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Project Frost: Robotics and Automation in JDAM Packaging Processes

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Robotics and Automation in JDAM Packaging Processes
Executive Summary

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Introduction

As the United States and its allies continue to fight ISIL and other terror organizations, the need for affordable, reliable, and precise weapons is now greater than ever. One such weapon is Boeing's Joint Direct Attack Munition, or JDAM, a guidance kit used to convert unguided free fall bombs into precision smart weapons. Over the lifetime of the program, JDAM has grown significantly in popularity and usage with US and international militaries and is now commonly recognized as the "warfighter weapon of choice" (Coffey).

Problem Statement

Ultimately, the JDAM facility can only produce tail kits as quickly as it can package them for shipment. However, the current packaging line, primarily the strapping system, experiences a number of equipment reliability issues. Strapping machines are often out of operation for need of maintenance, and when they are operational it is common for the machines to "mis-strap" shipping containers. A "mis-strap" is any strap that is not sufficiently tensioned or sealed, or in an incorrect position or configuration. Beyond strapping equipment reliability issues, there are advantages to be gained in equipment that decreases the need for touch labor. There are plans to decrease the facility's overall Takt time by increasing the number of workstations within the facility. Automated equipment can prevent the need to hire as many mechanics for additional workstations.

This project addressed processes within the JDAM assembly line that can be automated for increased reliability and decreased need for touch labor. Focus was confined to the packaging line. This line was the source of various reliability problems, to the extent that there was a pending Capital Budget Request for packaging line improvements.

Recommendations were offered on how capital funding for improvements addressing the packaging issues noted above can be best spent. The cost of suggested changes were estimated, to determine if another Capital Budget Request for additional funding was necessary. Recommendations were defined in the form of system requirements so as to assist in the equipment procurement process.

Joint Direct Attack Munition Background

JDAM is a low-cost, battery-powered guidance kit that is installed in the field onto existing unguided free-fall bombs, converting them into precision "smart weapons" (Coffey). Shown in Figure 2, the main components of a standard JDAM kit include a tail section, Internal Navigation System (INS), and body strakes.

JDAM kits can be installed on four types of bombs: 500 pound, 1,000 pound, and 2,000 pound MK-series blast fragmentation warheads, and the 2,000 pound penetrator warhead ("Boeing Weapons"). JDAM-compatible bombs are referred to as the MK-82, MK-83, MK-84, and BLU-109 respectively. JDAM tail kit sizes are custom designed to fit each of these four bomb sizes ("Boeing Weapons").

Add-on kits are used to improve or alter certain aspects of a weapon's performance. When add-on kits are combined with the standard JDAM kit, a variant kit is created. A variant kit is a JDAM kit that has increased capability, range or flexibility, depending on the add-ons utilized. For example, the addition of a laser-guidance system to a JDAM creates a Laser JDAM variant kit that can be used for mobile targets.

Likewise, wing sets can be added for a JDAM Extended Range variant with a range of over 40 nautical miles. This can be compared to the standard JDAM kit's 15-mile range (Coffey). With 12 total variants compatible on 14 aircraft platforms, the modular nature of the JDAM kit allows for increased configurations and capability. JDAM also boasts a mission reliability rating of over 95%, making it one of the most precise and reliable weapons in US Air Force and Navy inventories. Major Mike Benitez, US Air Force weapons system officer and air combat veteran shared: "There are a lot of things that run through my mind, having that great responsibility to employ this weapon. The one thing I have never thought about is if the JDAM will work" (Coffey).

Project Statement, Goals and Objectives

The problem this project addressed was to propose methods and designs by which the Boeing JDAM packaging line can be made more automated and reliable.

The specific goal of this project was to make recommendations on equipment modification and replacement that will increase automation and reliability in the JDAM packaging line, capture these recommendations in systems requirements, and obtain rough estimates for the cost to implement the proposed improvements and changes.

Per the goal of this project, objectives are as follows:

1. Understand the current JDAM line, its limitations, existing improvement efforts, and areas for improvement
2. Determine appropriate project scope and deliverables, based on time constraints and the engineering abilities of one MQP (Major Qualifying Project) student
3. Explore equipment solutions
4. Develop and document equipment requirements for packaging line changes
5. Determine cost of recommended changes
6. Produce a detailed report and presentation

Systems Approach

The completion of this project necessitated a systems-level approach. As is the case with any modification to a production line across the Boeing enterprise, the focus of this project was not on the specific design of a machine or robot, but rather how a new process would fit into an existing system, and what the consequences of such a change might be. The scope, purpose, goals, objectives, and deliverables of this systems-level project are defined below.

Deliverables

JDAM Current State

In order to make recommendations on how the JDAM line can be improved to adapt to significantly higher production rates, it was necessary to become as familiar as possible with the current line. To do this, informational interviews and shadowing sessions were conducted with personnel of varying roles in the JDAM program. The author even rotated between using the desks of the first and second shift foremen, so as to be immersed in the environment of the production line. The more time the author

spent in or around the line, more was learned about the necessary changes to adapt to increased production rates.

Determine Project Scope and Deliverables

The JDAM assembly facility, which has been running for over fifteen years, needs improvements in multiple areas. The available time in which the project could be completed, as well as the author's educational background and professional experience were factors used in narrowing down the areas of improvement to focus on. These factors were also used to determine an appropriate project scope, end goals and deliverables.

Explore Potential Solutions

Research was performed to learn more about what is possible and common in industry wide packaging and strapping equipment. It was discovered that there are a number of existing strapping machine designs and configurations that could replace the line's current unreliable strapping machines. Furthermore, if the now-manually operated lift assist devices were replaced with automated equipment performing the same tasks, the need for touch labor in the packaging line could be decreased. Initial analysis found both these possibilities viable.

Capture Requirements

Beyond an MQP project report, a specific definition of recommendations in the form of system requirements was needed. System designs are commonly specified through the identification of needs and the subsequent statement of requirements resulting from and understanding of these needs.

Determine Cost

As explained in the Background section, this project is being completed in the context of a pending Capital Budget Request, with a portion allocated towards packaging line improvements. Therefore, it was important that any suggested changes be presented with an approximate cost. In the initial stages of the project, the author was informed that JDAM leadership is willing to pursue additional capital funding for packaging line improvements with another Capital Budget Request. Rough Order of Magnitude (ROM) requests were sent to potential vendors and used to gauge funding needed to implement the changes suggested herein.

Produce a detailed Report and Presentation

Lastly, it was necessary to collect all relevant background, methodologies, findings, etc. in a detailed project report as well as a formal presentation delivered onsite at The Boeing Company.

7.0 References

"Boeing Weapons." *The Boeing Company*, The Boeing Company, www.boeing.com/defense/weapons/.

Coffey, Greg. "Aviation Week Network 2017 Program Excellence Awards Submission: Boeing Joint Direct Attack Munition Tail Kit Program." Aviation Week, a Division of Penton Media, Inc., 21 Apr. 2017.