LOCKHEED MARTIN

INTERNSHIP REPORT

LOCKHEED MARTIN AERONAUTICS COMPANY

F-35 Quality Engineering Intern

1/16/2017 – 6/15/2017

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1 Preface

In regards to this internship I would like to give a special thankyou to all the people who made this possible and were a part of giving me an experience of a life time.

Firstly I would like to thank the people at Terma and Lockheed who were a part of the intern selection process. This thanks is mostly aimed at Michael Ahrndt Lehmann and Thor Paulli Andersen from Terma together with David P. Leblanc and Scott Sadler from Lockheed Martin. They were a really good help in preparing for the interviews and the preparation for the internship.

Secondly I would like to thank my coworkers at Lockheed Martin for being so welcoming and showing me a good time both at and off work. It is especially my team in QE wing with Kyle Anspach, Lacie Brown, Jennifer Martin, Melissa McGuire and Kyle Kravitz, who I can thank for this.

Thirdly I would like to thank my internship coordinator Eleanor Nave and my supervisors Sam Bartholomew and Sam Rodriguez for helping out during the internship with whatever questions I had.

Finally a big thankyou to my university, Aarhus University, and my student counselor Lars Bräuner for making this internship accessible during my master's degree.

Contents

2 Introduction

This internship stands as an extraordinary part of my master's program in mechanical engineering at Aarhus University. The internship program is valid for 30 ETCS points and runs over the spring semester of 2017 in the period from 16th of January to the 15th of June. As a part of the program an internship report shall be handed in as a documentation for the stay.

This report contains a descriptive overview of the projects that I have been a part of and the training courses I have attended. The report only touches the major projects I have worked with and leaves out smaller things in between such as meetings, small tasks and data analysis.

The last part of the report contains a self-reflecting chapter describing my take on the internship and good advices/heads up for new future interns.

3 Lockheed Martin

Lockheed Martin is a global security and aerospace company with headquarters in Bethesda, Maryland, USA. Lockheed Martin strive to solve complex challenges and advance in scientific discoveries with their innovative solutions and employee base of approximately 97.000 people worldwide[1]. Their company profile touches several areas of today's modern technology such as aerospace, green energy and space exploration.

3.1 History

In 1912 Glen L. Martin established the Glen L. Martin Company in Los Angeles, California, after building his first aircraft. During the same year Allan and Malcolm Lockheed founded the Alco Hydro-Aeroplane Company, later renamed the Lockheed Aircraft Company[2].

Since back then a lot have happened and Lockheed Martin has grown to be one of the biggest aerospace companies in the world and have expanded to other fields as well. Together with their innovative Skunk Works department they stand behind some of the most iconic and advanced aircrafts known, such as the F-117 Night Hawk, SR-71 Black Bird and the newest 5th generation fighter jet F-35.

3.2 Departments

Lockheed Martin operates in 4 different business areas; Aeronautics, Missile and Fire Control, Rotary and Mission Systems, and Space systems[3]. Their largest area with regards to sales is Aeronautics.

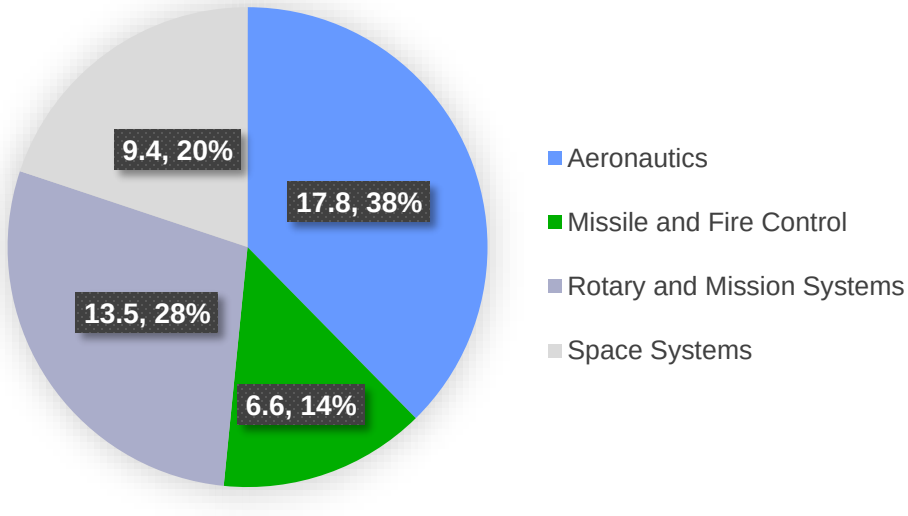

Figure 1 - Lockheed Martin Business Areas. Sales in Billions (2016)

[1] http://www.lockheedmartin.com/us/who-we-are.html
[2] http://www.lockheedmartin.com/us/100years.html
[3] http://www.lockheedmartin.com/us/who-we-are.html

3.3 F-35 Program

The F-35 program is the world's biggest and most expensive aviation project. It is a worldwide project including 9 partner countries working in collaboration to produce the most advanced 5th generation fighter jet ever[4].

The program started in 1997 where Lockheed Martin and Boeing were selected to build the replacement for the F-16, A-10, F/A-18 and AV-8B. Lockheed Martin won the contract over Boeings X-32 with their X-35 in 2001. Both aircrafts met the requirements but the X-35 was seen to have more growth potential[5]. Lockheed Martin teamed up with Northrup Grumman and BAE Systems, and in 2006 the first F-35 rolled out of the assembly in Fort Worth Texas[6]. Since 2006 all effort has been put into getting the aircraft production ready and ramping up the production line to meet the requirements.

3.4 Variants

There are three different variants of the F-35 where each are designed to fit a specific area in the US military. The F-35A CTOL (conventional takeoff and landing) is designed for the US air force. It is designed for landing at traditional air force bases and has an inbuilt mini gun on the upper left side of the aircraft[7]. The F-35B STOLV (short takeoff and vertical landing) is designed for the US marine corps. It can land and takeoff vertically which make it ideal for operating from austere bases and air-capable ships[8]. The F-35C CV (carrier version) is designed for the US navy's carrier ships. It has a 30% bigger wingspan than the other two models and the tip of the wings can turn upwards for better storage options on the carrier.

To make the aircraft stealthier each variant is built with a weapons bay to hide the weapons inside the aircraft. With weapons located on the inside the aircraft's surface is cleaner, hence reducing its radar cross-section and making it harder to detect.

Even though the three variants are built from the same base skeleton there are still differences between each of them, see Figure 2.

[4] https://www.f35.com/global
[5] https://en.wikipedia.org/wiki/Lockheed_Martin_F-35_Lightning_II
[6] https://www.f35.com/about/history
[7] https://www.f35.com/about/variants/f35a
[8] https://www.f35.com/about/variants/f35b

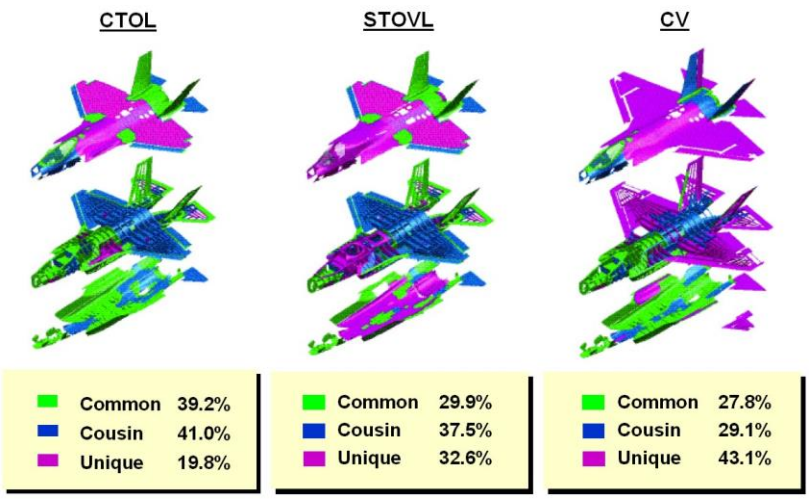

Figure 2 - Uniqueness between the Variants[9]

The key features on each of the aircrafts can be seen on Figure 3.

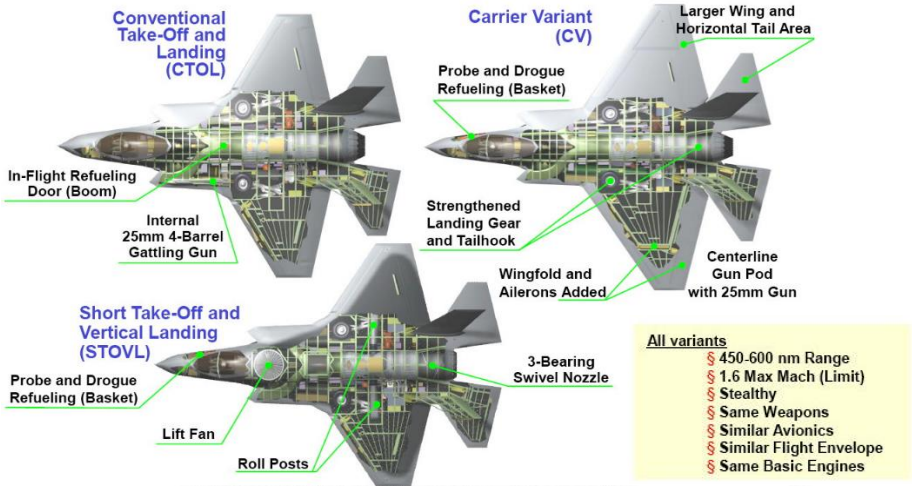

Figure 3 - Key Features on the three Variants[10]

3.5 Denmark and F-35

Denmark is one of the 9 partners on the F-35 program. The F-35 is set to replace the F-16 by 2025 where 27 F-35A should be the new backbone of the Danish air force. Terma is the Danish supplier on the program with more than 70 different parts such as air-to-ground pylons, gun pod and multiple composite skins and panels[11].

[9] http://www.defenseindustrydaily.com/lightning-rod-f-35-fighter-family-capabilities-and-controversies-021922/
[10] http://www.defenseindustrydaily.com/lightning-rod-f-35-fighter-family-capabilities-and-controversies-021922/
[11] https://www.terma.com/aerostructures/the-worlds-largest-industrial-project/

4 Quality Engineering - Wing Structure

The production line is divided into several departments where each department has a quality section. The main responsibility of the quality departments are to solve quality issues found in their respective area. There are 7 different departments/areas, see table below.

Wing	Responsible of the wing box (wings and center piece they are mounted to)
Forward	Responsible for the forward section (cockpit)
EMAS	Electronic Mate and Alignment System.
Final Assembly	Responsible for further assemblies. Ex. horizontal and vertical tail installation.
CFF	Component Final Finish. Responsible for components that needs special treatment before installation.
AFF	Aircraft Final Finish. Ex. paint and testing.
Flight line	Test flights.

Table 1 – Departments

Within wing there are 3 sub-departments, Wing Structure, Wing Mate and Wing Systems.

Quality issues can be a big variety of things for example; tool marks, hole misalignment, defective parts from suppliers, tolerances not being met or damage to parts during preparation/assembly. The quality engineer's job is to deal with these issues and find solutions so the issues can be eliminated in the future.

Working in Wing Structure the quality work is focused on issues found in wing. The issues varies with some consuming more time and energy than others. The issues are divided into categories such as, structure, tubes and harnesses which are split amongst the quality engineers.

4.1 Acronyms

A big part of working at LM is coping with all the acronyms which are highly used throughout the whole company. The most used acronyms in quality is QAR and SQWK.

QAR

Quality Assurance Report. A QAR is a defect or an issue that is hard to repair and comes with a significant cost. The QARs are usually written down in production and send to the quality engineers in the respective area where the QAR was noted.

SQWK

Squawk. A SQWK is a minor QAR that is not as time consuming and severe. It is often quick to repair at a low cost.

All QARs and SQWKs are stored in a database which holds descriptive information for each. The database is often used in many analyzing tools. The severity of each QAR or SQWK is determined from the amount of SRR hours that are put into them. SRR stands for Scrap, Rework and Repair. The longer it takes to repair the higher the cost.

4.2 Red-X

When dealing with some of the larger QARs it's necessary to do a root cause analysis of the issue. A tool used for this is the Red-X approach. Red-X projects can take a long time and is occasionally also used to educate employees to be better at solving issues. They use Red-X projects as a part of their Shainin Strategies[12] training which is another way of addressing problem solving, like Six-Sigma in a way. Here you also increase in rank (Six-Sigma: Green belt, black belt, master belt. Shainin: Apprentice, Journeyman, Master), but to increase your rank you have to do projects whereas in Six-Sigma you can increase in rank by attending courses and seminars.

The Red-X methodology is a guidance in problem solving. Unlike most traditional problem solving strategies where you look at the possible causes which could lead to effect, you look at the effect and analyze out from that.

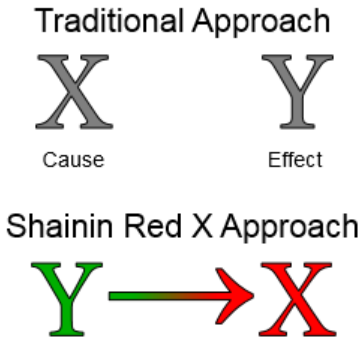

Figure 4 - Red X Methodology

4.3 Work Environment

Work will be done both at your desk as well as on the production floor. Your desk is placed in an office environment with cubicles dividing the room into small sections. Each cubical has 1-4 employees, where ours have 4 (including ourselves). In QE Wing we work two interns, so we sit in the same cubical together with two other QE engineers. Everyone around you is incredibly nice and welcoming which makes it easy to get along and get used to the new surroundings.

Sometimes your work will move from the desk to the production floor. Here you may work in collaboration with your colleagues on different projects. This will in many cases let you get very close to the aircraft and let you observe daily routines at the floor.

[12] https://en.wikipedia.org/wiki/Dorian_Shainin

5 Projects and Responsibilities

During my internship I worked on different projects of varying size. This chapter gives a description of the larger projects and what my role in them have been.

5.1 Heat Map

The Heat Map is an ongoing MATLAB project that mainly has been occupied by interns in the wing quality department. It's a project interns have worked on for multiple years where each new group have added something new and or made changes to the program. The Heat Map serves as a tool for the quality engineering team and is used in different projects across the department. In Figure 5 can the start window of the Heat Map be seen.

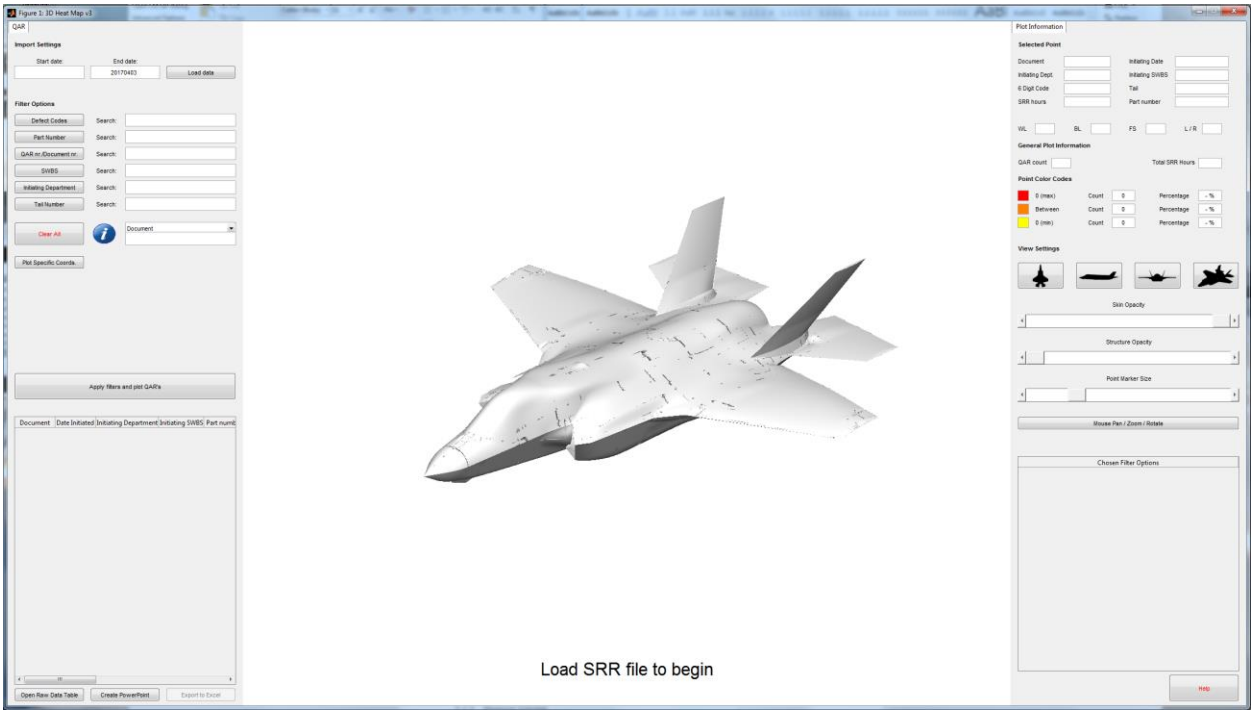

Figure 5 - Heat Map Start Window

The main function of the Heat Map is to graphically show the user where on the aircraft QARs or defects has been found. It's a powerful tool where the user easily can get an overview and look for patterns in the defects. The defect is shown with a point plotted on the aircraft located in a XYZ coordinate system based on the Water Line, Butt Line and Fuselage Station which are the areas the aircraft is divided into. When plotted the user can interact with the points and get more information about the specific QAR by clicking on it (Figure 6).

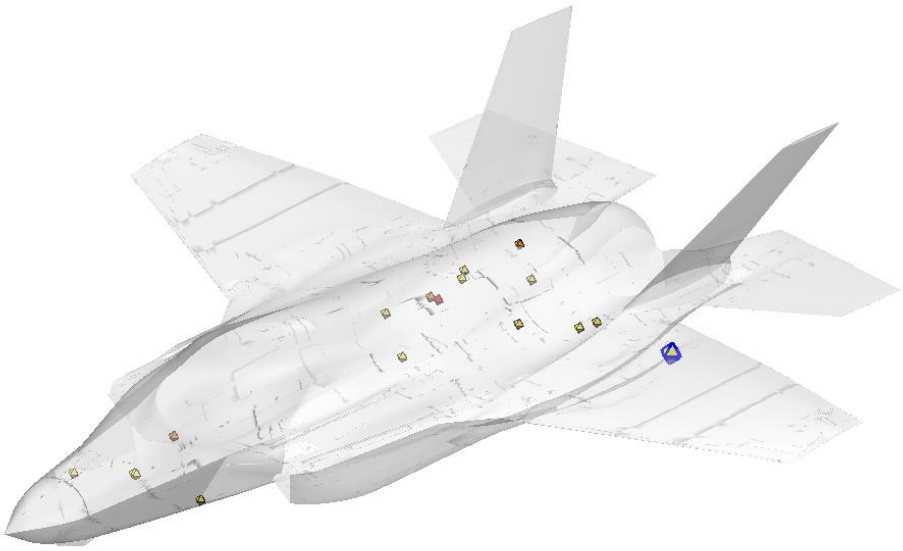

Figure 6 - Defects Plotted on the Aircraft, highlighted point is clicked for more information (Dummy Data)

The 3D model of the aircraft is combined by a skin (the grey surface) and a structure underneath. The structure is sensitive information which is why only the skin is shown in the figure. Both the skin and structure can have their opacity changed so the user easily can see points plotted within the structure.

The QAR information comes from an excel file which is uploaded to the Heat Map. When uploaded the user can work with the data through varies search functions and plotting possibilities. All of this is managed from the menus located on the left on Figure 5. The code running the Heat Map is written in MATLAB.

The 4 next sections describes the functions I have added to the Heat Map when I took over the project. These will also give a more thorough description of how the user manage the data.

5.1.1 Search function

The search functions lets the user search through the QARs uploaded to the program. This helps filtering out specific areas of interest. Say you wanted to see if a part had some specific defect, you would type in the search words in the search fields and the program would filter out anything else. The search functions have before been a part of the Heat Map but were not implemented again after it had gone through some severe changes primarily made to the 3D structure and speed optimization.

There are 3 ways of filtering data which are shown on Figure 7 in the red marked areas.

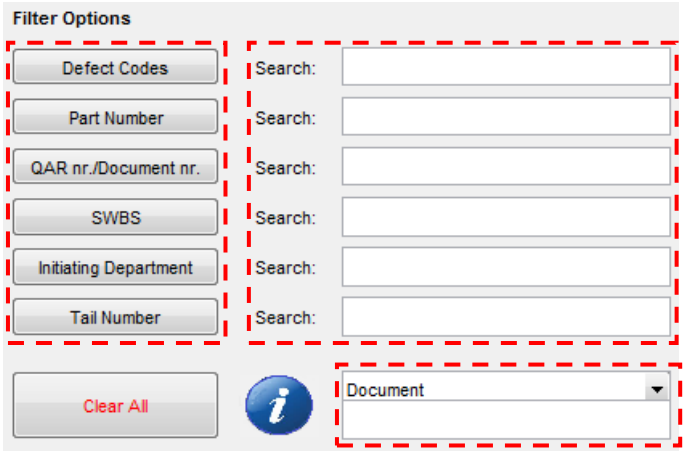

Figure 7 – Filtering and Search Functions

The first area to the left was already in the Heat Map when I got it. Each button will let the user pick pre specified filtering options from menus that appear when clicked. The filtering options found in the menus are taken from the excel file uploaded to the Heat Map.

I have implemented two search functions which are the two remaining boxes in Figure 7. The upper box to the right lets the user search in the category stated on the button next to the search field (the top search field searches in Defect Codes). The search function will take the input and search for a match in the uploaded QAR data. When a match is found it will take the QAR information and write it out in the table which is seen in the lower left corner on Figure 5. This is done automatically for each search. The user can write a single search input or multiple by adding a space between. By using space to separate multiple inputs the user can copy data directly from excel and paste it in the search field. The user can search in all the search fields at the same time. In Figure 8 can a flowchart of the process be seen.

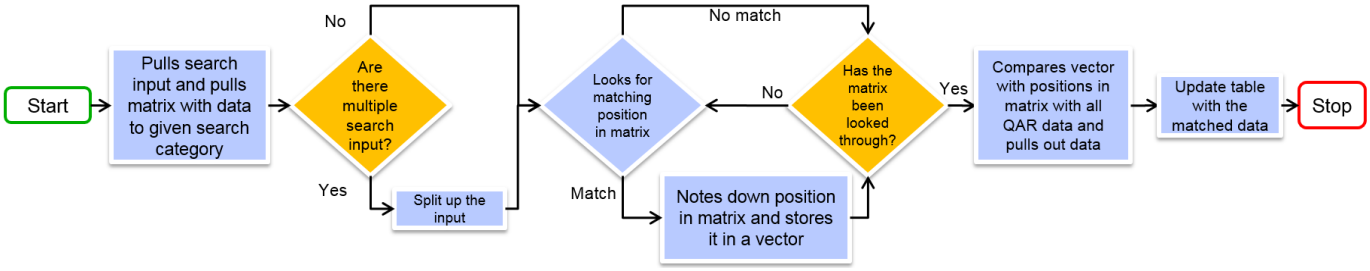

Figure 8 - Flowchart for Search Function

The last search function is based on the same code as the other but with some additional features. In the dropdown menu, where it says Document, the user can choose between all the QAR information uploaded to the Heat Map and search in these. On Figure 9 can the search options be seen.

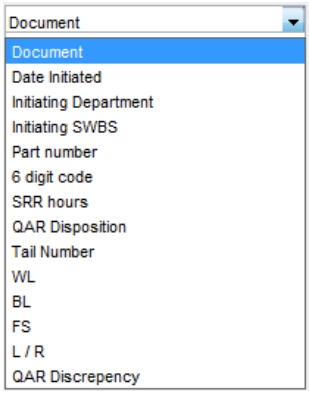

Figure 9 – Dropdown Menu for Specified Category Search

When searching in WL, BL or FS the user can search for single specific coordinates, multiple or in ranges. The multiple searches works the same with a space separator as before and the ranged search is separated with a ':'. Only one category can be searched in at a time.

5.1.2 PowerPoint Generator

To reduce time consumption when presenting data from the Heat Map, I have implemented a function that generates a Power Point presentation for the user. The function will automatically take pictures of the aircraft in fixed and user defined angles and generate a Power Point with data about the plots as well.

By clicking the Create PowerPoint button shown on Figure 10, a menu for setting up the Power Point will open.

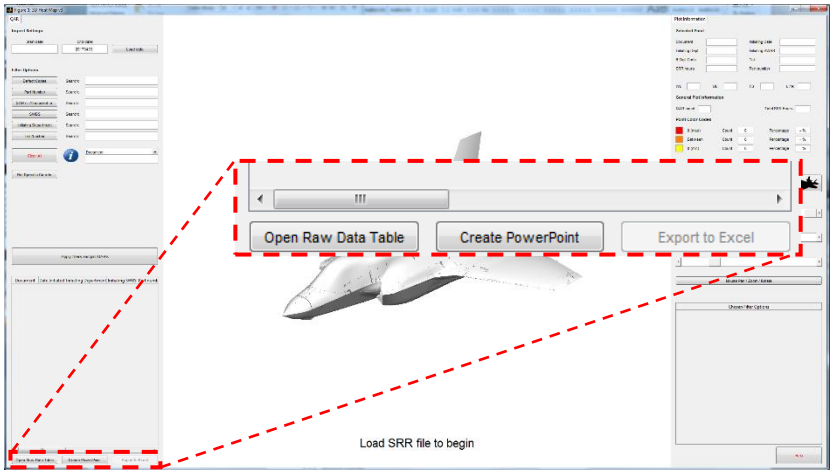

Figure 10 - Activating the Power Point Creation Menu

The menu will appear on top of the table area and can be closed and opened by clicking the button mentioned before. The menu can be seen on Figure 11.

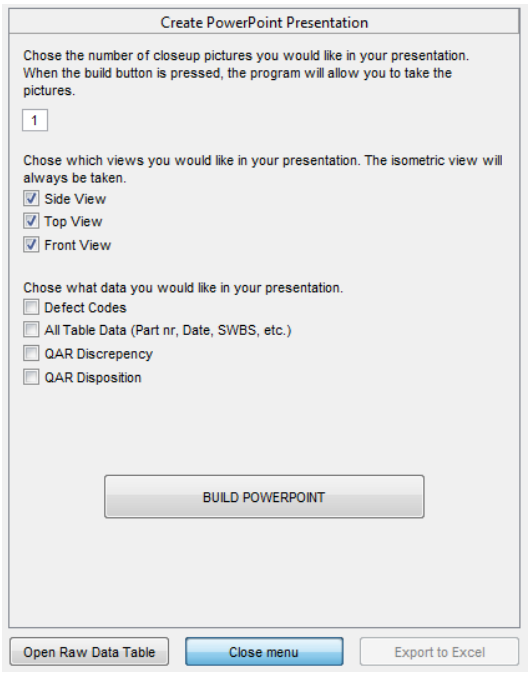

Figure 11 - Power Point Creation Menu

The menu lets the user edit the presentation and add specific types of data. The first option of editing is in the top of the menu. Here the user can specify how many user defined pictures there should be incorporated in the presentation. When the build button is pressed and a value has been entered in the field, a red frame will appear on the 3D model which indicates the picture frame (Figure 12). A button under the frame will also appear which tells the user how many pictures to take and how to proceed, as an example see the zoomed in area on Figure 12. While taking the pictures the user can rotate and zoom in on the model.

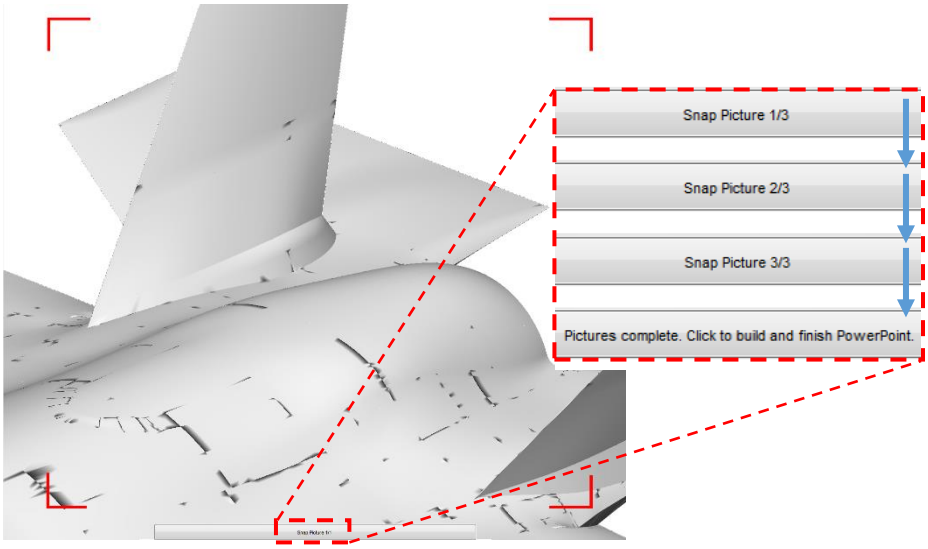

Figure 12 - Picture Frame for User Defined Pictures

If a point is marked when the user-defined pictures are taken, the data from the marked point will be put together with the taken picture in the presentation.

The second option of editing will take a picture of the aircraft in a predefined view (side, front or top). By checking the boxes the user can enable or disable the views. They are by default enabled.

The last option of editing pulls data from the Heat Map and store it in tables in the presentation. By default these are turned off because it's heavy for the program to build them.

Each option of editing will generate a separate slide in the presentation with a title and related data.

5.1.3 Coordinate Plotting

The Heat Map gets all data from the Excel file which is uploaded to the program, but in certain instances the user is only interest in seeing where a particular point is located. By clicking the Plot Specific Coords. Button shown in Figure 13, the user gets access to a menu where this can be done.

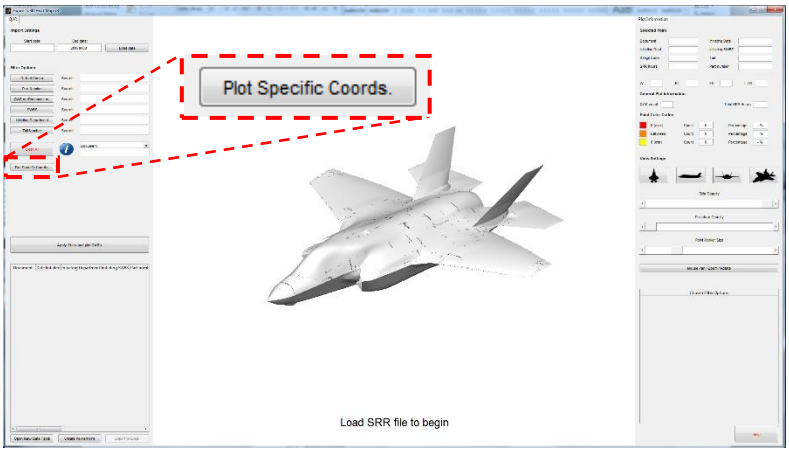

Figure 13 - Accessing Plotting Menu

The menu opens underneath the button (Figure 14) and hides the regular plotting button because a different set of plotting points are used.

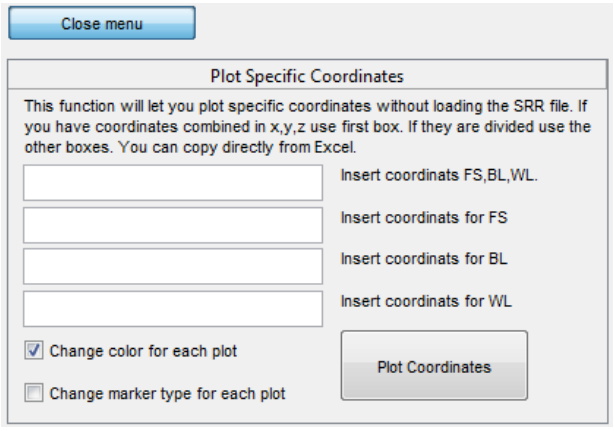

Figure 14 - Menu for Plotting Specific Coordinates

There are two ways of plotting data, either the user puts in a line with FS,BL,WL or the user splits it up into the three separate. This is an option because when receiving coordinate data it's structured as one of the two. The coordinate input can be copied directly from Excel.

This plotting function can plot multiple times whereas the regular one deletes the previous plot, hence the hiding of the button. When plotting multiple times the two boxes can be checked which will change the color for each plot and or marker type. In Figure 15 can an example of this be seen.

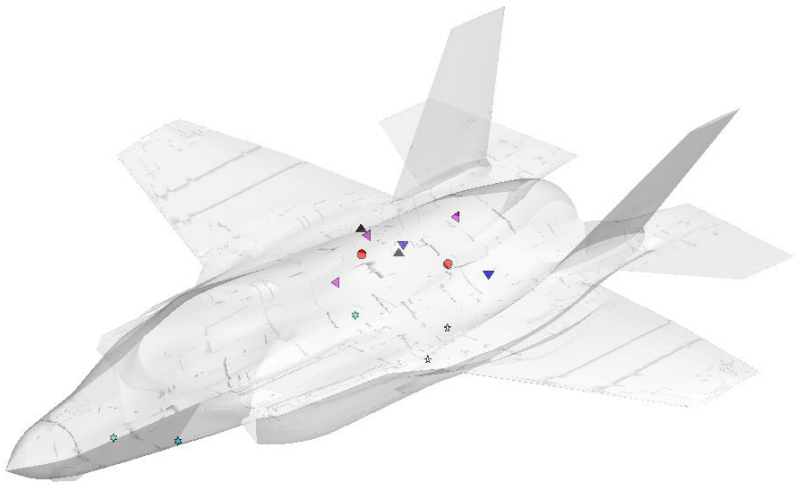

Figure 15 - Multiple Plots using Specific Coordinate Option (Dummy Data)

5.1.4 User Optimization

5.1.4.1 Progress Bar

To make the Heat Map more user friendly I have implemented small help functions which helps with overview and guidance. In the middle of the screen on Figure 16 below the 3D model there is a progress bar. The bar updates the user during the use of the Heat Map. In Table 2 is an overview of its outputs.

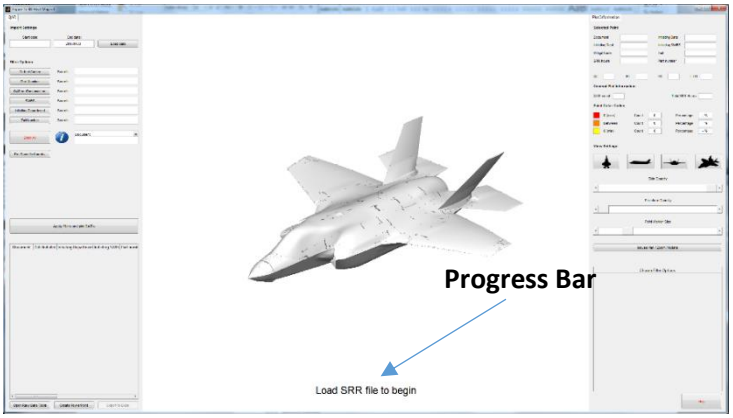

Figure 16 - Progress Bar

Action	Progress Bar Response
Starting the up Heat Map	Load SRR file to begin (the excel file with data)
File has been uploaded	SRR file has been loaded
Using the filters -> finds matches	XX QARs matched your search
Using the filters -> No matches	No QARs matched your search
Finished generating Power Point	Power Point is complete

Table 2 – Progress Bar Response Options

The progress bar is automatically updated each time the user changes something.

5.1.4.2 Chosen Filters

When using multiple filters the user may lose track and or forget which filters are active. To help with an overview I have implemented a table in the lower right corner of the Heat Map, where all chosen filter options will be registered together with the date (Figure 17). The table both takes inputs from the filters chosen from the menus and the searched ones.

Chosen Filter Options
Start Date: 20150404
End Date: 20170404
Defect Search: All defect codes
Part Search: All part numbers
QAR Search: All QAR numbers
SWBS Search: All SWBS's
InitialDep Search: All departments
Tail Search: All tail numbers

Figure 17 - Chosen Filter Table

When the Power Point is generated this table is also build in the presentation.

5.1.4.3 Different Platforms

The figure window for the Heat Map is very sensitive to different screen resolutions. The layout can easily be skewed which will also disturb some of the other functions such as the power point generator. To get around this the Heat Map now detects the users screen resolution before building the layout and will therefore automatically adapt to the specific screen.

5.2 Blowout Holes

The aircraft structure is covert in a composite skin which is the outer surface you would see on the finished aircraft. The skin is mounted with bolts and is therefore drilled to make the holes.

The holes drilled in the skin mounted on the forward fuselage does not always meet the expected tolerances. When drilled, some of the holes experience a small form of countersinking or damage around the top of the hole (blowout), see

Figure 19. The hole must have a sharp edge at the top so the bolt is kept fixed. With an uneven edge the stresses in the hole will increase which is not desirable.

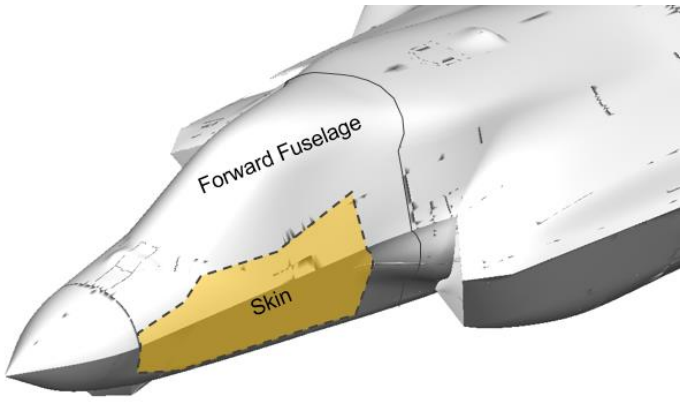

Figure 18 – Illustration of Forward Fuselage Skin (Not actual size and shape)

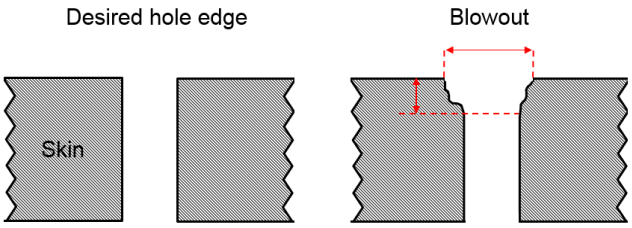

Figure 19 - Illustration Blowout seen in Holes

To get an overview of the problem and see if the blowout happens to specific holes or in a pattern the Heat Map is used.

5.2.1 Blowout Occurrences

The blowouts has been seen in different places on the forward skin on several aircrafts. To get an understanding in where they occur and if it's the same holes that are affected on each aircraft, I plotted all the blowout holes from all known instances in one plot. If a blowout was seen in the same hole for multiple aircrafts, the plotted point would increase in size and turn color from yellow towards red, see Figure 20.

Figure 20 - Illustration of shared blowout holes across different aircrafts (Dummy data)

To plot the points each point needed to be extracted from the technical drawing of the skin and combined with the coordinate noted for the specific blowout hole. Because the skin has a lot of holes the combining was done with a macro written in excel (VBA). Running the macro on the data produced an excel sheet with all the coordinates for the affected holes which could then be plotted in the Heat Map.

This function was used to get an overview of all the blowouts measured on each plane during the past year and will be used in the future to see if any improvements has happened after countermeasures has been taking.

5.2.2 Blowout Volume

The next step in the data processing was to look for patterns in which holes had the most blowout volume (removed material). The volumes were first calculated for each hole from the measured data and were then put together with their respective hole coordinate. By changing a few lines in the function for the occurrences, the code could be modified to work on this as well. Now the points plotted are sized and colored after the amount of blowout. The more volume missing the bigger and redder the point.

With these plots we could look for tendencies and check the effected holes against the drilling processes and structural designs.

5.2.3 Pressure Film

To further investigate the tendencies of blowout holes we placed pressure film underneath the skin before drilling to check if the skin is pressed together with the structure. If there is no contact/pressure between the skin and the structure, the skin might be flossed on the backside when drilled.

The pressure film is strips of tape with an adhesive side and a pressure sensitive side. The pressure sensitive side is covered in a substance containing small ink bubbles, that when pupped, because of pressure, will release the ink and color the pressurized area red. An illustration of the pressure film on the forward skin can be seen on Figure 21.

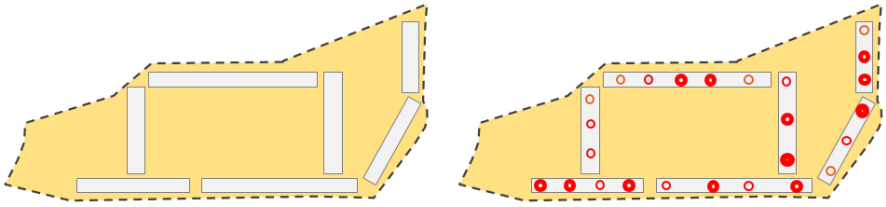

Figure 21 - Pressure Film: Grey rectangles. Left Picture: Pressure Film before Drilling. Right Picture: Pressure Film after Drilling. Red Areas indicates Pressurized Zones. (Figure does not include any actual data)

After the skin had been drilled as illustrated above, the skin was taken off for inspection. The tape worked as it was supposed to and showed the pressurized areas. However, after the drilling the skin had been washed to get rid of any redundant drilling fluid which may have affected the results since some of the areas looked "washed". Because of this it was hard to conclude anything, but is seemed like red appeared around all drilling points, hence there was pressure.

We didn't make it to any conclusion on why the blowout happens within the period of my internship. As of now there are still no consistencies in why and where the blowouts are seen. There are still a few theories that needs to be tested which hopefully will unveil the cause. This project will probably continue with the next interns.

5.3 VBA Programming

When working in QE there is a lot of data processing every day. Nearly all data is processed in or by Excel and spans throughout tons of files scattered on different locations. Accessing and working with data can because of this be very tedious and time consuming. To accelerate many of the daily data processes VBA is used.

VBA stands for Visual Basic for Applications and is in the QE department mainly used in Excel. VBA is a programming language that uses the functions you would normally have available in an Excel sheet. With VBA you can program regular tasks and automate them by writing so called macros (sections of code). Macros are like functions in MATLAB, they do a certain task and can be activated through buttons placed within the Excel sheet. With this you can build up user interfaces in Excel which will make many tasks easy and quicker with just a few clicks.

VBA can be accessed in Excel by pressing ALT+F11 which opens the programming window. When programming you can't always remember how to do all things, luckily there is an inbuilt recording function which helps you along. The recording function records all your moves in the Excel sheet and transfers it into lines of code.

5.3.1 Sorting Algorithm

All the data I received for the Heat Map was in Excel, ex. the data behind the blowout holes was given in over 200 independent Excel files. Working through these manually would take a long time. To accelerate this I made a VBA macro to sort the data for me.

In each of the 200 Excel files I needed to pull out 4 specific columns ranging from a specific row down to the last row with data in the sheet. All the files were gathered in a single folder from where I could run my macro.

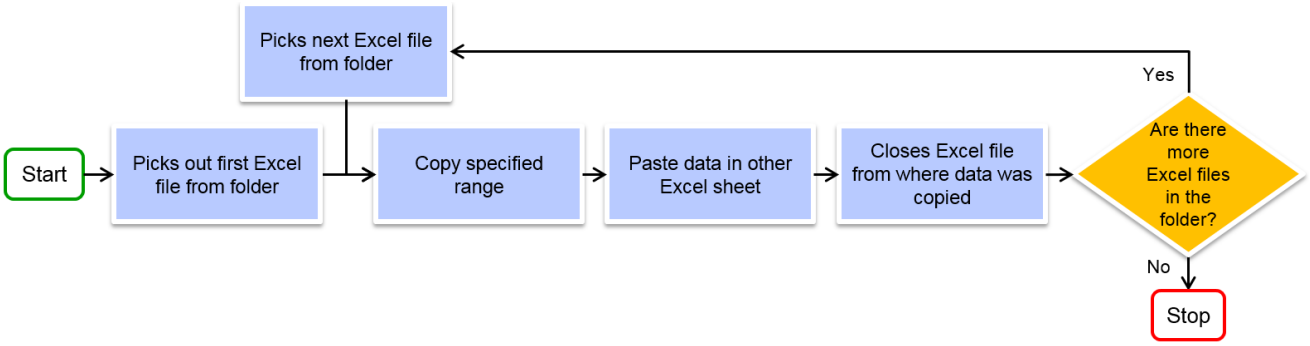

Figure 22 - Flow Chart Sorting Macro VBA

The macro loops through all the files and pulls out the wanted data in each and gathers it in a separate excel file.

The new sheet of data produced by the macro contains a hole number (PT point) and its coordinate. This data had to be combined with the hole measurements (blowouts) before being ready to be put into the Heat Map. All the measurements are contained in an Excel sheet with a corresponding PT point for each measurement. Having an individual PT point for each data range in both of the Excel documents the two could be combined into one using a macro, Figure 23.

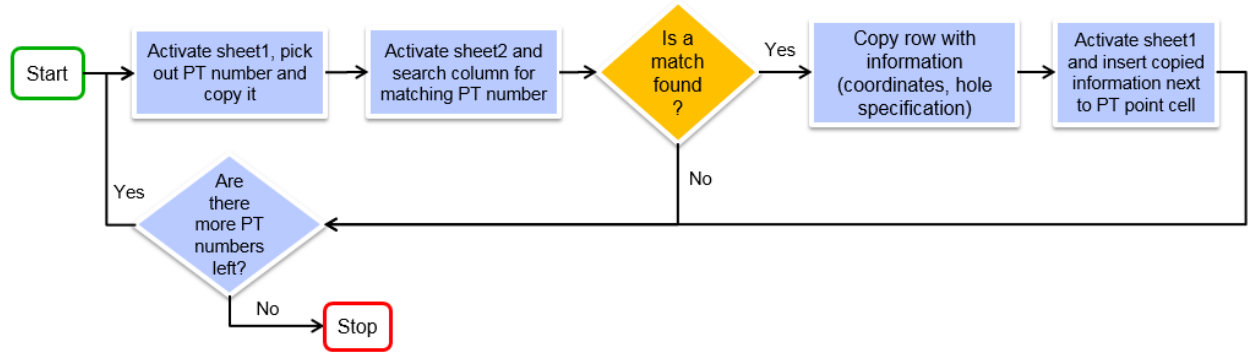

Figure 23 - Flow Chart Combining Macro VBA

5.3.2 CART and CAB Combiner

CART (Corrective Action Request Team) and CAB (Corrective Action Board) are meetings that are held several times each month where metrics (collected data) and progress for the wing department are discussed. Before each meeting a presentation is put together with the necessary data which is pulled from multiple Excel sheets and power point presentations. Combining all these files and setting up the presentation takes between 3-5 hours depending on weather it's CART or CAB (CAB takes the longest). This sums up to a lot of time during a year which is why our department wanted to automate some of the steps and implementing the result in the other departments as well.

Since all data for the presentation is pulled from either Excel or power point a macro can be implemented to ease up the process. A lot of the steps creating the presentation is copy and pasting charts from different locations which is the most time consuming part.

The presentations for both CART and CAB uses the same individual data each time, the only thing changing is the charts and slides being updated. Because the building process of each presentation is always the same I created a macro in Excel to automate this job.

The macro is built with userforms which enables buttons, lists and other intractable items in the Excel sheet, whereas the other macros I built ran through the coding window. Using userforms makes the macro more user friendly and accessible. When opening the Excel macro the user will see what is shown on Figure 24.

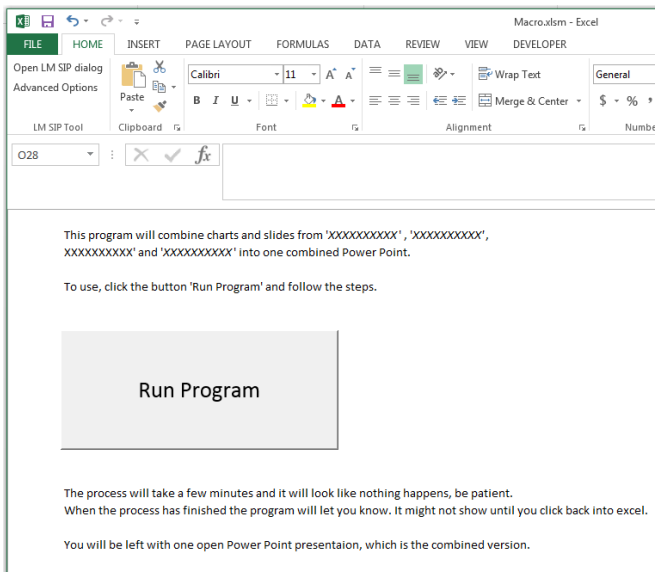

Figure 24 - Program Start Window

The Excel sheet contains a button for running the macro and some information on how to use it. Clicking the button will start the macro which will open the top window shown on Figure 25. From the top window the other two windows can be activated by clicking one of the two buttons. Theses menus are used to setup and gather the right information for the presentation.

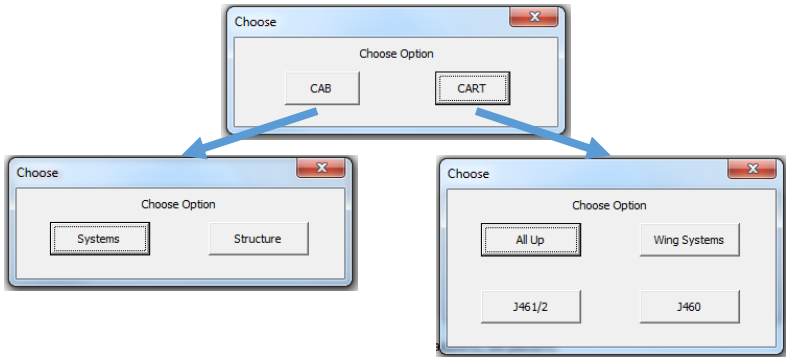

Figure 25 - Presentation Building Options Menus

When the user has clicked through the menus, the user is automatically guided to folders containing files from where the data is pulled. These files are to be chosen and afterwards the macro will start building.

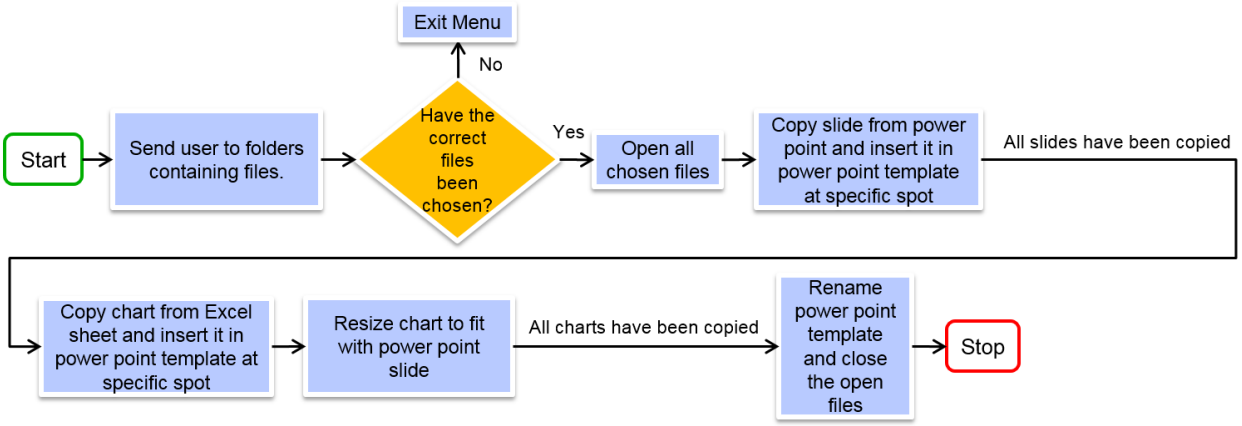

Figure 26 - Flow Chart CART and CAB Macro VBA

The macro will firstly insert the copied slides in the power point template and then insert charts copied from different excel sheet. When all done, the date on the first slide is set to the current and the files from where data has been pulled are closed so the user is left with the finished product.

The code is built linearly so it will run through each command one time, hence no loops or while commands. This is done because it's always the same files that are being used.

Automating this process has saved a lot of time each month.

6 Courses and Training

During the internship we attended 6 different courses throughout the first 3 months. The course length varies from a few hours up to 3 days.

6.1 F-35 Familization Course

The F-35 Familization Course is a 3 day course where you learn all the basic knowledge behind the F-35. It's a systematic walkthrough where you will lightly touch the different areas of the aircraft such as, cockpit, engine, landing gear, weapons bay, electronic systems, stealth and the differences between the 3 variants (CTOL, STOVL, CV). The course is set in place to give you a better understanding of the aircraft and the F-35 program.

6.2 FOD Class

FOD Class is a one day course that teaches you about the hazards and prevention of foreign object debris/foreign object damage. If it's a capital D it's damage and lowercase debris. After the course you take a small test and receive a badge that allows you to walk in FOD critical areas.

It's important to have knowledge about FOD when working with the aircraft. FOD is a big driver in delays and unwanted time spending on the production line. It is critical that the aircraft is FOD free to prevent damage inside plane when it's in use. FOD can in worst cases lead to crash of the aircraft.

6.3 PDCA Problem Solving Training

PDCA training is a one day course.

Plan, Do, Check, Adjust (PDCA). PDCA is a technique used to reinforce employees problem solving and root cause analysis skills. The flow of the method is illustrated in Figure 27.

Figure 27 – PDCA Model

Plan – The hypothesis expressed as goals, metrics and actions.

Do – An experiment, entails deployment of goals and activities.

Check – Observing and assessing results against defined targets.

Adjust – Reflecting on the results confirming the hypothesis or identifying needed adjustments.

The idea is to "*Grasp the Situation*", realizing there is a problem or a process that can be optimized by doing observations or checking standards (knowns ways, same outcome). If a problem is confirmed further investigation can be planed from which corrective action can be taken (DO). Executing the plan

leads to follow ups where the results of the actions are checked (CHECK). If the actions does not meet the requirements adjustments are made (ADJUST).

PDCA is built upon a lean Six Sigma way of thinking where waste is a main subject. Waste is in this context an activity that takes time, resources and space, but does not address the customer's requirements. This means that anything that does not add value for the minimum time taking to do, is characterized as waste. It also works in the other end of the spectrum, where over performing when not needed leads to waste as well.

The waste methodology is divided into eight forms of waste – TIMI WOOD.

Figure 28 - TIMI WOOD

Each of the eight categories contains a certain type of waste. Examples of this could be:

Transportation; multiple moves of material, multiple storage locations. *Inventory*; unnecessary or extra copies, buildup of material between processes. *Motion*; trips for information or tools, excessive reaching or bending. *Injuries*, safety hazards, lost work days. *Waiting*; information/data waiting to be processed, waiting for feedback/approval. *Over-Processing*; numerous handoffs, excessive reviews or approvals. *Over-Production*; building ahead of demand, expanding the work scope. *Defects/corrections*; incorrect assumptions, scrap.

The waste found in each category are in a work environment most likely to affect each other adding up even more waste. As an example; bad motions (moving around stuff) can lead to injury which then can lead to waiting for others since you may be of on sick days. Reducing these wastes is a key essential in PDCA.

PDCA is used as an improvement process where waste is reduced and processes are optimized. To monitor these improvements the *Problem Solving A3* is used, see Figure 29.

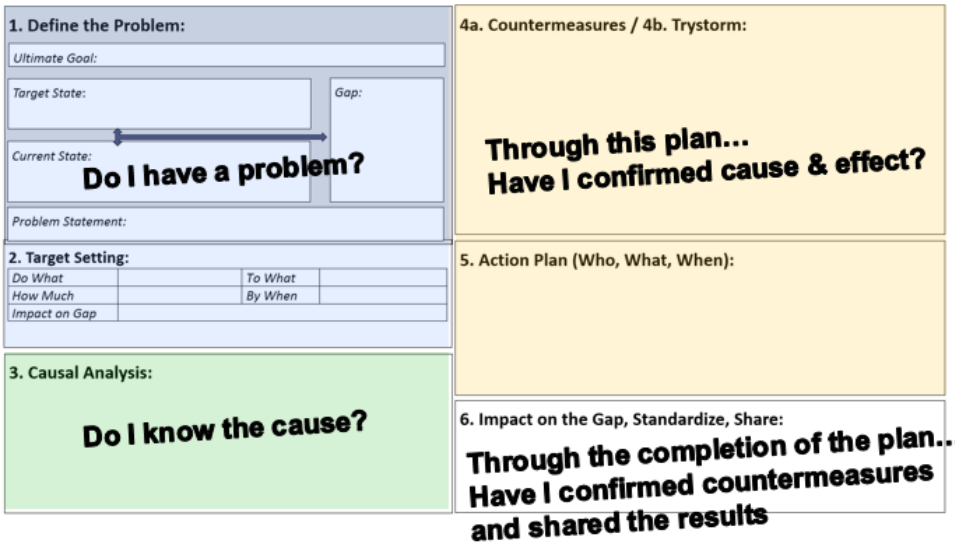

Figure 29 - Problem Solving A3

The *A3* shows a 6 action steps to complete the process:

1. Define the Problem	
Ultimate Goal	Stating the highest goal and why this problem is important to solve.
Target State	Ideal/desired outcome of the process (use values).
Current State	Current state described in values to compare with target.
Gab	Difference between target and current state.
Problem Statement	Restates the Gab in words.
2. Target Setting	
Cut target into smaller pieces so it's more defined.	
3. Casual Analysis	
Identify potential root causes. Analysis using 5 whys or the fishbone technique, or other.	
4. Countermeasures/Trystorm	
Brainstorm and note down possible solutions and look for the most suitable one.	
5. Action Plan	
Identify status for all key actions	
6. Impact on the Gab, Standardize, Share	
Document its effect. If good standardize and share.	

Table 3 - A3 Steps

Going through the steps and filling out the sheet gives a clear, specific description of the problem and corrective actions in one page. It's build upon logical flow based on facts and clear goals that are measureable.

6.3.1 PDCA Project

As a part of the PDCA training we had to complete a project of our own to show we master the technique and understand the concept. The PDCA methodology was used on the Heat Map to reduce time spend on working with QARs. Because it was only a small project I picked out one area to optimize which was the filtering options. On the next 2 pages can the *A3* and flow charts for the project be seen.

1. Define the Problem:

Ultimate Goal:
Faster execution of Quality Assignment Reports

Target State:
Finding QARs for 10 part numbers takes 1 min

Gap:
4 m 26 s

Current State:
Finding QARs for 10 part numbers takes 5 min 26 s

Problem Statement:
It takes 4 min and 26 seconds too long to find QARs for 10 part numbers.

2. Target Setting:

Do What: **Reduce time**	*To What*: **QAR Search Process**
How Much: **To 1 min**	*By When*: **2/27/2017**
Impact On Gap: **Reduces the gap by 4 min 26 s.**	

3. Causal Analysis:

Focused Problem Statement:
It takes 4 min and 26 seconds too long to find QARs for 10 part numbers.

Why — Because you manually look up the parts numbers in a table
Why — Because the part numbers are imported to a table in HeatMap
Why — Because the program is set up to read from that table
Why — Because of programming syntax

4a. Countermeasures / 4b. Trystorm:

4a.

- Filtering of part numbers with respect to selected beginning letters of the part number
- An algorithm that automatically finds the wanted QARs for specified part numbers.
- Direct import of excel document containing part numbers to the HeatMap
- Develop more intuitive table system such as part numbers shown on plane

4b.

- A search function that matches search input with part numbers showed to decrease the process time significantly. The search function takes both single and multiple inputs.

5. Action Plan (Who, What, When):

No further actions are required.

6. Impact on the Gap, Standardize, Share:

- The implemented search function reduced the process time by 4 min 59 s at best case
- The implemented search function reduced the process time by 2 min 29 s at worst case
- At best case the gap was eliminated and at worst case a gap of 1 min 57 s remains
- Training – Instruct users in how to operate the search function
- Share new search function with relevant coworkers.

Figure 30 - PDCA A3 on Heat Map Project

Current State

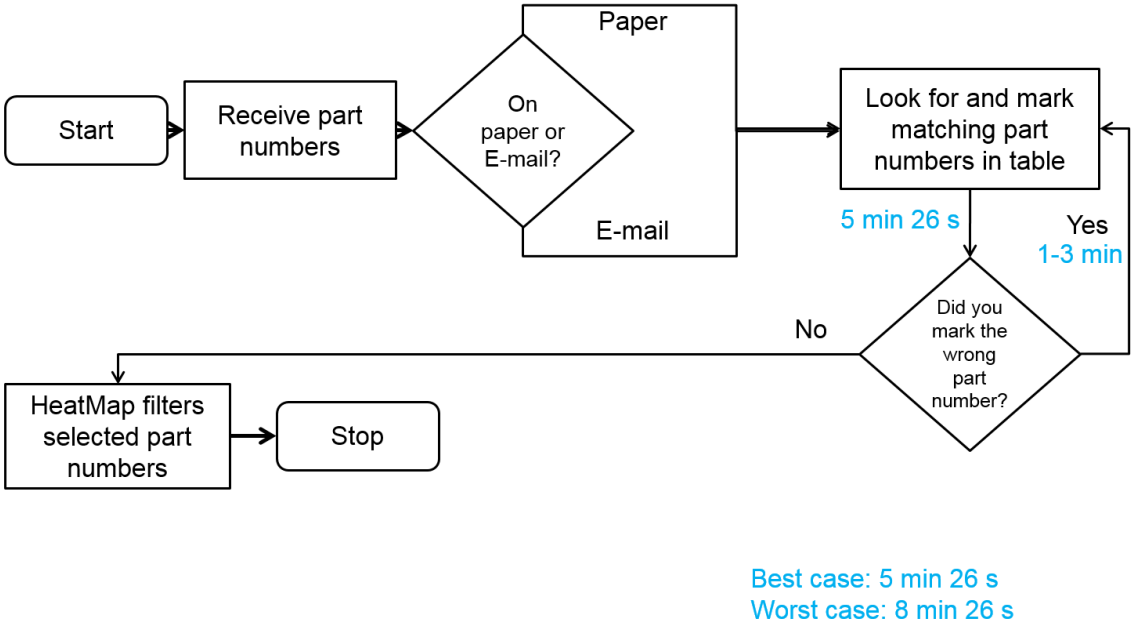

Figure 31 - Current State Flow Chart

Optimized State

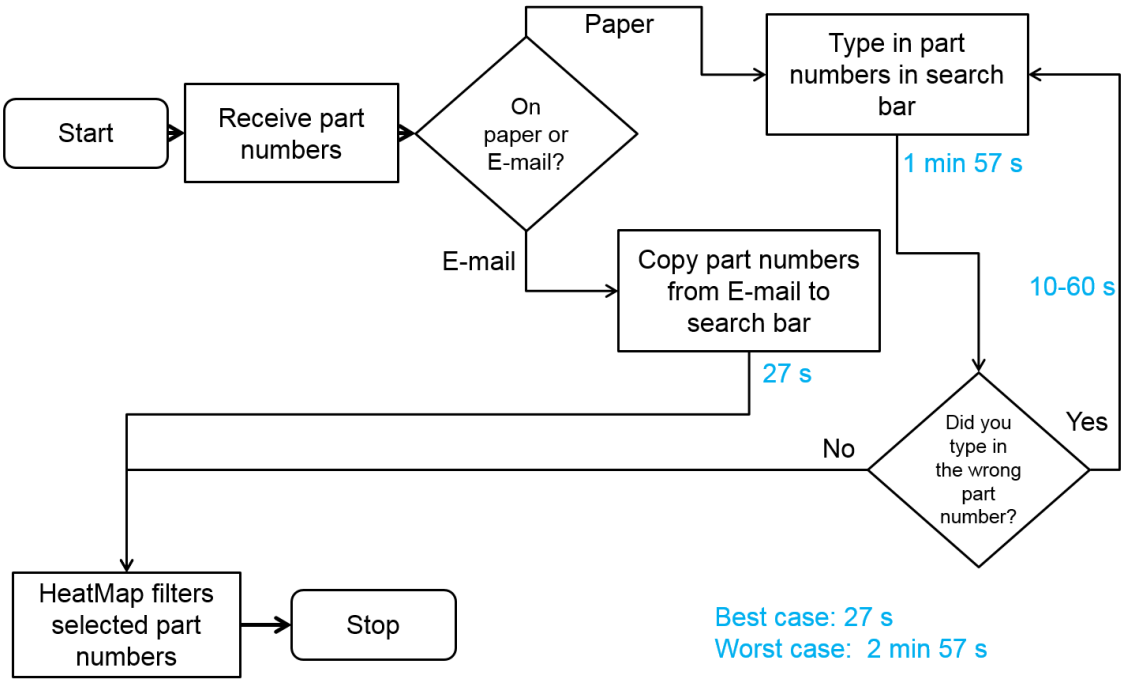

Figure 32 - Optimized State Flow Chart

6.4 CATIA V5 Training

The CATIA Training is a 6 day course divided into two sections of 3 days. CATIA is the CAD program LM uses. It's similar to Solid Works. The first half of the course worked with fundamental use of the program. Here we went through the different functions and basic commands regarding building 3D parts while doing small tasks.

The second half of the course was about technical drawing and assembly. This was done in the same manner with small tasks and guidance in the different commands.

6.5 PDM Navigation and Application Class Training

PDM (product data management) is a 3 day course where you learn about the PDM program. Since none of us had access to it during work we briefly went over its commands. We didn't do any tasks and was only informed about the program.

PDM is the system LM uses as share point/data storage for all relevant data on the F-35 program, such as CAD parts and drawings. The system works globally so all information is accessible for all the partners. This is a new initiative that was put in place when the F-35 program started, to make data sharing easy and quicker.

7 Self-Reflection

This chapter will describe my personal take on the internship both before and after experiencing it.

7.1 Expectations before arriving

Before arriving here I had really high expectations about the internship. I attended all the meetings I could about the internship and tried to get answers to all my questions. I expected the first few weeks to be very tough! I heard that the learning curve was very steep, with new program languages to learn, new people and all their acronyms. I expected to work on some exciting projects both alone and in collaboration with my colleagues. I hoped to get opportunities to get down to the production line and work up close to the aircrafts and the people down there.

When not at work I really looked forward to see a lot of the US. I have never been here before, so I was very excited about seeing as much as possible.

7.2 Thoughts after Internship

7.2.1 Work

When you arrive at Lockheed and meet your new colleagues for the first time, you will be welcomed with open arms, everyone here is super nice. The first two weeks was a bit quiet and I didn't have much to do. Instead of just sitting around I tried joining all the meetings I could and practice my skills in VBA. The learning curve during the first time here is a bit steep. There is a lot of new impressions and programs you need to learn. Furthermore everything is spoken/written in acronyms so you might not comprehend what happens during the first few meetings, luckily you will get used to this.

When sitting in QE, at least for my concern, many of my tasks consisted of programming in both MATLAB and VBA. I did join on a few projects during my time here, but it would be nice if there had been more. It was first nearly half way through the internship that I finally got on board on a bigger project (that was not just programming) where I really could experience what QE work looked like. It was really good and it

gave a lot of insight in the way they trouble shoot and solve problems. If you get any chances for joining up on a big project, do it! It gives you a lot of knowledge and it really makes the whole stay more exciting.

At times it can be very quiet with stuff to do, sometimes even too much. Your colleagues are not always good at handing you work, the same goes for your supervisors. If times comes with little work you really just have to throw yourself out there. Poke your coworkers, ask them for stuff to do, join them in meetings and hang around them when they do stuff. Eventually they will drop something off and as you get closer to them and they get used to you as a colleague, more work will automatically come. With that said, you colleagues are super sweet and open armed, they just need a push with the tasks sometimes.

7.2.2 Spare Time

There are a lot of opportunities for going on trips which is very nice! There is a whole lot to see in Texas and the areas around. Lockheed is also very flexible, if you need a few extra days off for a longer trip or if you have visitors, you can put in some extra hours and take them off at another point. We usually took trips in the long weekends (every other Friday is off) and chilled back at the apartments in the shorter ones. You can drive to many awesome destinations in Texas or fly to some further away. We flew to Denver and Washington, and drove to a lot of the cities in Texas.

Besides traveling the US thin there are a lot of social things to do as well. We often had lunch with our coworkers or did things after work. They are good and fun people with whom you can spend a lot of time. They also know the area quit well and can easily pin point you to fun locations or advise you on stuff to experience.

7.2.3 All in All

My stay here has been an experience of a life time! I feel so lucky to have been a part of this. I have experienced so many awesome things both on and off work that would never have happened back home. When I'm traveling home my backpack will be full of new knowledge and knowhow that I couldn't get anywhere else in the world.

Even though this has been an amazing internship, there is still room for improvement. I think there has been a bit too many periods where I have been low on work, even though I have asked for it. It is a bit of a shame since I'm here to learn and get all out of it as possible. Furthermore I wish that I could have been a part of several big projects instead of just a few. It's when you do the projects that you really learn how things work here. They are a great source of experience and you learn a lot.

8 For Future Interns

8.1 At Work

From my experience there will be times where you will be low on work, if this happens it's important that you speak up and ask your colleagues or supervisors for work. They are not always good at handing over work, so make yourself noticeable. There are also people outside your team you can ask for work if you want to expand a little.

When contacting your colleagues for information or answers to questions, it's much quicker just going to their cubical instead of relying on email. Emailing back and forth can sometimes be quit time consuming and tedious. Go to them and ask, you will also get to know them better this way.

In the first few weeks there is a lot to get used to. I was particularly afraid that my English skills wouldn't be good enough. Don't be afraid of this! You will quickly get used to your surroundings and the language. Everyone is super nice and helpful which really helps out a lot.

8.2 Trips

Try going on as many trips as possible. There is so much to see over here and this is a great opportunity to do so. There are a lot of nice areas in driving distance (up to 9 hours) just in Texas that are worth seeing. One particular event that you have to experience is Mardi Gras in New Orleans. It's a huge carnival which is held every year in February. Go there! A good tip, there are a lot of big parades throughout the carnival days and on some days there are more than one. The parades during the day are usually small (still takes nearly 2-3 hours for them to pass) and the things they show are very uniform. If you go there, get good spots at the parades around evening, they are worth seeing! You might want to go there 2-4 hours before it actually starts, there are ridiculously many people.

8.3 Cars

You will definitely need some sort of transportation, people drive in Texas, and it's more convenient for you. We bought two cars, a Ford Focus ST 2007 manual and a Volvo XC90 2005 automatic. Cars can be a pain to buy. We bought ours from two different car dealerships, where one of them had a very nasty sales man. He was just as you would imagine a slicky car sales man. So be on your toes and be very thorough when buying your car. You can easily end up with a bad deal. If you don't want to buy a car and sell it when you leave, there is also the possibility of leasing. Car leasing is ok cheap here and as an employee of Lockheed you can get a 5% discount at Enterprise, so it might be worth looking in to.

8.4 Other

There is a fellow here at Lockheed called Don Kinard. He is a really great guy and a good person to know. He knows a lot about Lockheed and the plant here in Fort Worth. See if you can get in contact and try getting him to give you a tour. You might already meet him during the first days here if Lockheed invites you out for dinner. He also teaches small one hour courses which are super nice to attend. Hear him out about that as well.

It can be quit cold sitting in your cubical because of air conditioning, so bring a few sweaters.

If you got any questions about the stay please feel free to contact me! You can reach me on my email: anders_wilms@homtail.com or on LinkedIn: linkedin.com/in/anderswilms.

Remember to enjoy your stay and get the most out of it!

Figure 33 - Intern Team and Internship Coordinator (Woman in pink top)

Looking from left to right:

- Anders Jensen
- Christopher Klingaa
- Helene Birkebaek
- Patrick Moritzen
- Eleanor Nave (Internship Coordinator)
- Anders Hjermitslev
- Victor Hvidt

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