F35 program internship - Quality Engineering

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2 INTRODUCTION

This report will describe the courses and some of the projects I have participated in during an internship as a F35 quality engineer at Lockheed martin's plant 4, Fort Worth, Texas. The internship is organized through the Danish aeronautics company "Terma", which is a supplier to the F35 program at Lockheed Martin. The internship lasted 5 month from the 15th of January 2018 to the 14th of June 2018.

The projects I have participated in has mostly been creating "tools" in excel by VBA programming in order to simplify or optimize different working procedures in the final assembly or EMAS department. Other working tasks has been PPV observations, which has the purpose to optimize the assembly of the aircraft.

During the internship I also had the chance to participate in different courses related to the projects I worked on.

3 LOCKHEED MARTIN

In 1912 Glenn L. Martin started the "Glenn L. Martin Company" in California after he had built his first aircraft in a church. Later the same year the brothers Allan and Malcolm Lockheed started the "Alco Hydro-Aeroplane Company" where they built aircrafts for oversea flights in a garage. Later they changed the name of the company to "Lockheed Aircraft Company". Below at right the Lockheed brothers can be seen in their F1 flying boat. Below to the left Glenn L. Martin can be seen in one of his aircrafts.

In 1995 the two companies merged and became "Lockheed Martin" which today employs close to 100000 people worldwide.

3.1 THE F35 PROGRAM

The F35 is a Fifth generation stealth fighter aircraft which comes in 3 versions in order to replace older U.S. Aircrafts. The 3 versions is described below.

- **F35A (CTOL)** This is the conventional landing and takeoff version which is the most prevalent variant since it is a multirole fighter. The CTOL is the only variant to carry an internal cannon. The CTOL can be seen in the picture below

- **F35B (STOVL)** This version is made for the Marine Corps and is the first supersonic aircraft that is able to take off on a short runway and land vertically. This means that it can land and take off on smaller ships. The STOVL can be seen in the picture below

- **F35C (CV)** This is a carrier variant for the navy. Therefore it has larger wings and a double front wheel so I is able to take the extra weight. As it can be seen on the picture below the CV is able to bend its wings in order to have more storage room on ships

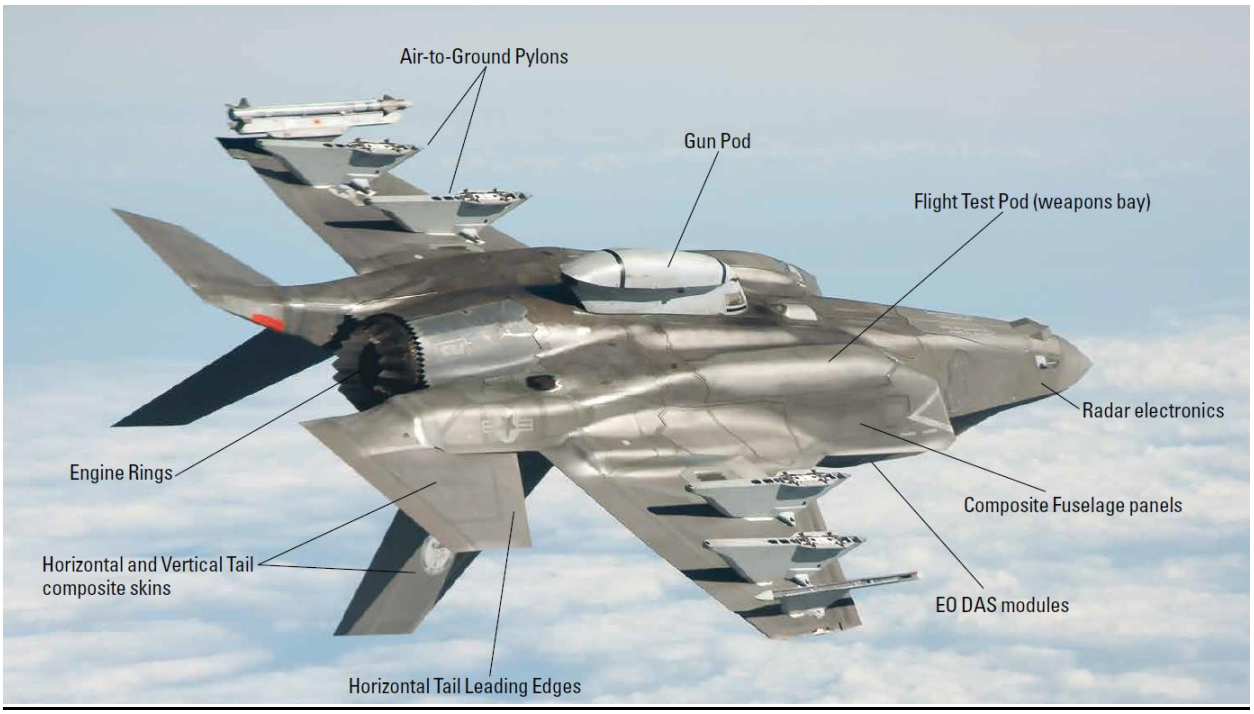
4 TERMA

During the internship we are employed at Terma which is a supplier for different component to the F35 aircraft. Terma is owned by the Thomas B. Thrige Foundation and was established in 1949. The company has it's headquarter at Lystrup, Denmark but has subsidiaries placed around the world.

Terma is involved in the following fields.

- Aeronautics
- space
- surveillance and mission control
- Terma support and services

On the picture below it can be seen which components Terma provide to the F35 program.



5 COURSES

5.1 PDCA - PLAN, DO, CORRECT, ADJUST

In the beginning of the internship we had a coarse called PDCA (Plan, do, correct, adjust). In this course we learned how to solve problems on a structured way by Appling different methods. The course was at "White belt level"

5.2 CATIA V5

During the internship we attended a Catia V5 course which lasted 1 week. This course gave a good introduction to the CAD software.

5.3 CULTURE OF ACCOUNTABILITY

At Lockheed martin, Culture of accountability is held as a meeting every second week. At this meeting a new chapter in a work related book is discussed such that the book is seen from multiple viewpoints. Every meeting 4 new engineers has to present a new chapter. The book we read is called "influencer" and describes how to influence other people in a good way so the company's goal is achieved. During the internship I participated in the presentations of one of the chapters in the book.

6 PROJECTS

During the internship I was allowed to participate in different project. Some of the projects are described below

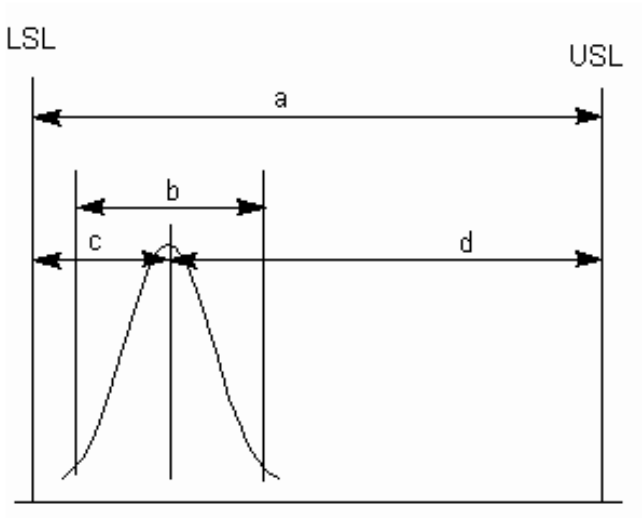
6.1 SEAM VERIFICATION TOOL

In order to keep the aircraft stealth it is Important to keep the right distance between panels. Therefore the seam thickness between the panels are evaluated. If the seams doesn't meet the requirements it's because the specific measurements on either the panel or the parts that the panel is mounted at doesn't meet the specifications. This measurements is marked as Key characteristics (KC) since they directly influence the seam thickness. This KC measurement will have an upper specification limit (USL) and a lower specification limit (LSL). The range between those is called the tolerance. As long as the KC measurement is within tolerance the seam will have the right thickness in the end. However variances coming from the manufacturing process can make the measurement out of tolerance. Therefore the variance has to be minimized.

6.1.1 CP and CPK values

To evaluate the size of the variance and hence the process capability, the process capability index (CP) can be used. Of cause most of the measurements should lay within the tolerance to minimize the amount of failures, see the picture below. Therefore the "width" of the variation is assumed to be 6 times the standard deviation. The CP value is calculated by dividing the tolerance with the "width" of the data set, see the figure and equation below

$$CP = \frac{a}{\mathrm{b}} = \frac{USL - LSL}{6 \cdot \sigma}$$



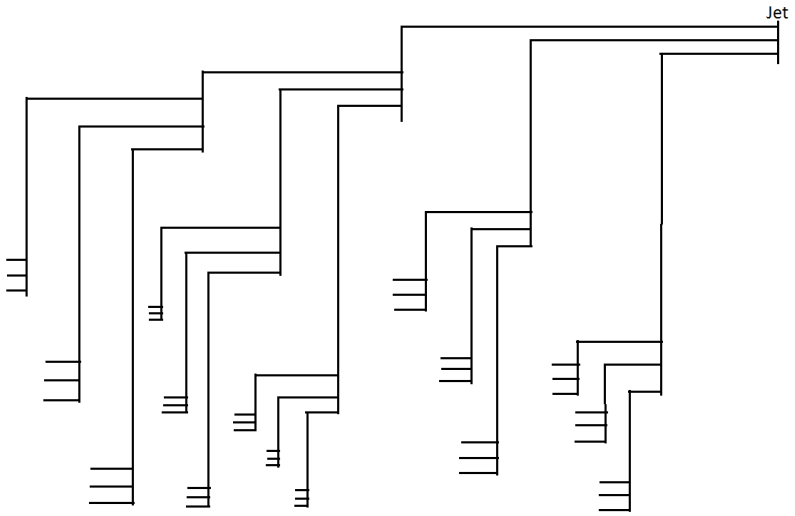
This means that the higher the CP value the better. However the CP value does not describe how well the data set is placed in the center between the upper limit and the lower limit and hence the data set can be out of tolerance even though the CP value is very high. Therefore the CPK value is used in this project to evaluate the process capability, since this value takes both the size of the variance and the placement of the data set in the tolerance in to account. The CPK value is found by dividing a "c" value by 3 times the standard deviation which is assumed to be half of the variation "width". The "c" value is the distance from the mean of the data set to the closest tolerance boundary, se figure above. The equation for the CPK value can be seen below.

$$CPK = \frac{c}{\frac{1}{2}\cdot b} = \text{Min}(\frac{USL-\mu}{3\cdot\sigma}, \frac{\mu-LSL}{3\cdot\sigma})$$

By this equation it can be seen that the higher the CPK value the better.

6.1.2 The tool

It can be hard to find out which KC measurement failed when a seam on the final jet doesn't pass since the jet spits op in serval assemblies and subassemblies. All this assemblies consist of parts that can have KC measurements and can therefore be the reason to a failed seam. A simplified version of this "assembly tree" can be seen in the figure below where the horizontal lines in the ends are parts that are used to build subassemblies which again can be used to build bigger subassemblies until the final aircraft is assembled



Together with the CPK value and a seam number this tree can be used to track the parts with insufficient KC measurements. However the tree and the CPK values is listed in 2 different excel databases and hence these needs to be combined. This is done by programing a VBA script which uses a base number and a part number to combine the databases.

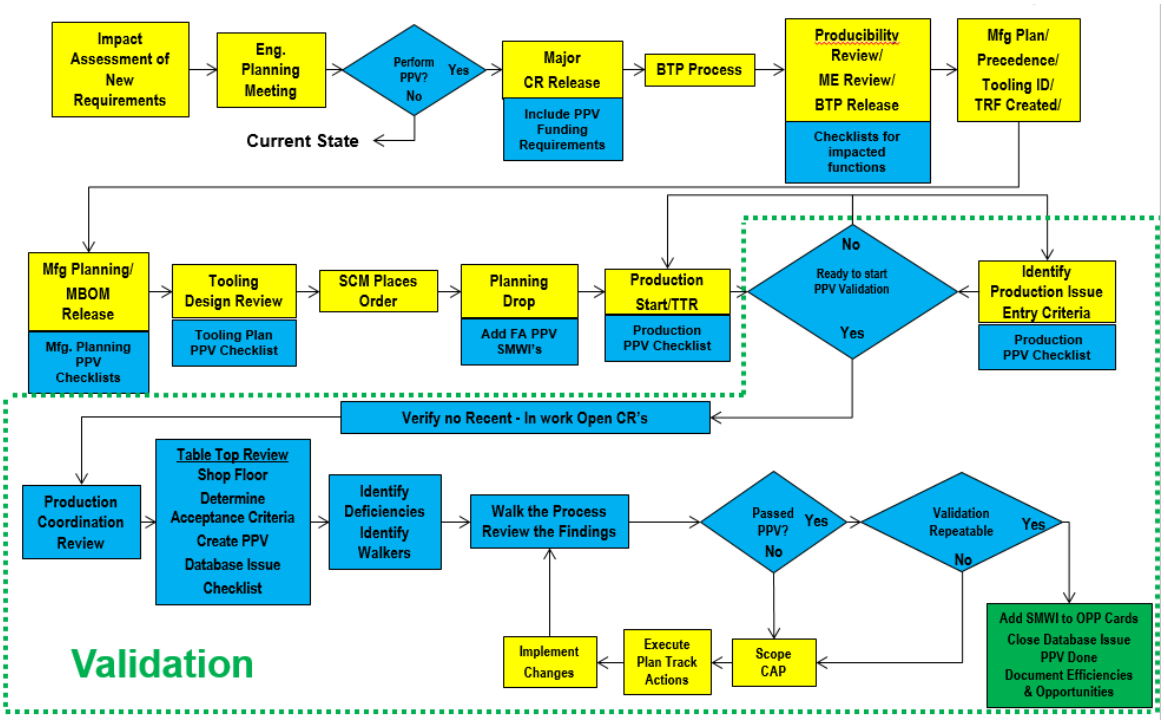
7 PPV OBSERVATIONS

The PPV (Process Product verification) address two possible objectives:

1. Validate new production configuration change implementations when required per the change implementation plan and Engineering Change Process

2. Target operations that have demonstrated repetitive failures, build performance inefficiencies, safety concerns and customer concerns.

In the figure below a flowchart of the complete PPV process is shown



During the internships we were allowed to contribute to the part of the PPV process where the "process observation" was performed. The process observation is a detailed observation and evaluation of a specific assembly proses on the floor. This means that engineers follows a mechanic while he preform the assembly process in order to optimize the process and to document issues that can occur in order to enhance the assembly process.

8 CONCLUSION

The internship has given a lot of knowledge and experience in the following fields

- I have learned to code in VBA and in general I have obtained experience with Excel
- The internship has given a good introduction to the CAD program Catia V5
- I have learned how to evaluate data from manufacturing with statistical tools
- I have learned problem solving methods at "White belt level" by a certified Teacher