Operations | Aerospace and defense | Improved process performance | Statistical Analysis

How Complexity Drives Long Lead Times: A Queueing Theory Space Industry Application

BLUE ORIGIN

BUSINESS PROBLEM

The space industry is going through a major transformation. In today's space industry, commercial companies compete in the market for customers and resources; no longer the exclusive domain of government agencies and legacy aerospace giants. Many aerospace companies produce their components in high-mix, low-volume operations known as job shops. Job shops are notorious for having long lead times. The research for this thesis was conducted at a manufacturing site at Blue Origin that operates as a job shop. The purpose was to identify the sources for the long lead times observed in the production of machined components.

APPROACH

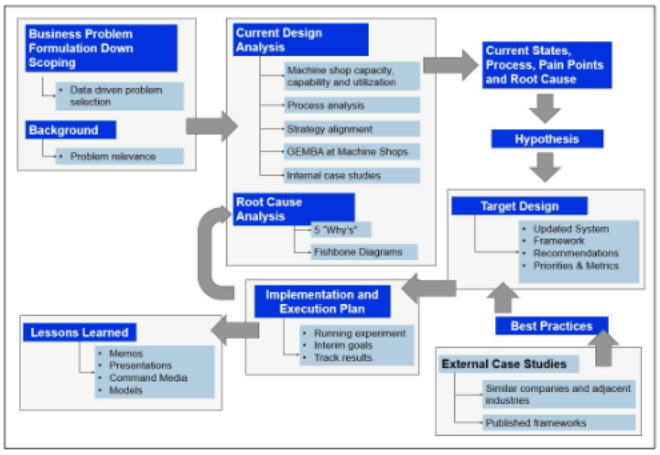
The hypothesis the thesis investigates is long lead times are the result of high variability caused by the complexity of producing space components. Using the method proposed by Factory Physics and queueing theory, this thesis demonstrates via case studies and a queueing simulation that high variability drives long wait times leading to the long lead times experienced in job shop operations.

DATA SOURCES

All data used for this research is data recorded in the manufacturing system as part of standard operations. The data was captured over several months that were representative of the current system operations. All analyses are based on the data from the same time period.

Data Types and Format

Engineering and manufacturing data can be accessed with SQL queries. The data is captured as lists and can be processed using Python or Excel.



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IMPACT

The research conducted for this thesis helps the business understand their sources of long lead times and potential options to reduce them. The simulation can be used to iterate through different solutions and test improvements to the production system.

DRIVERS

Morgan Stanley's Space Team estimates that the roughly $350 billion global space industry could surge to over $1 trillion by 2040; a $650 billion increase from 2020. The cost of space launches has decreased 95%. This creates pressure to increase launch frequency which can be achieved by making components reusable and/or producing components at high rate.

BARRIERS

In complex operations of complex products, observed issues can hide the true problem. Therefore, some of the issues being experienced can actually be symptoms of the main problem. In addition, often times there are proposed solutions on the table based on an understanding of the problem. However, as proposed in Factory Physics, one must spend time defining the problem from a systems view.

ENABLERS

Blue Origin is rich in manufacturing data and open to improvements. They also provided me the time to conduct the research and define the problem statement.

ACTIONS

Once I identified the problem statement and the root cause, it became obvious the problem was a queueing problem. I looked for research that proposed solutions to approach this type of operations, which are commonly known as Jackson open queueing networks (OQN). I selected a mathematical model proposed by Bitran and Morabito (1994), then took a transfer line python simulation from MIT course 2.854 and modified to be an OQN simulation.

INNOVATION

I validated the OQN simulation using observed data from the job shop at Blue Origin. It now can be used for improvement ideas comparisons.

IMPROVEMENT

My solution provides Blue Origin with a tool to investigate potential solutions for improvement in their job shop operations.

BEST PRACTICES

One of the best practice is to approach the problem methodically to ensure the solution is addressing the root cause of the problem. Then, the model and simulation require verification and validation as proposed by Factory Physics.

OTHER APPLICATIONS

The simulation can be used to any job shop operations, not just the space industry.