is driven by the operational demands for the specialized aircraft, which are in high demand and have small fleets (6-8 aircraft in some cases). As the average flow days increase for all aircraft, the ability to accurately predict any single aircraft's completion becomes more difficult as resources are spread farther across increasing requirements. The unpredictable nature of the structural maintenance is also affecting the workload and predictability. Due to these factors, the ALCs and the MAJCOMs have agreed to prioritize the Special Operations aircraft ahead of other aircraft. Based on the results of this study, this practice of prioritization of AFSOC aircraft is detrimental to the PDM meeting their overall goal of Duty Day Performance. The average flow days for all the aircraft increase when the AFSOC aircraft are moved up in the queue, as indicated in table 5. The difference between the mean flow days for the baseline model and the prioritization model is the largest of the pairs, at 23.1 days. This could indicate the impact of prioritization is more significant than gaining additional dock space. In this study, the dock spaces also represent available manpower, so the management policies could have more impact than additional manning on the average time to complete the PDM inspection. Further research using multf-factor testing would be useful in identifying the impact of additional resources and management policies.

Data Collection and Accessibility

There also seem to be problems with the maintenance data entered during the inspection process. The data used in this study represents the start and end dates for the 11 sub-processes in the PDM inspection process. The scheduled dates are set up as a series of tasks, but the actual recorded data appears to be concurrent or overlapping tasks. Several of the tasks show start dates before the preceding task ends, or tasks which overlap preceding and subsequent tasks. Other tasks are started and completed before the preceding task is completed. This may be due to sharing limited resources among priorities which shift depending on the day. Tasks may also be interrupted when another aircraft becomes a higher priority and resources are diverted to complete that aircraft quickly. Anecdotal data suggests the in-dock average is 100 days (Johnson G. , 2010), but the recorded data shows over 140 days for repairs (Appendix E). Data entry problems could be related to the pressure to improve production rates and aircraft are updated in the system to show an activity is started.

Throughout this study, various levels of leadership mentioned the need for a shared, transparent information system which would allow decision-makers to have decision level information readily available. There is a program in work to meet this need, currently called Expeditionary Combat Support System (ECSS). However, funding is limited and the delivery dated has slipped multiple times. Based on the site visit and follow-up conversations to attain data, it is clear that this system is not a panacea for the production problems in the depot. There was concern throughout the study about sharing proprietary data with agencies outside the depot. ECSS is not a simple fix and will take years to fully implement. In the process, many of the current business processes will need to be adapted to fit into this enterprise resource program.

The concern about proprietary data also impacted the access to data. It took several weeks and multi-level requests to get a relatively small amount of data. In addition, the analyst who sent the data indicated the individual aircraft data is deleted from the system once the aircraft has departed to the owning unit. The baseline data for 13 aircraft is included in this study, but the C-130 fleet is over 400 aircraft which are inspected at four facilities located in Singapore, New Zealand, Ogden ALC and Warner-Robins ALC. Since the fleet is over 40 years old, there are several hundred data sets which are currently unavailable, perhaps to due to the perception of proprietary data and current data archival practices at the inspection facilities. This data set probably does not represent the characteristics of the entire fleet accurately. A larger data set would improve the fidelity and capability of this model.

Implication to HVM Transition

The C-130 is scheduled to transition from the PDM inspection concept to the HVM inspection concept over the next inspection cycle through attrition. The tenets of HVM include increased throughput via reduced flow times and shorter inspection intervals. This study indicates reducing the flow times to improve throughput may be problematic. The current data collection methods do not accurately record the start and end dates of the major sub-processes, so it is difficult determine the flow times through the major sub-processes. The problems with the current data management processes need to be addressed and resolved to facilitate the new inspection concepts.

Communication across levels and agencies currently includes formal updates and requests, as well as informal communication among the various levels and agencies involved with the PDM inspection. Managers at multiple levels spend time tracking down information and answering data requests, rather than spending time on planning to address future concerns. An enterprise resource program such as ECSS would certainly address some of these issues and improve the communication between the inspection organization, management levels and owning agencies.

Future Research

There are many options available for further research with this level of production. The model as written uses limited categories of resources to estimate overall production time. A more accurate model could add resource categories to better identify the impact of additional resources or different management policies. In addition, these models focus on the processes using two variants of aircraft. In reality, there are several variants of C-130s which go through the inspection process at WR-ALC. Adding this clarification would add fidelity to the simulation results.

The AFMC Analysis Branch is currently reviewing the variance of the major inspection and production processes at the depots (Richards, 2010). Incorporating those results into this type of model could provide more accurate results for the overall flow days through the inspection. This information could also help to identify possible improvements for induction policies. While prioritizing AFSOC aircraft is important, it appears to come a cost to the overall goal of on-time completion and delays the return of other aircraft to owning units.

One of the expectations with the HVM concept is the pre-induction inspection (PII). The intent of these inspections is to assess the major inspection requirements so parts can be ordered and equipment scheduled. PDM personnel will travel to the owning units to assess the induction aircraft several weeks prior to the aircraft arriving at the depot. The assessment team will identify parts which may have long sourcing times or require special equipment for installation. One issue with ordering parts ahead of the inspection is the funding source, since the aircraft will still be assigned to the owning unit instead of the depot. The costs associated with this inspection may be another area of research. Cost benfit analysis could be used to assess the value of information on the aircraft status from the pre-induction inspection.   The costs associated with this assessment are unknown at this time and it is important to determine if these inspections provide enough information to reduce the downtime required for the inspections.

There were significant issues with getting data from the ALC regarding these inspection processes. There was concern about releasing proprietary data to anyone outside the depot, including the AFMC Analysis Branch. Data input and information sharing could be required through revised Air Force Instructions, which would improve communication and problem identification. Also, the implementation of ECSS in the near future could alleviate some of the concerns with sharing information outside of the owning organization.

These models assume dedicated manpower for each of the major sub-processes. This assumption is probably incorrect and manning is reassigned on a short-term basis to address higher priority tasks. Manpower production also varies with the seasons when hot weather limits work time available or leave schedules over the holidays affect available manning (Romero, 2010). Future research could identify manning assignments and processes to clarify the availability and impact of this critical resource.

Summary

Aircraft maintenance in general is a complex and labor-intensive task. Finite resources and a heavy operations tempo combine to necessitate a change to a decades-old inspection concept. The managers and personnel assigned to accomplish the daunting task of inspecting this diverse fleet are producing aircraft which continue to support global requirements. This study indicates there may be more efficient ways to leverage the available resources to better meet ongoing operational demands.

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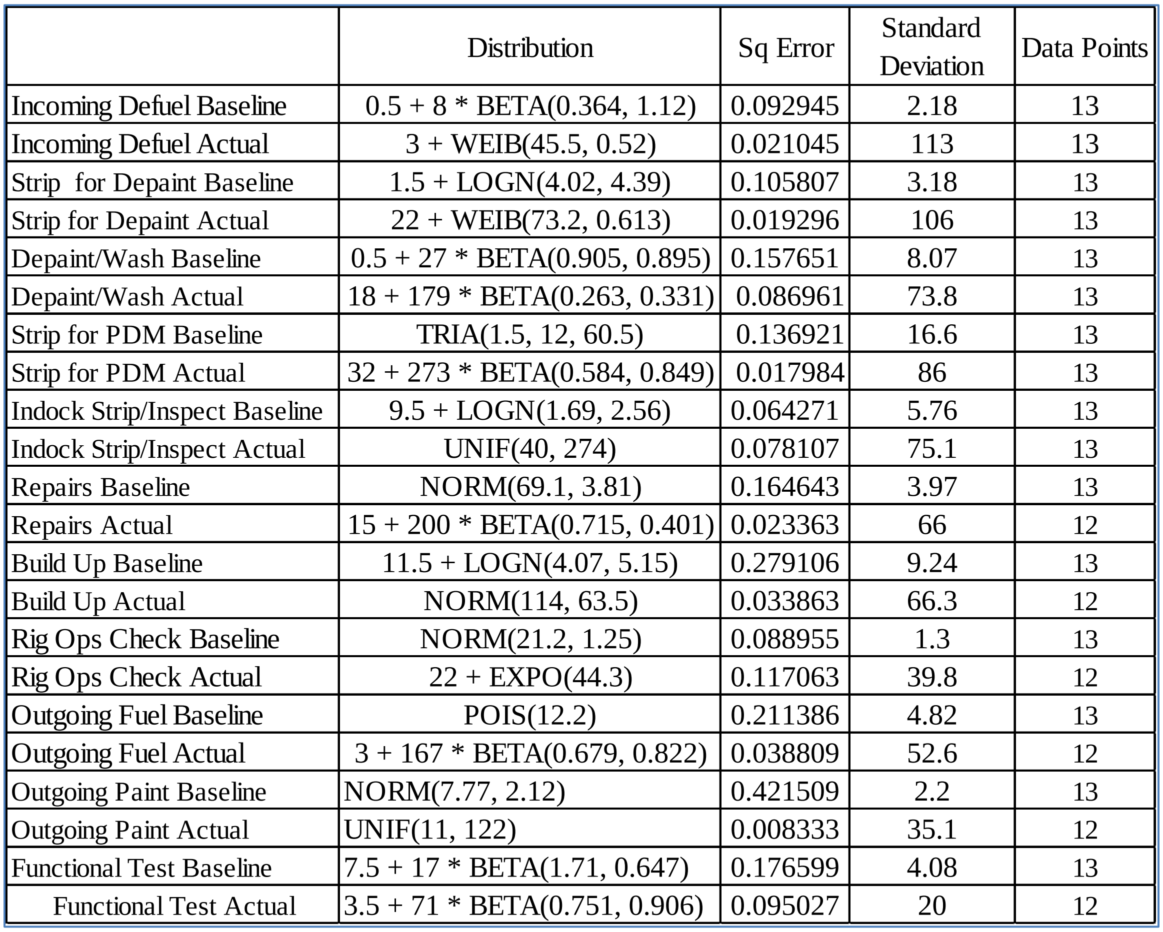
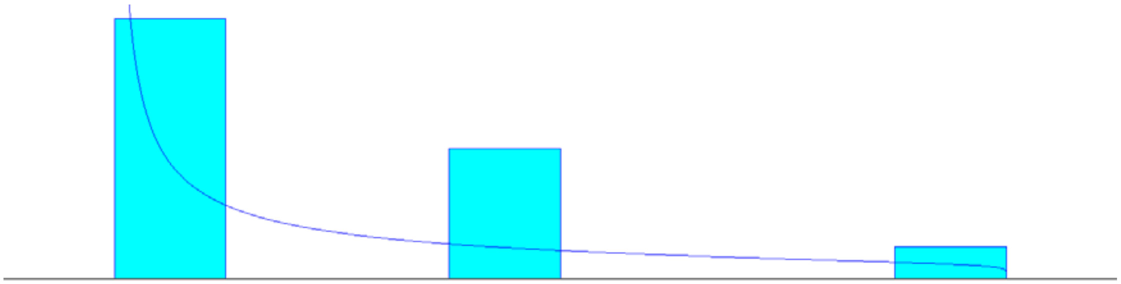
Appendix A: Input Analysis

Table 5 Arena Input Analysis for Inspection Processes



	Distribution	Sq Error	Standard Deviation	Data Points
Incoming Defuel Baseline	0.5 + 8 * BETA(0.364, 1.12)	0.092945	2.18	13
Incoming Defuel Actual	3 + WEIB(45.5, 0.52)	0.021045	113	13
Strip for Depaint Baseline	1.5 + LOGN(4.02, 4.39)	0.105807	3.18	13
Strip for Depaint Actual	22 + WEIB(73.2, 0.613)	0.019296	106	13
Depaint/Wash Baseline	0.5 + 27 * BETA(0.905, 0.895)	0.157651	8.07	13
Depaint/Wash Actual	18 + 179 * BETA(0.263, 0.331)	0.086961	73.8	13
Strip for PDM Baseline	TRIA(1.5, 12, 60.5)	0.136921	16.6	13
Strip for PDM Actual	32 + 273 * BETA(0.584, 0.849)	0.017984	86	13
Indock Strip/Inspect Baseline	9.5 + LOGN(1.69, 2.56)	0.064271	5.76	13
Indock Strip/Inspect Actual	UNIF(40, 274)	0.078107	75.1	13
Repairs Baseline	NORM(69.1, 3.81)	0.164643	3.97	13
Repairs Actual	15 + 200 * BETA(0.715, 0.401)	0.023363	66	12
Build Up Baseline	11.5 + LOGN(4.07, 5.15)	0.279106	9.24	13
Build Up Actual	NORM(114, 63.5)	0.033863	66.3	12
Rig Ops Check Baseline	NORM(21.2, 1.25)	0.088955	1.3	13
Rig Ops Check Actual	22 + EXPO(44.3)	0.117063	39.8	12
Outgoing Fuel Baseline	POIS(12.2)	0.211386	4.82	13
Outgoing Fuel Actual	3 + 167 * BETA(0.679, 0.822)	0.038809	52.6	12
Outgoing Paint Baseline	NORM(7.77, 2.12)	0.421509	2.2	13
Outgoing Paint Actual	UNIF(11, 122)	0.008333	35.1	12
Functional Test Baseline	7.5 + 17 * BETA(1.71, 0.647)	0.176599	4.08	13
Functional Test Actual	3.5 + 71 * BETA(0.751, 0.906)	0.095027	20	12

Incoming Defuel Baseline Input Analysis



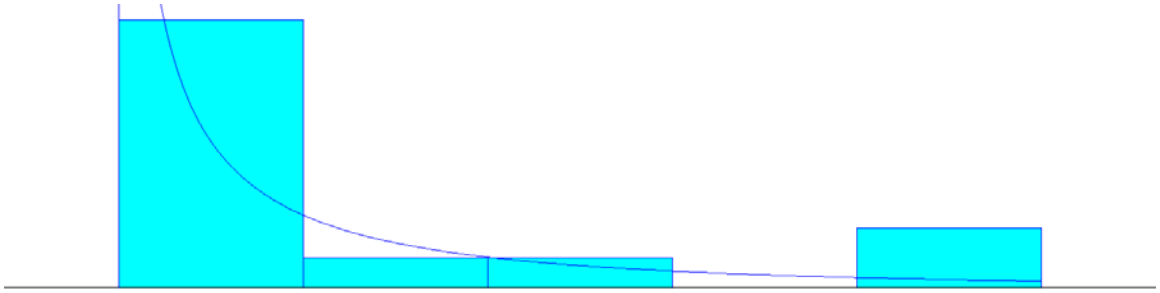
Distribution Summary

Distribution: Beta
Expression: 0.5 + 8 * BETA (0.364, 1.12)
Square Error: 0.092945

Data Summary
Number of Data Points = 13
Min Data Value = 1
Max Data Value = 8
Sample Mean = 2.46
Sample Std Dev = 2.18

Histogram Summary
Histogram Range = 0.5 to 8.5
Number of Intervals = 8

Incoming Defuel Actual Input Analysis



Distribution Summary

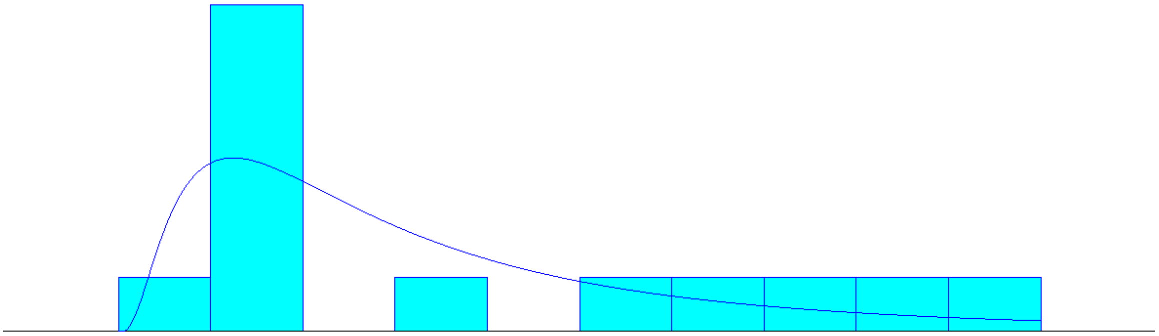
Distribution: Weibull
Expression: 3 + WEIB (45.5, 0.52)
Square Error: 0.021045

Kolmogorov-Smirnov Test
Test Statistic = 0.195
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 13
Min Data Value = 3
Max Data Value = 333
Sample Mean = 79.4
Sample Std Dev = 113

Histogram Summary
Histogram Range = 3 to 333
Number of Intervals = 5

Strip for Depaint Baseline Analysis



Distribution Summary

Distribution: Lognormal

Expression: 1.5 + LOGN (4.02, 4.39)

Square Error: 0.105807

Histogram Summary

Histogram Range = 1.5 to 11.5

Number of Intervals = 10

Data Summary

Number of Data Points = 13

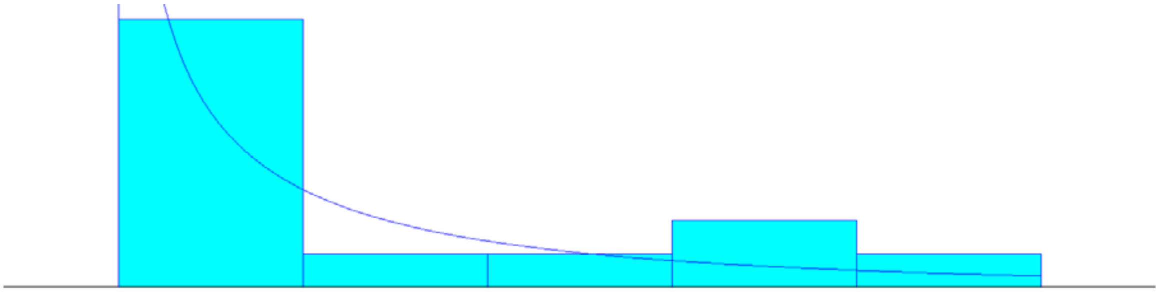
Min Data Value = 2

Max Data Value = 11

Sample Mean = 5.38

Sample Std Dev = 3.18

Strip for Depaint Actual Analysis



Distribution Summary

Distribution: Weibull

Expression: 22 + WEIB(73.2, 0.613)

Square Error: 0.019296

Kolmogorov-Smirnov Test

Test Statistic = 0.134

Corresponding p-value > 0.15

Data Summary

Number of Data Points = 13

Min Data Value = 22

Max Data Value = 336

Sample Mean = 117

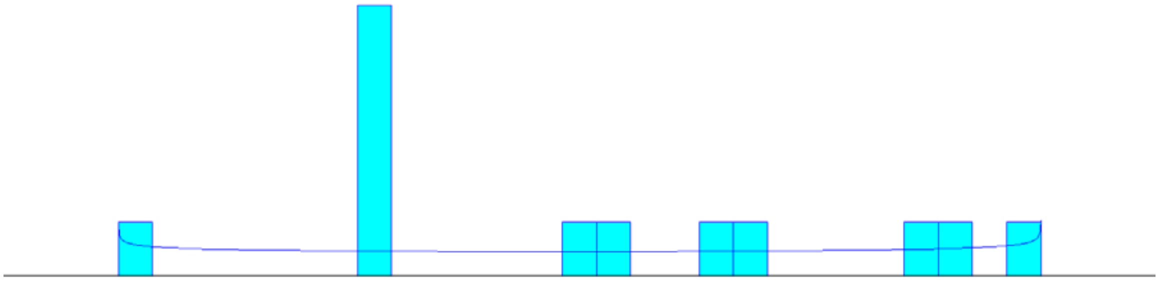
Sample Std Dev = 106

Histogram Summary

Histogram Range = 22 to 336

Number of Intervals = 5

Depaint/Wash Baseline Analysis

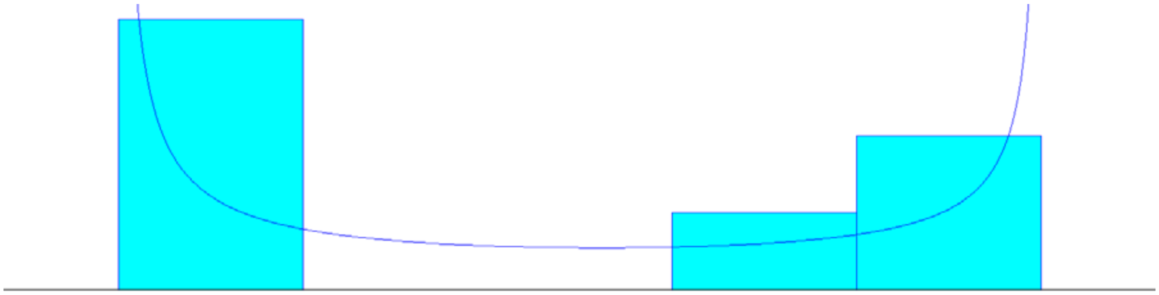


Distribution Summary
Distribution: Beta
Expression: 0.5 + 27 * BETA (0.905, 0.895)
Square Error: 0.157651

Data Summary
Number of Data Points = 13
Min Data Value = 1
Max Data Value = 27
Sample Mean = 14.1
Sample Std Dev = 8.07

Histogram Summary
Histogram Range = 0.5 to 27.5
Number of Intervals = 27

Depaint/Wash Actual



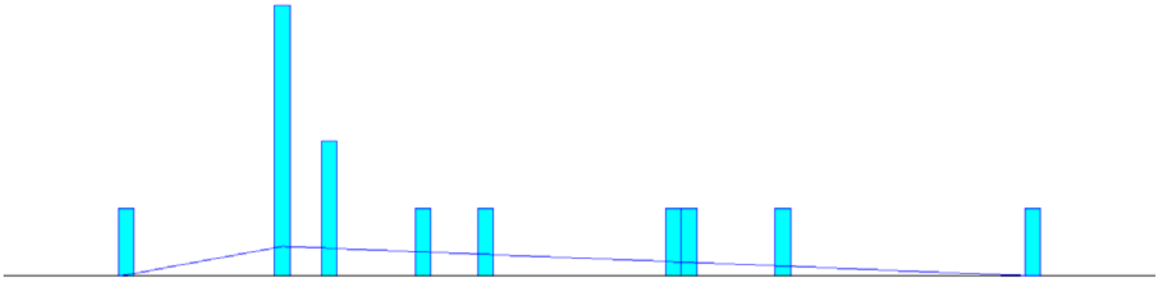
Distribution Summary
Distribution: Beta
Expression: 18 + 179 * BETA (0.263, 0.331)
Square Error: 0.086961

Kolmogorov-Smirnov Test
Test Statistic = 0.288
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 13
Min Data Value = 18
Max Data Value = 197
Sample Mean = 92.2
Sample Std Dev = 73.8

Histogram Summary
Histogram Range = 18 to 197
Number of Intervals = 5

Strip for PDM Baseline

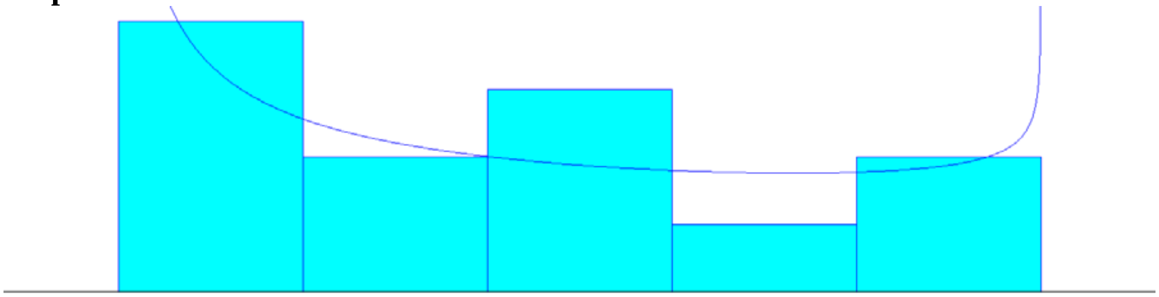


Distribution Summary
Distribution: Triangular
Expression: TRIA(1.5, 12, 60.5)
Square Error: 0.136921

Histogram Summary
Histogram Range = 1.5 to 60.5
Number of Intervals = 59

Data Summary
Number of Data Points = 13
Min Data Value = 2
Max Data Value = 60
Sample Mean = 23.5
Sample Std Dev = 16.6

Strip for PDM Actual



Distribution Summary
Distribution: Beta
Expression: 32 + 273 * BETA(0.584, 0.849)
Square Error: 0.017984

Kolmogorov-Smirnov Test
Test Statistic = 0.139
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 12
Min Data Value = 32
Max Data Value = 305
Sample Mean = 143
Sample Std Dev = 86

Histogram Summary
Histogram Range = 32 to 305
Number of Intervals = 5

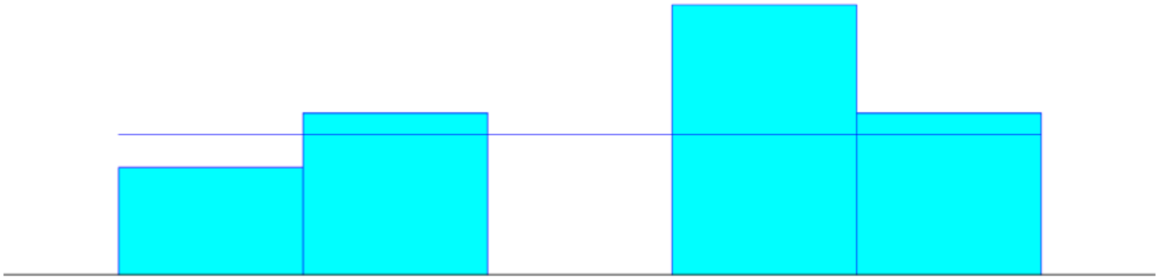
Indock Strip/Inspect Baseline

Distribution Summary
Distribution: Lognormal
Expression: 9.5 + LOGN(1.69, 2.56)
Square Error: 0.064271

Histogram Summary
Histogram Range = 9.5 to 31.5
Number of Intervals = 22

Data Summary
Number of Data Points = 13
Min Data Value = 10
Max Data Value = 31
Sample Mean = 12
Sample Std Dev = 5.76

Indock Strip/Inspect Actual



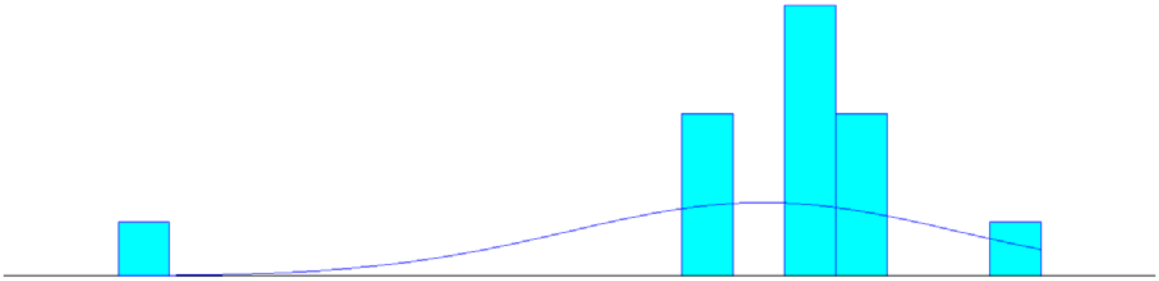
Distribution Summary
Distribution: Uniform
Expression: UNIF(40, 274)
Square Error: 0.078107

Kolmogorov-Smirnov Test
Test Statistic = 0.248
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 13
Min Data Value = 40
Max Data Value = 274
Sample Mean = 169
Sample Std Dev = 75.1

Histogram Summary
Histogram Range = 40 to 274
Number of Intervals = 5

Repairs Baseline

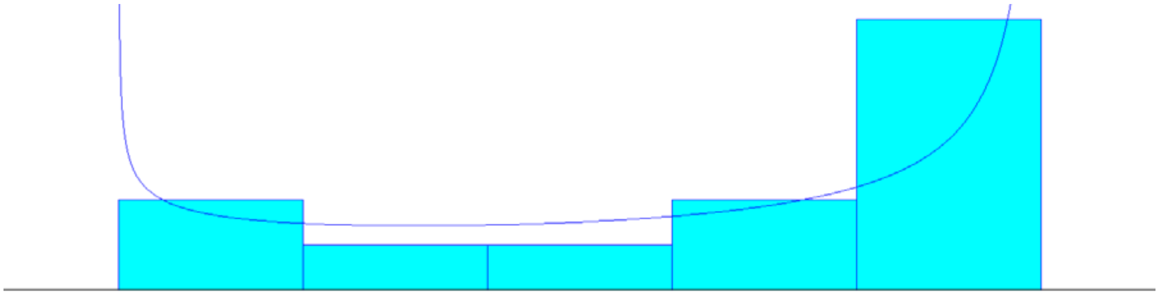


Distribution Summary
Distribution: Normal
Expression: NORM(69.1, 3.81)
Square Error: 0.164643

Histogram Summary
Histogram Range = 56.5 to 74.5
Number of Intervals = 18

Data Summary
Number of Data Points = 13
Min Data Value = 57
Max Data Value = 74
Sample Mean = 69.1
Sample Std Dev = 3.97

Repairs Actual



Distribution Summary
Distribution: Beta
Expression: 15 + 200 * BETA(0.715, 0.401)
Square Error: 0.023363

Kolmogorov-Smirnov Test
Test Statistic = 0.198
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 12
Min Data Value = 15
Max Data Value = 215
Sample Mean = 143
Sample Std Dev = 66

Histogram Summary
Histogram Range = 15 to 215
Number of Intervals = 5

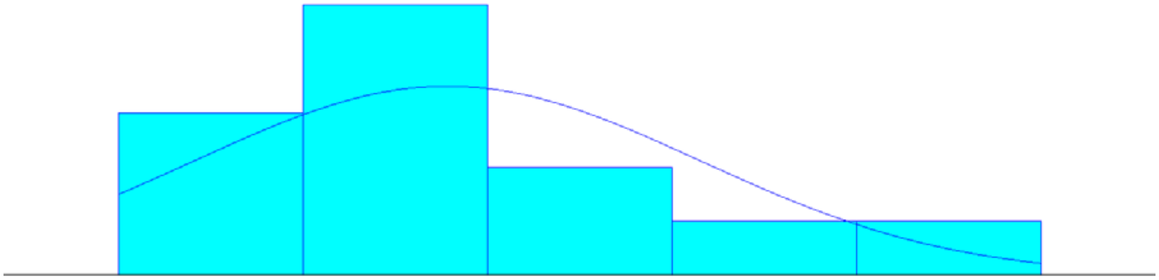
Build-up Baseline

Distribution Summary
Distribution: Lognormal
Expression: 11.5 + LOGN(4.07, 5.15)
Square Error: 0.279106

Histogram Summary
Histogram Range = 11.5 to 47.5
Number of Intervals = 36

Data Summary
Number of Data Points = 13
Min Data Value = 12
Max Data Value = 47
Sample Mean = 16.4
Sample Std Dev = 9.24

Build-up Actual



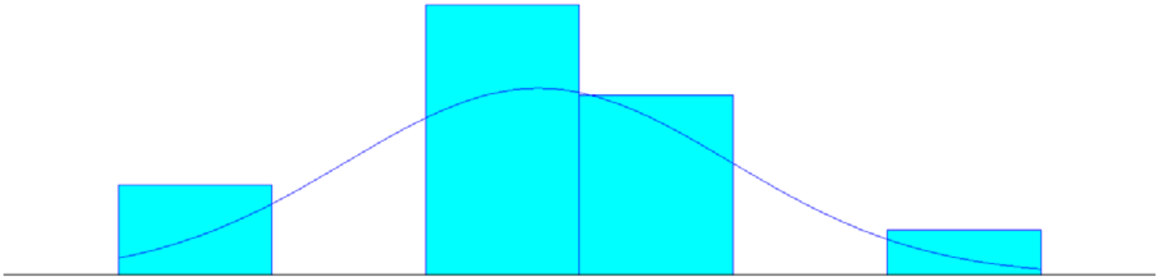
Distribution Summary
Distribution: Normal
Expression: NORM(114, 63.5)
Square Error: 0.033863

Kolmogorov-Smirnov Test
Test Statistic = 0.28
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 12
Min Data Value = 31
Max Data Value = 263
Sample Mean = 114
Sample Std Dev = 66.3

Histogram Summary
Histogram Range = 31 to 263
Number of Intervals = 5

Rig Ops Check Baseline

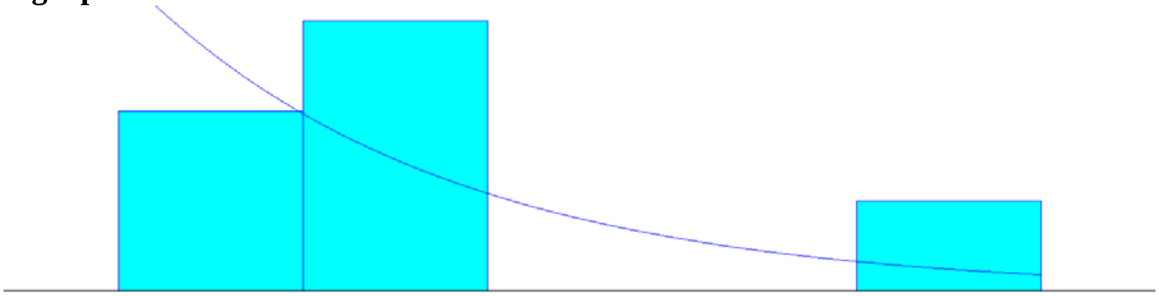


Distribution Summary
Distribution: Normal
Expression: NORM(21.2, 1.25)
Square Error: 0.088955

Data Summary
Number of Data Points = 13
Min Data Value = 19
Max Data Value = 24
Sample Mean = 21.2
Sample Std Dev = 1.3

Histogram Summary
Histogram Range = 18.5 to 24.5
Number of Intervals = 6

Rig Ops Check Actual



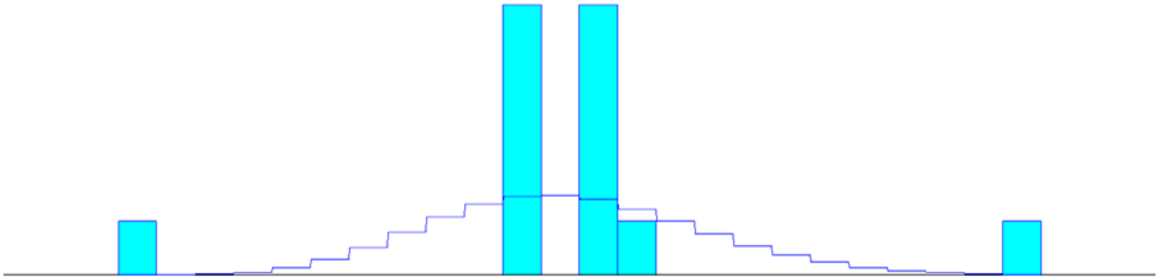
Distribution Summary
Distribution: Exponential
Expression: 22 + EXPO(44.3)
Square Error: 0.117063

Kolmogorov-Smirnov Test
Test Statistic = 0.178
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 12
Min Data Value = 22
Max Data Value = 154
Sample Mean = 66.3
Sample Std Dev = 39.8

Histogram Summary
Histogram Range = 22 to 154
Number of Intervals = 5

Outgoing Fuel Baseline

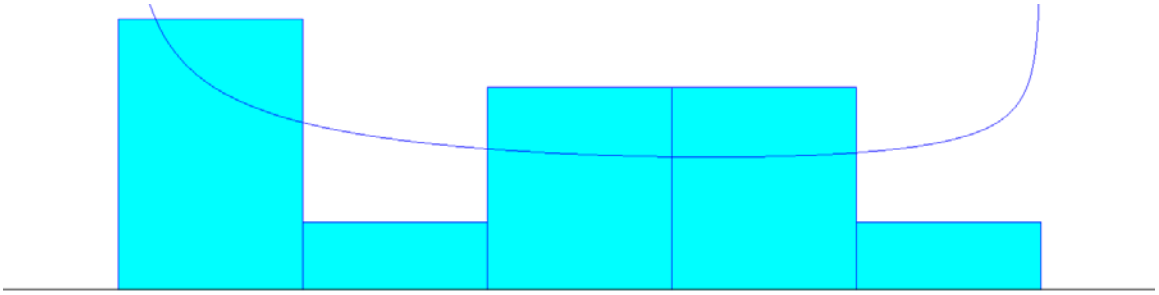


Distribution Summary
Distribution: Poisson
Expression: POIS(12.2)
Square Error: 0.211386

Histogram Summary
Histogram Range = 0.5 to 24.5
Number of Intervals = 24

Data Summary
Number of Data Points = 13
Min Data Value = 1
Max Data Value = 24
Sample Mean = 12.2
Sample Std Dev = 4.82

Outgoing Fuel Actual



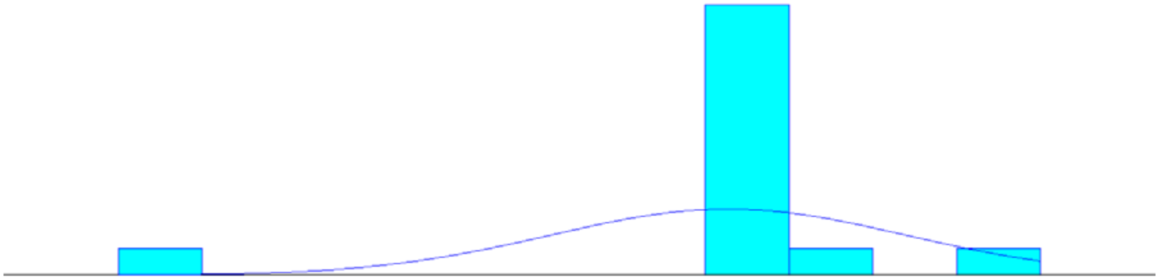
Distribution Summary
Distribution: Beta
Expression: 3 + 167 * BETA(0.679, 0.822)
Square Error: 0.038809

Kolmogorov-Smirnov Test
Test Statistic = 0.175
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 12
Min Data Value = 3
Max Data Value = 170
Sample Mean = 78.5
Sample Std Dev = 52.6

Histogram Summary
Histogram Range = 3 to 170
Number of Intervals = 5

Outgoing Paint Baseline

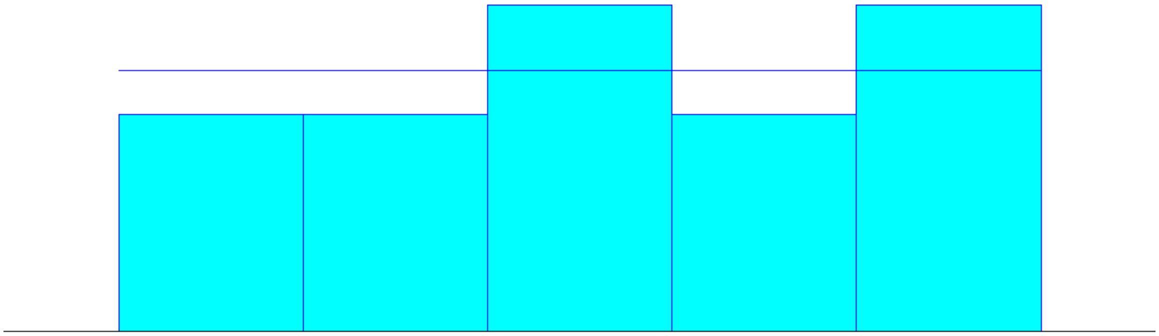


Distribution Summary
Distribution: Normal
Expression: NORM(7.77, 2.12)
Square Error: 0.421509

Histogram Summary
Histogram Range = 0.5 to 11.5
Number of Intervals = 11

Data Summary
Number of Data Points = 13
Min Data Value = 1
Max Data Value = 11
Sample Mean = 7.77
Sample Std Dev = 2.2

Outgoing Paint Actual



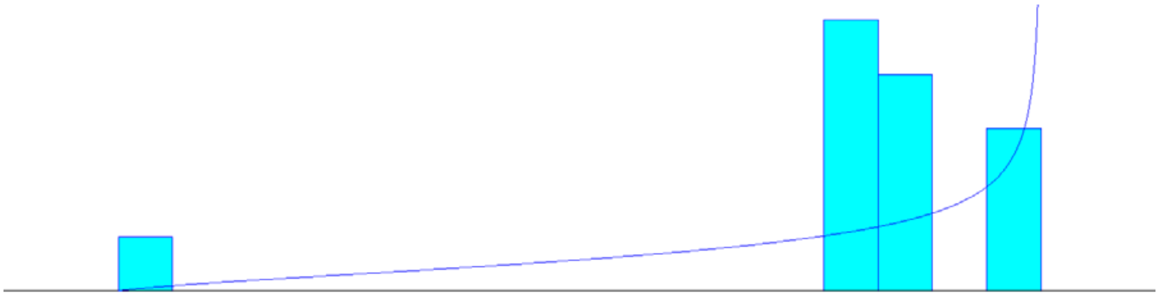
Distribution Summary
Distribution: Uniform
Expression: UNIF(11, 122)
Square Error: 0.008333

Kolmogorov-Smirnov Test
Test Statistic = 0.137
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 12
Min Data Value = 11
Max Data Value = 122
Sample Mean = 67.6
Sample Std Dev = 35.1

Histogram Summary
Histogram Range = 11 to 122
Number of Intervals = 5

Functional Test Baseline

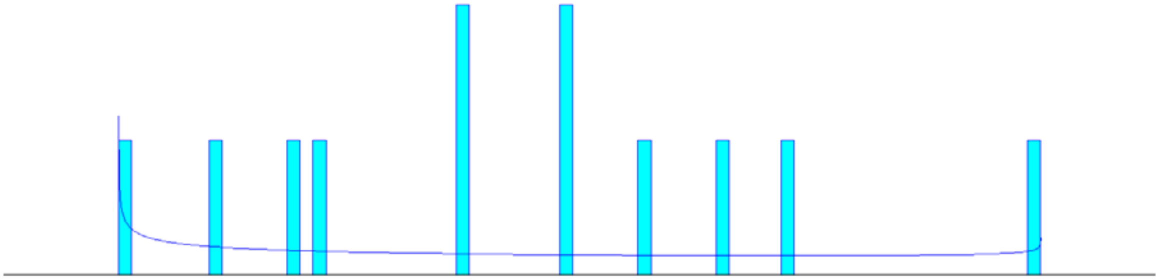


Distribution Summary
Distribution: Beta
Expression: 7.5 + 17 * BETA(1.71, 0.647)
Square Error: 0.176599

Histogram Summary
Histogram Range = 7.5 to 24.5
Number of Intervals = 17

Data Summary
Number of Data Points = 13
Min Data Value = 8
Max Data Value = 24
Sample Mean = 21
Sample Std Dev = 4.08

Functional Test Actual



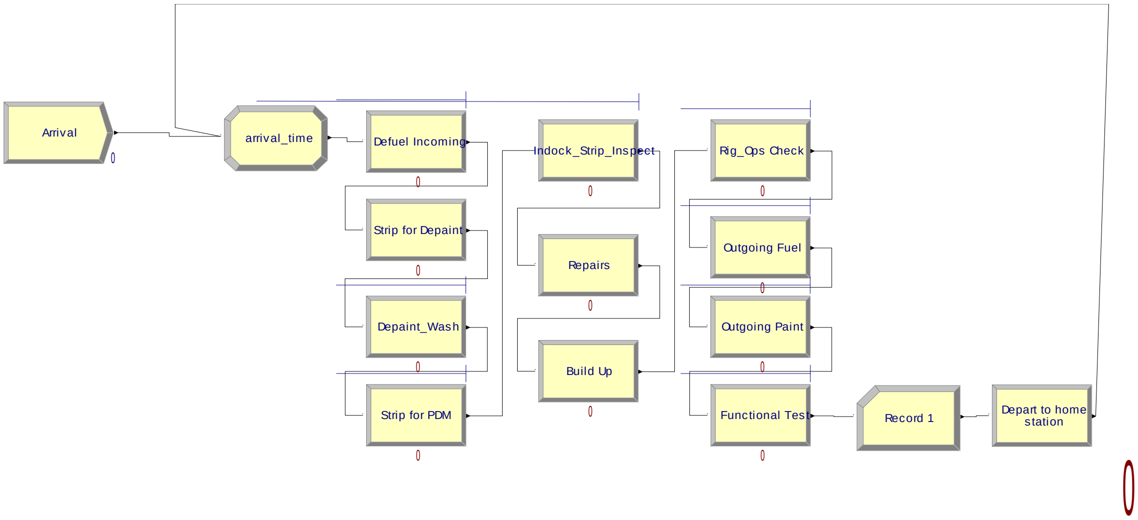
Distribution Summary
Distribution: Beta
Expression: 3.5 + 71 * BETA(0.751, 0.906)
Square Error: 0.095027

Data Summary
Number of Data Points = 12
Min Data Value = 4
Max Data Value = 74
Sample Mean = 34.2
Sample Std Dev = 20

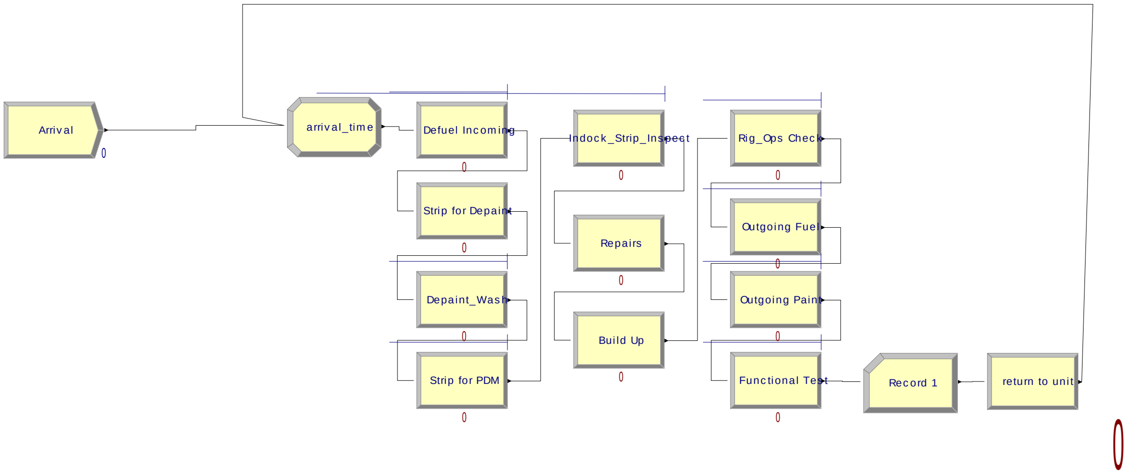
Histogram Summary
Histogram Range = 3.5 to 74.5
Number of Intervals = 71

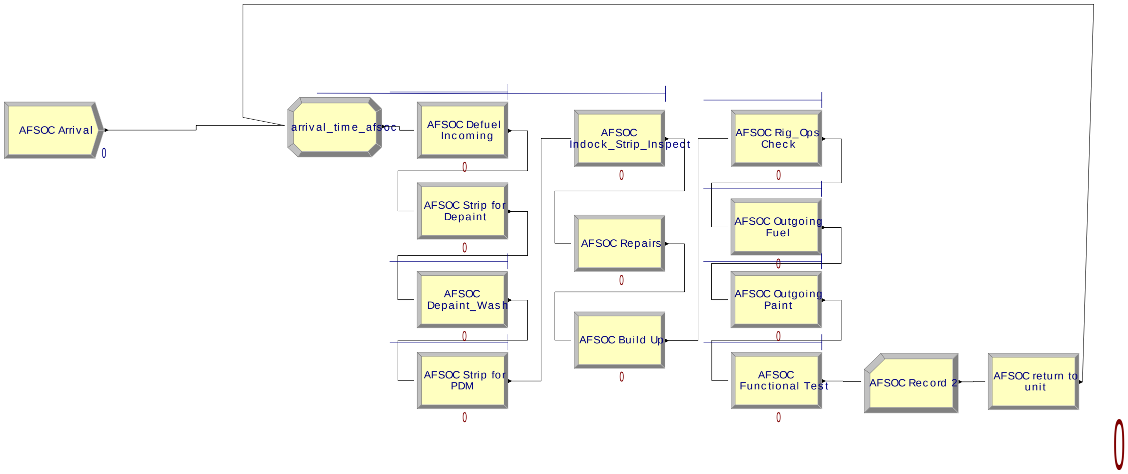
Appendix B: Arena Models

Model 1



Model 2





Appendix C: C-130 Business rules

(Lancaster, 2010)

All MAJCOMs except ACC and AFSOC load the -6 requirements into GO81; squadron level loads the tail numbers against the requirement, HSC and ISO. Schedule is produced in GO81.
ACC/AFSOC Gained units use CAMS to load requirements.

AFSOC (AFSOC HOI 63-1110 28 September 2009)

A4.1. Planning Guidelines. For planning purposes, the number of AFSOC aircraft in modification, PDM, and test at any one time is restricted to that number which preserves the minimum number of aircraft available for warfighter requirements and pipeline/sustainment training. The actual number available for modification, PDM, and test is set by the 623 AOC/SPD during the Air Tasking Cycle.

MDS	**MAX NUMBER OF AIRCRAFT DOWN**
AC-130H	2
AC-130U	4
CV-22	1 (see note)
MC-130E	2
MC-130H	4
MC-130P	4
MC-130W	2 (see note)
EC-130J CS	1
EC-130J Slick	1
NSAv	1 per MDS (see note)

Note: Fleet sizes of CV-22, MC-130W and NSAv aircraft are growing. Additional aircraft may become available for modification but this must be planned through the 623 AOC/SPD.

A4.2. Long Range Planning Guidelines. These are long-range planning guidelines. Long range apportionment of 23 AF is set by 23 AF/CC.

AMC/AETC/ANG/AFRC/ACC/USAFE/PACAF

All MAJCOMs and bases use two aircraft down criteria for maintenance and PDM, exceptions are approved on an individual basis between MAJCOM and owning base.

AFRC/A4MY will limit # of acft from one unit in depot at one time based on # of acft assigned and mission requirements but have nothing in writing.

Programs/Events and Average Flowdays (Calendar)

PDM Durations:
MCP- 153 Calendar Days
MCE/H- 201 Calendar Days
AH- 186 Calendar Days unless accelerated
AU- 181 Calendar Days unless accelerated
MW- 160 Calendar Days
E – 200 Calendar Days
H- 153 Calendar Days
HP- 225 Calendar Days
HN- 210 Calendar Days
WCH- 180 Flowdays

PDM-T- Same as PDM flowdays until established

HVM Durations:
Cycle 1 (Fuselage)-
Cycle 2 (Wing)-
Cycle 3 (Empennage)-
Cycle 4 (Paint)-

CWB Inductions**:**
FY 10- 18
FY 11- 16
FY12- 11

H, HN and HP- 220 Calendar days Non SOF aircraft
H, HN and HP- 180 SOF aircraft only
AU and MH- 301 Calendar days
Should have 10% reduction in calendar days in FY 11

J Model Inductions:
Letter check style Progressive Maintenance Program (PMP)- Duration determined by inspections to be performed
Aircraft input at 12 yr mark then every 3 yrs after
Add 21 days for Paint
Add 30 days for Rainbow fitting changes

WCJ- 100 Flowdays total
All other J- 90 Flowdays total

UDLM Durations: Depending on Capacity (Resources and Manpower availability)

MAFFS/ Hurricane Spotter Durations: Minimal aircraft down during June- November to support possible mission requirements

AMP LRIP durations
1st 2 aircraft 365 days
Aircraft 3-6 330 days
Aircraft 7-9 300 days
10th aircraft 270 days

Parking Spots/ Work Areas: All C-130 ramp spaces considered a spot to work a C-130

F-1 thru F4 – Used for FT and engine runs
F5-F8- used by C-17 and C-5 for FT
N1 thru N5- Used as alternate FT slots but no engine runs C-130
N6-N11- used as shared spots for C-5 and C-17
N12-N14- used as fuel repair spots or aircraft after final fuel C-130
N15-N25- used as strip or outgoing ops checks C-130
N26- shared with C-17 and C-130
N27-N28- used by C-17
N29-N31- used as strip or outgoing ops checks C 130
B 44- one C-130
B50- depaint or paint one C-130
B54 – paint C-17
B59 – paint C130 or C-5
B81- four C-17
B82- two C-17
B83 Dock 1 and 2 – one each C-17
B83 Dock 3 and 4- three to four C 130 for buildup after CWR
B 89- paint one C-130
B 91 – eight docks and two tents for PDM, PDMT or HVM (currently)
B110- used by C-130 for CWR (six) spots with fixtures (spots 1-6)
North Hanger- being built available third quarter FY11- four C 130
ANG Hanger 2316- two C 130 presently in hangers and 1 outside

- AFSOC: Kadena, Hurlburt Field, Eglin, Mildenhall, Yokota, Cannon
- AFRC: Duke Field, Patrick, Pope, Minneapolis, Niagara, Maxwell, Dobbins, Peterson, Youngstown, Pittsburgh, Keesler
- USAFE: Ramstein, Yokota
- AMC: Dyess, Little Rock
- AETC: Little Rock, Kirtland, Palmdale
- ANG: Suffolk, Nashville, Channel Island, New Orleans, Kanawha, Moffett Field, Martin Field, Schenectady, Wilmington, Quonset Point, Charlotte, McEntire, Savannah, Jacksonville, Mansfield, Louisville, Martinsburg, Peoria, Selfridge, Rosecrane, Carswell, Will Rogers, Cheyenne, Boise, Olmsted, Muniz, Hickam, Kulis, Puerto Rico, Willow Grove
- ACC: Moody, Pope

- J models arrive on Tuesdays
- AMP mod aircraft arrive on Wednesdays
- CWB aircraft arrive on Thursdays
- PDM aircraft arrive according to TAKT time
- No two C 130 aircraft arrive on same day. PDM aircraft takes precedence if two aircraft scheduled for same day. Second aircraft would arrive either day earlier or later whichever day is available; Zero aircraft arrive on weekends

Appendix D: ROCIT data

Table 6: Baseline (Scheduled) Flow Days

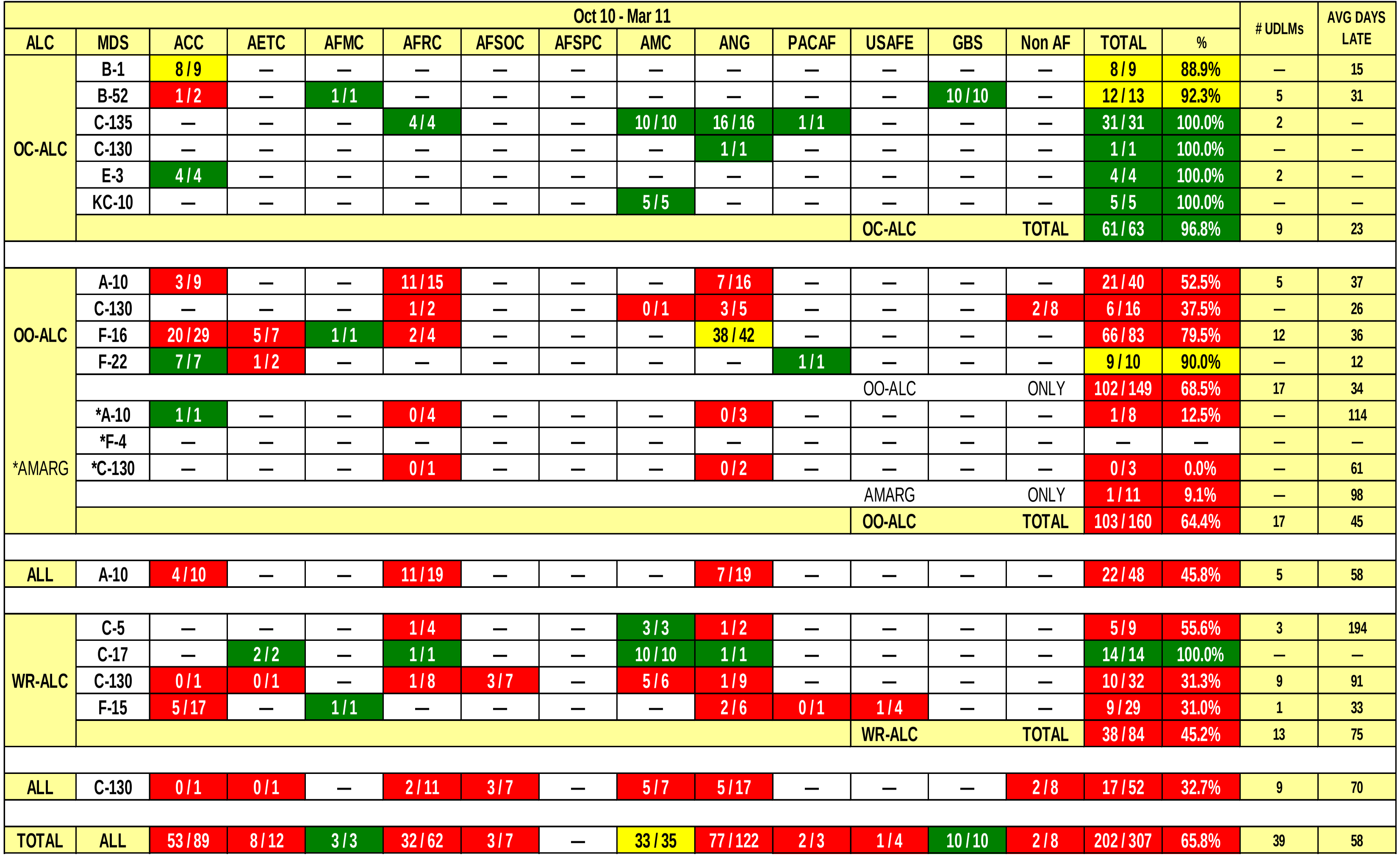
TAIL NO	MDS	JON	Defuel Incoming Baseline Time	Strip for Depaint Baseline Time	Depaint/ Wash Baseline Time	Strip for PDM Baseline Time	Indock Strip/ Inspect Baseline Time	Repairs Baseline Time	Build-up Baseline Finish	Rig Ops Check Baseline Time	Outgoing Fuel Baseline Time	Outgoing Paint Baseline Time	Functional Test Baseline Time
80000321	C-130H	014/PDM/RBF /ACI	8	10	24	44	10	68	14	21	11	8	22
90001794	C-130H	028/PDM/SS	4	3	8	12	10	68	12	21	1	8	21
89001187	C-130H	023/PDM/SS	1	3	25	60	10	70	14	22	13	8	22
88004404	C-130H	025/PDM/SS	1	9	27	21	12	70	14	22	11	8	22
69005821	MC-130P	029/PDM/SS	4	3	14	25	10	70	14	21	13	8	22
90001791	C-130H	021/PDM/SS	4	11	8	15	10	70	15	21	13	8	21
64014852	HC-130P	031/PDM/RBF /Depaint/ #2ISO	1	8	18	38	11	70	14	19	11	11	21
91001239	C-130H	034/PDM/SS	1	2	15	15	10	68	15	21	11	9	21
69005825	MC-130P	026/PDM/SS	1	7	19	37	12	71	12	22	11	8	24
82000060	C-130H	039/PDM/RBF /Depaint	1	3	8	12	10	71	14	21	14	8	24
89009101	C-130H	038/PDM/SS	1	3	8	12	10	71	14	22	13	8	24
69006575	AC-130H	035/PDM/ Paint	4	3	8	12	10	74	14	24	13	8	21
89000281	MC-130H	AVZ/IDLM for IDS Machine Plate and Alignment	1	5	1	2	31	57	47	19	24	1	8

Table 7: Actual Flow Days

TAIL NO	MDS	JON	Defuel Incoming Actual Time	Strip for Depaint Act Time	Depaint/ Wash Act Time	Strip for PDM Actual Time	Indock Strip/ Inspect Actual Time	Repairs Actual Time	Build-up Actual Finish	Rig Ops Check Actual Time	Outgoing Fuel Actual Time	Outgoing Paint Actual Time	Functional Test Actual Time
80000321	C-130H	014/PDM/RBF /ACI	40	53	166	72	89	127	111	34	3	65	11
90001794	C-130H	028/PDM/SS	333	336	154	305	221	162	126	71	56	58	50
89001187	C-130H	023/PDM/SS	16	33	142	74	246	215	39	45	130	122	38
88004404	C-130H	025/PDM/SS	3	201	173	271	215	209	193	65	121	110	17
69005821	MC-130P	029/PDM/SS	8	56	39	134	241	178	93	67	170	102	38
90001791	C-130H	021/PDM/SS	292	126	172	212	104	146	86	73	14	18	30
64014852	HC-130P	031/PDM/RBF /Depaint/ #2ISO	14	29	20	148	274	186	263	154	97	86	19
91001239	C-130H	034/PDM/SS	17	78	22	32	195	184	98	130	114	40	44
69005825	MC-130P	026/PDM/SS	151	273	18	N/A	194	15	169	50	93	56	4
82000060	C-130H	039/PDM/RBF /Depaint	8	52	197	154	83	63	84	23	22	11	74
89009101	C-130H	038/PDM/SS	118	221	22	114	188	182	31	22	89	89	30
69006575	AC-130H	035/PDM/ Paint	19	22	32	163	102	50	71	62	33	54	55
89000281	MC-130H	AVZ/IDLM for IDS Machine Plate and Alignment	13	40	41	41	40	N/A	N/A	N/A	N/A	N/A	N/A

Appendix E: DDP chart

Organic Aircraft Produced On Time or Early / Aircraft Produced (Revised Date)
FY11 (as of 31 Mar 11) (ALL)



		Oct 10 - Mar 11															
ALC	MDS	ACC	AETC	AFMC	AFRC	AFSOC	AFSPC	AMC	ANG	PACAF	USAFE	GBS	Non AF	TOTAL	%	# UDLMs	AVG DAYS LATE
OC-ALC	B-1	8 / 9	—	—	—	—	—	—	—	—	—	—	—	8 / 9	88.9%	—	15
	B-52	1 / 2	—	1 / 1	—	—	—	—	—	—	—	10 / 10	—	12 / 13	92.3%	5	31
	C-135	—	—	—	4 / 4	—	—	10 / 10	16 / 16	1 / 1	—	—	—	31 / 31	100.0%	2	—
	C-130	—	—	—	—	—	—	—	1 / 1	—	—	—	—	1 / 1	100.0%	—	—
	E-3	4 / 4	—	—	—	—	—	—	—	—	—	—	—	4 / 4	100.0%	2	—
	KC-10	—	—	—	—	—	—	5 / 5	—	—	—	—	—	5 / 5	100.0%	—	—
											OC-ALC		TOTAL	61 / 63	96.8%	9	23
OO-ALC	A-10	3 / 9	—	—	11 / 15	—	—	—	7 / 16	—	—	—	—	21 / 40	52.5%	5	37
	C-130	—	—	—	1 / 2	—	—	0 / 1	3 / 5	—	—	—	2 / 8	6 / 16	37.5%	—	26
	F-16	20 / 29	5 / 7	1 / 1	2 / 4	—	—	—	38 / 42	—	—	—	—	66 / 83	79.5%	12	36
	F-22	7 / 7	1 / 2	—	—	—	—	—	—	1 / 1	—	—	—	9 / 10	90.0%	—	12
											OO-ALC		ONLY	102 / 149	68.5%	17	34
*AMARG	*A-10	1 / 1	—	—	0 / 4	—	—	—	0 / 3	—	—	—	—	1 / 8	12.5%	—	114
	*F-4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	*C-130	—	—	—	0 / 1	—	—	—	0 / 2	—	—	—	—	0 / 3	0.0%	—	61
											AMARG		ONLY	1 / 11	9.1%	—	98
											OO-ALC		TOTAL	103 / 160	64.4%	17	45
ALL	A-10	4 / 10	—	—	11 / 19	—	—	—	7 / 19	—	—	—	—	22 / 48	45.8%	5	58
WR-ALC	C-5	—	—	—	1 / 4	—	—	3 / 3	1 / 2	—	—	—	—	5 / 9	55.6%	3	194
	C-17	—	2 / 2	—	1 / 1	—	—	10 / 10	1 / 1	—	—	—	—	14 / 14	100.0%	—	—
	C-130	0 / 1	0 / 1	—	1 / 8	3 / 7	—	5 / 6	1 / 9	—	—	—	—	10 / 32	31.3%	9	91
	F-15	5 / 17	—	1 / 1	—	—	—	—	2 / 6	0 / 1	1 / 4	—	—	9 / 29	31.0%	1	33
											WR-ALC		TOTAL	38 / 84	45.2%	13	75
ALL	C-130	0 / 1	0 / 1	—	2 / 11	3 / 7	—	5 / 7	5 / 17	—	—	—	2 / 8	17 / 52	32.7%	9	70
TOTAL	ALL	53 / 89	8 / 12	3 / 3	32 / 62	3 / 7	—	33 / 35	77 / 122	2 / 3	1 / 4	10 / 10	2 / 8	202 / 307	65.8%	39	58

Data Source: AO30D (AMREP)

🟩 ≥ 95%   🟨 ≥ 85%   🟥 < 85%

Vita

Major Heather Cooley was commissioned in 1998 through the Reserve Officer Training Corps at Miami University, Ohio. Her maintenance experience includes flightline and backshop maintenance assignments on bomber, airlift and fighter aircraft. Her previous bases of assignment include McChord AFB, Washington, Dyess AFB, Texas and Elmendorf AFB, Alaska. She earned a Bachelor's Degree in Botany in 1998 and a Master's Degree in Organizational Leadership in 2002. Upon graduation, she will be reassigned to command the 379th Expeditionary Maintenance Squadron at Al Udeid AB, Qatar.

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14. ABSTRACT

The C-130 is a tactical airlifter and has been in steady use for decades in austere deployed locations. The inspection program to ensure its sustainment has faced increasing workload requirements due to structural issues related to heavy use and aging materials. The most in-depth inspection is the Programmed Depot Maintenance (PDM) inspection and is accomplished at two Air Logistics Centers (ALCs). In recent years, both centers have experienced increased maintenance time and decreased on-time production rates, with Due Date Performance (DDP) rates as low as 30%. This negatively impacts aircraft availability and mission capability. Another challenge facing the ALCs is the ongoing transition to High Velocity Maintenance (HVM), which is intended to improve aircraft availability to meet mission requirements.

This study utilizes a simulation model to assess the impact of adding dock spaces and the impact of prioritizing one aircraft variant over other variants. The model represents the expectation for the entire PDM inspection process based on technical data inspection requirements for the C-130 fleet. Data was generated using expected (scheduled) flow times for major sub-processes from induction into the inspection process through the functional test flight and the return to home station. Simulation results indicate several problems with the current production strategies, including the negative impact of prioritization on the overall due date performance for all C-130 variants.

15. SUBJECT TERMS

Discrete-event simulation, Programmed Depot Maintenance (PDM), Due Date Performance (DDP)

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