Production engineering | Aerospace and defense | Improved process performance | Deterministic / Stochastic

Parametric Study of Environmental Testing in Satellite Manufacturing

Amazon

BUSINESS PROBLEM

As Amazon Project Kuiper transitions to full-scale production in its satellite factory, the manufacturing team needs to estimate the proper amount of environmental testing equipment. The machines are expensive and take a lot of space on the shop floor. However, there is little data for the suspected failure rates of the different components in the satellite resulting in uncertainty around throughput. The research tries to solve the estimation of the number of environmental test machines that will be required for a new production process.

APPROACH

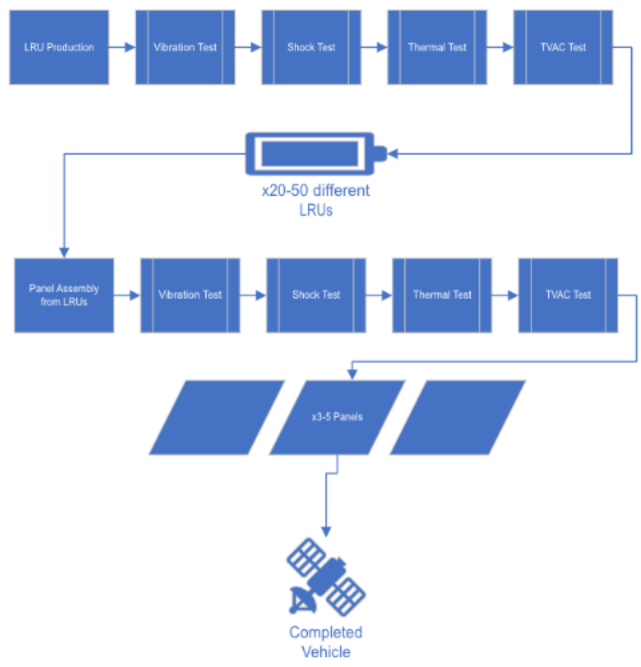
I created a deterministic model to calculate the number of machines that are required at a factory level. This model aims to predict testing requirements at all of the different time periods that the factory will experience in its first three years of production. These outputs can be used to appropriately plan for the large expenses required from these machines.

DATA SOURCES

The model uses inputs for each main test: Vibration, Shock, Thermal, and TVAC. Data for each of these tests were collected through experimentation and published standards in accordance with SMC-S-016. This data includes specific temperatures and times that are needed to conduct a test.

Data Types and Format

These includes times, temperatures, and costs for each of the machines. These were all collected in comma-separated-value (CSV) format and analyzed using Microsoft Excel.



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IMPACT

Low Earth Orbit Satellite constellations have begun to provide consumers with internet access in remote and under-served areas. Firms have begun to manufacture satellites at a higher rate than ever seen before in the aerospace industry. These satellites require environmental qualification testing to meet the standards required to launch and operate in space. For a new product, it is unclear how much testing capability will be necessary. This research provides an in-depth look at efforts to estimate the correct capital expenditure for the purposes of environmental testing for satellite manufacturing. It uses uncertainty analysis and parametric studies to compare options for precision manufacturing in an unknown field of production. The study finds that testing machine requirements vary through different periods of production, challenging the producer to purchase more capacity than will ultimately be necessary. These results highlight the need to develop failure rate predictions at the lowest component level to accurately assess testing requirements for the overall system.

DRIVERS	A major driver for the project was the need to conduct critical path analysis and understand that testing was a key capacity limitation in the overall system. This led to the effort to identify current capacity constraints and model projected demand from the production system.
BARRIERS	The largest barriers were assumptions that had to be made for yield rates, rework times, and projected build rate. There was little information for some of the key inputs to the model and assumptions had to be made to produce meaningful results.
ENABLERS	This project was enabled by a strong team at the company and enabled by a willingness to creatively problem solve. The company's open structure allowed for collaboration across different departments to come to a working model for this problem.
ACTIONS	Interview and speak with numerous experts across the company to come up with an approach that helped to solve this problem. I also simplified the problem when possible to get results that could then be iterated when more data became available.
INNOVATION	The use of a model to predict the test machine capacity and collaboration amongst many different teams of component engineers to compile the data and information in one model.
IMPROVEMENT	The final solution provides a range of scenarios that the company must consider in the environmental test machine purchase decision. Each scenario provides a specific number of machines that will be necessary in order to meet demand from scheduled launches.
BEST PRACTICES	Develop a strong relationship with the testing team and manufacturing engineers while networking across as many sub-component teams as possible. Understanding each individual team's perspective can help make the model more practical and useful to the entire production team if input from the lowest level is included.
OTHER APPLICATIONS	This research could apply to any production process where large capital expenditures are required and there is uncertainty around the performance characteristics of the product. Unknown failure rates drive the need to create a model to better predict outcomes and advise decision makers with the most accurate information.