Transformation of Collin Aerospace's Fire Suppression Production Lines:

The process of updating, modernizing, and integrating a "Mom and Pop" production company into a multibillion-dollar organization.

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Abstract

After the purchase of Kidde Aerospace by United Technologies Corporation (UTC) in 2005, and the subsequent merger of UTC with Raytheon in 2020, the mid-scale manufacturing plant in Wilson, NC went through numerous personnel and resource changes. Yet, through these changes and the backing of a multi-billion-dollar company, the lack of transparent and organized manufacturing practices coupled with the mindset of a small-scale manufacturing operations remained in this immature plant. During my cooperative experience at Collins Aerospace, I worked with a project Industrial Engineer to organize and develop the pre-work for a Value Stream Transformation that is to occur in mid-to-late 2023. This transformation focuses on implementing greater equipment capacity, systematic manufacturing practices, and the physical layout of cells of the Fire Suppression products offered by Collins. This prework involved analyzing and creating current state models of modular production cells through detailed mapping and inspection, developing advanced models of current flow and progression of a manufactured parts using Visual Basic for Applications, and evaluating present value streams to find deficiencies in production.

Introduction and Background of Problem

History of Kidde Aerospace

Kidde was founded in 1917 by Walter Kidde, who with limited remaining money in savings, purchased the patent to the “Rich” fire detection system. Following this purchase, Kidde begin to acquire more patents of siphon devices for fire extinguishers, industrial smoke detectors, and aerospace fire suppression. After World War Two and into the early 1960s Kidde begin growing rapidly from $40 million in revenue to $400 million by diversifying “into areas of machinery and tool manufacturing, siphon devices for consumer and medical uses, and aircraft accessories” (Encyclopedia.com).

From 1980s through the early 2000s, Kidde was plagued with merging and un-merging with numerous companies, as well as a recall of close to a million products. Kidde was first bought out by August Hanson Industries, who turned around to sell a portion of Kidde’s production to Pilgrim House Group. Pilgrim House was bought out by William Holdings not one year later, who in 1989, “merged with Graviner (another Williams Holdings business) to form Kidde Graviner” (www.kfp.co.uk). A few years later William Holdings bought Dunford Hepburn and Chubb Security, combining all three’s fire detection and suppression production together. Then in March 1999, Kidde released a recall for two faulty Carbon Monoxide Alarms resulting in the later separation of Williams company and demerging from Chubb plc.

Collins and Raytheon Take Over

In 2005 United Technologies Corporation (UTC), a technology conglomerate, bought Kidde PLC and added it to its Fire & Security portfolio. When Rockwell Collins joined UTC in 2017, Kidde was filed under the newly formed Collins Aerospace. Finally, in early 2020, UTC finalized and completed the merger of UTC with Raytheon to create the now standing Raytheon Technologies (RTX).

As seen in this abbreviated and simplified explanation of history of Kidde, the company has gone through at least 5 leadership changes over a 30-year period, with the most recent being only three years ago. Through each of these changes, files must be transferred, engineers and production managers must catch up with the new systems and methodologies the new managing company uses. Yet, through each of these previous transfers, the lackluster practices continued.

Current State and Problem

As of March 2023, site leadership presented that over 80% of current employees working at the Wilson production plant were hired within the last 2 years. With this rate of turnover in the manufacturing plant, systems to ensure ease of change would be in place, yet changes across production are gone undocumented, uncommunicated, and checked. Changes done to the layout are done with a limited to no current state layout drawing of the area. Overdue production is soaring at over $15 million, and waste from one production line alone is growing to over 75%.

Creating A Current-State Layout

When arriving at Collins Aerospace in January of 2023, I was paired with a Project Industrial Engineer whose project was to develop a transformation plan for the Fire Suppression (FireX) production line. FireX encapsulates over 35% of manufactured parts, while holding over half of the plant's overdue parts ($7.9 million from FireX alone). Therefore, site management decided that FireX should be the next main Value-Stream that undergoes transformation. The first assignment with this engineer was to create a current state-model of all FireX in order to better understand what equipment is being used for production.

Layout Pre-Internship

Before arriving at Collins Aerospace in January, the upkeep and development of the current-state layout was left to a single Project Engineer that was simultaneously working on a separate transformation project for a different value-stream. Therefore, the process of updating the layout was slow and the accuracy was rushed. When this engineer started 2022, there was no central layout that was used by the plant. He instead, had to use four different half-developed layouts ant piece together the layout seen in Figure 1. Of the four present Value-Streams manufactured in this plant, the most updated Value-Stream layout was sitting at 45% complete.

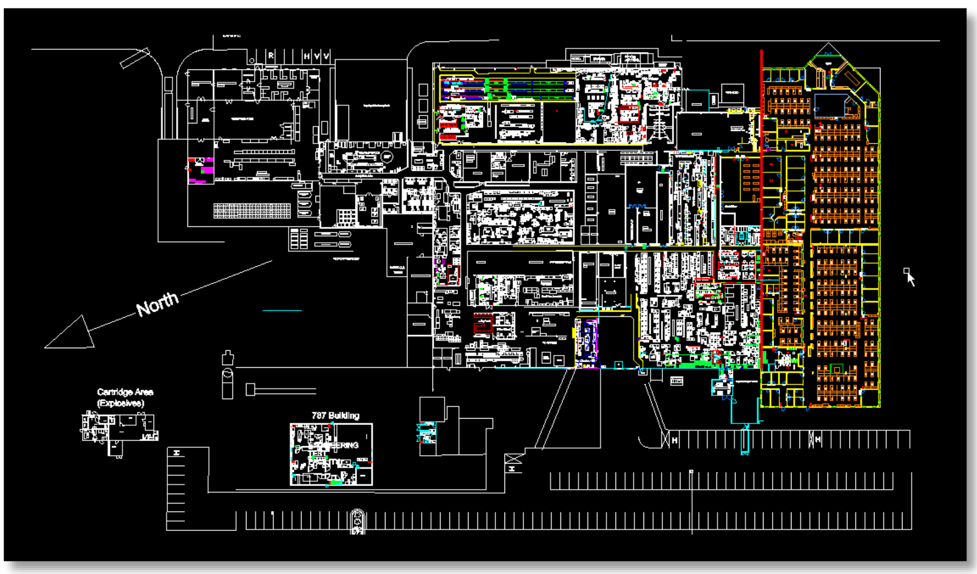

Figure 1: Pre-2023 Current-State Layout

Developing Strategies

When starting, I began working with the Project Engineer who previously held the layout, and we discussed potential strategies on how to approach updating a 150,000 sqft production facility. The first idea was to start at a specific corner as a reference point and shift and draw the equipment using the distance from this point. Another idea discussed was hiring a sub-contractor to create a survey plot and layout using advanced tools to capture the equipment. While working on the analysis of these approaches, predicted timeline of completion, and potential cost, it was decided that I would continue the development of the new layout with the assistance of the project engineer. Additionally, we would use the reference point strategy, however, instead of using a specific corner, we would work off the placement of columns.

Execution

When starting this process, we confirmed the placement and size of the columns on our layout. We found that not only were most of the columns a foot or more laterally offset, but the size of the column in the drawing was incorrect, yet another testament of how inaccurate and inadequate previous layouts were. After placing these columns in the correct locations in reference to corrected walls, I started to develop current state layouts of each module cell in the FireX Value-Stream. One example of this large update came in the Final Assembly area. In the previous drawing of Final Assembly, one line is completely not present, and the other was a completely outdated. This difference and be seen below in Figures 2A and 2B.

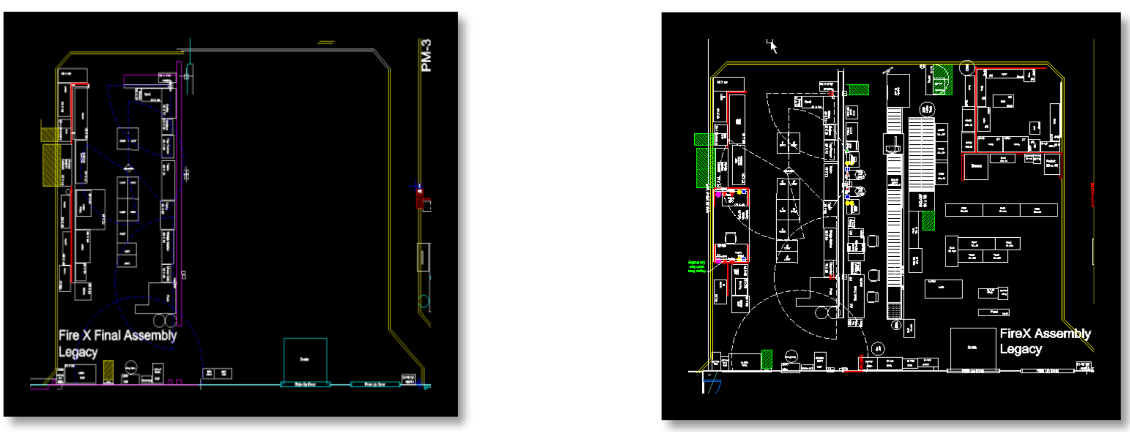

Figure 2A and 2B: FireX Final Assembly Before and After

This task heavily relied on previously learned and honed skills of Auto-Cad from ISEN/ENGR 281. Using this prior knowledge, I was able to measure and electronically draw equipment across the production floor using an unfamiliar drawing software. Through this knowledge and skills learned, I was able to draft and develop a current-state layout for the FireX value-stream within two-months, going from only 2 out of 19 cells drawn, to all 19 as seen in Figure 3.

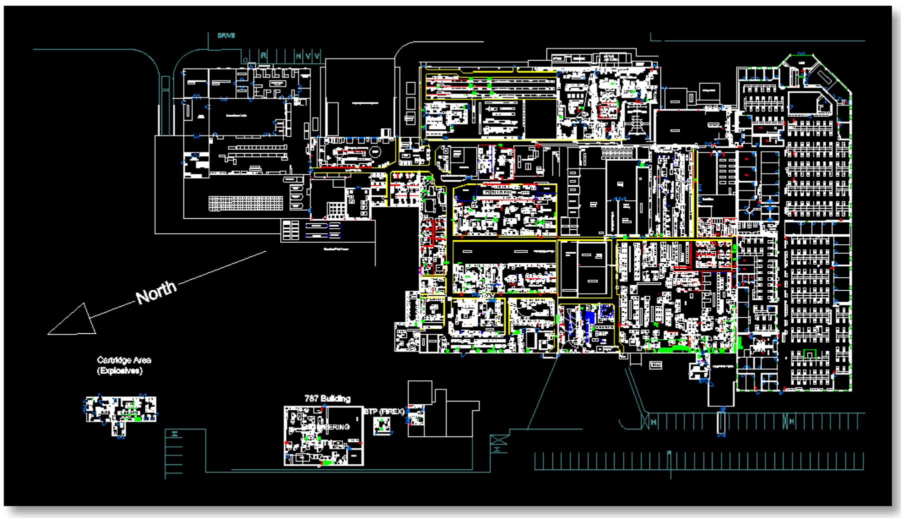

Figure 3: Current State Layout as of April 1st, 2023

The most challenging of which was the Machine Shop/Tooling area where pieces are milled, cut, and developed from raw materials into weld-ready components. This was especially challenging due to the complex nature of machinery and the necessity of exact detail of the drawing. The Machine shop is shown in Figure 4 below. Due to the rigor, challenges, and detail expected by instructors, in ISEN 281 the current-state drawings that I developed are in use now for production changes.

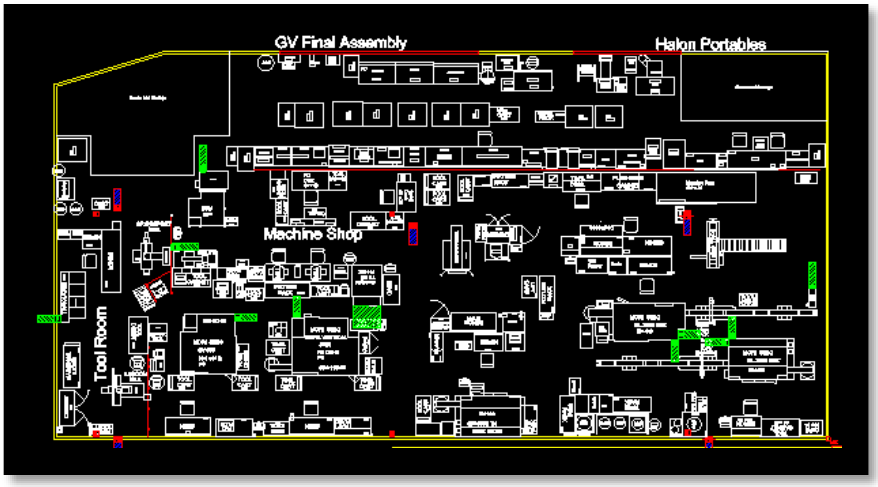

Figure 4: Current State Layout of Machine Shop

Developing Pre-Work

When starting this project, the Project Industrial Engineer that I was paired with identified pre-work that must be completed and understood by the stakeholders of the project before any transformation could occur. She set the goals and tasks to be completed as: understanding the current manufacturing process of FireX parts, developing and identifying part families, creating a current-state layout, and then reviewing the equipment capacity. With all this information, the Industrial Engineers can make a more informed decision about if the problem is a production process, capacity, or yield.

Router Updating and Process

After developing a current state model for the FireX, the Industrial Engineer tasked me to conduct a brief review of the part routers. A router is the documented steps that a specific piece goes through while being manufactured, or more simply, the 'route' of which the part takes through the plant. She had started to develop an excel spreadsheet that demonstrated the flow of parts through different cells throughout the plan, which is seen in Figure 5.

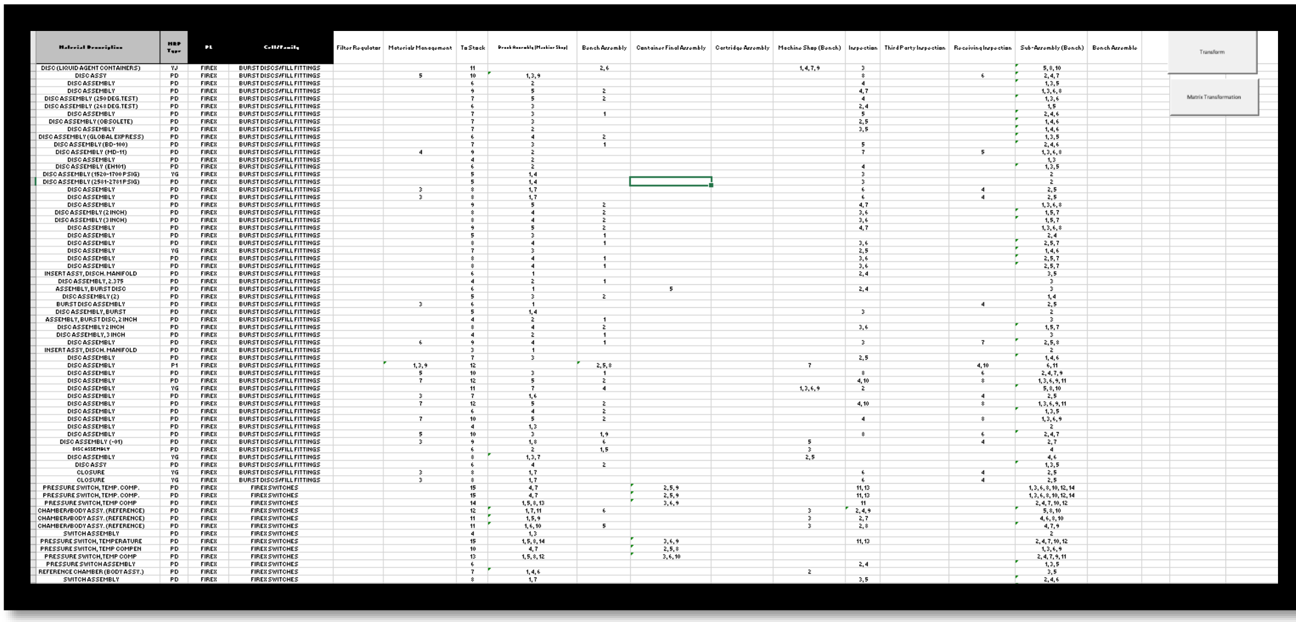

Figure 5: Router Organization Sheet

At the point I completed the layout, she had just over 100 of the 2998 parts completed. Working on this portion of prework I used Visual Basic for Application (VBA) to develop macros that would identify, analyze, organize, and then print the steps of the other 2898 parts.

I started this process by looking over a sample of the part routers to understand how they were typically composed. This means evaluating factors like the number of leading and/or following zeros, location and offset of specific cells I need to reference, and how the macro should deal with numerous steps occurring in the same cell. This process was only available to me because of the lessons and skills learned from ISEN 230. Figure 6 displays a portion of the Visual Basic for Application (VBA) code that I used to assist in organizing the routers information for easier use and reading. Many of the skills, variable naming methods, and loops that were learned in ISEN 230 were used to write and execute this macro.

```
For router_were_on = 1 To Material_count

    amount_of_steps = 0

''''' Pull information from Router and create needed arrays '''''

        'Get count of steps that this material number has'
        Sheet2.Activate
        For row = 1 To Total_materials
            If Range("a1").Offset(row, 0).Value = Nonrept_material_nums(router_were_on) Then
                amount_of_steps = amount_of_steps + 1
            End If
        Next row

        'Redeminsion the arrays to amount of stations listed'
        ReDim Orginal_station_nums(amount_of_steps)
        ReDim New_station_nums(amount_of_steps)

        'Loop through stations to get orginal station numbers'
        For i = 1 To amount_of_steps
            Orginal_station_nums(i) = Range("M1").Offset(i + first_row - 1, 0).Value
        Next i

        'runs thru each station number
        For i = 1 To amount_of_steps
            orginal_num = Orginal_station_nums(i)

            'Transform number into string
            newnum = Str(orginal_num)

            'cut the string to necessary numbers
            newnum = Mid(newnum, 2, 3)

            'select case/if statments for numbers that need seperate disquishing'
            Select Case Orginal_station_nums(i)
                Case 58500098
                    newnum = "58598"
                Case 58500099
                    newnum = "58599"
                Case 58500000 To 58500098
                    newnum = "58500"
            End Select

            If newnum = "575" Then
                newnum = "57510"
            End If

            'assign newnum to a new array'
            New_station_nums(i) = newnum

        Next i


''''' This portion eliminates any consecuative station numbers ''''

        'redimension new array of non-repeating station numbers'
        ReDim Nonrept_station_nums(1)

        'set the first index of non-repeating station array as the first index of new station nums'
        Nonrept_station_nums(1) = New_station_nums(1)

        'set current number as the first index, set counter = 1 to count amount of indexes needed.
        currentnum = New_station_nums(1)
        counter = 1
```

Figure 6: Router Organization Code

After extracting all the data and using the previously mentioned macro to reorganize the data into the previous sheet, I used that data to create a matrix that would show the frequency of locations that each part goes through. Meaning that this matrix (Figure 8) would show which station is the most common starting step, ending step, and steps in-between. I used VBA again to develop a macro that would take the information in the table I created above to turn it into a numerical matrix that is easy to decipher. This was another key point knowing and using VBA skills learned from ISEN 230 to develop a macro that did updated the matrix on the push of a user-button was a useful and helpful resource to pull from.

```
''''' find order of part number '''''

    'for range 1 to maximum step in this part number
    For l = 1 To maxstep
        'loop throguh all stations
        For array_were_on = 1 To Range(Range("T2"), Range("T2").End(xlToRight)).Columns.count
            'if station is not an array or if it is a number
            If IsArray(array_of_arrays(array_were_on)(1)) = False Or IsNumeric(array_of_arrays(array_were_on)(1)) = True Then
                'similar to above
                If array_of_arrays(array_were_on)(1) <> " " Then

                    len_array = UBound(array_of_arrays(array_were_on))

                    For k = LBound(array_of_arrays(array_were_on)) To len_array
                        'if the number in the array matches the step we are on
                        If CInt(array_of_arrays(array_were_on)(k)) = l Then
                        'update the matrix array and physical array
                            matrix(l, array_were_on) = matrix(l, array_were_on) + 1
                            Range("AP4").Offset(l, array_were_on) = matrix(l, array_were_on)
                        End If
                    Next k
                End If
            Else
                len_array = UBound(array_of_arrays(array_were_on)(1))

                For k = LBound(array_of_arrays(array_were_on)(1)) To len_array
                    If CInt(array_of_arrays(array_were_on)(1)(k)) = l Then
                        matrix(l, array_were_on) = matrix(l, array_were_on) + 1
                        Range("AP4").Offset(l, array_were_on) = matrix(l, array_were_on)
                    End If
                Next k
            End If
        Next array_were_on
    Next l
```

Figure 7: Matrix Code

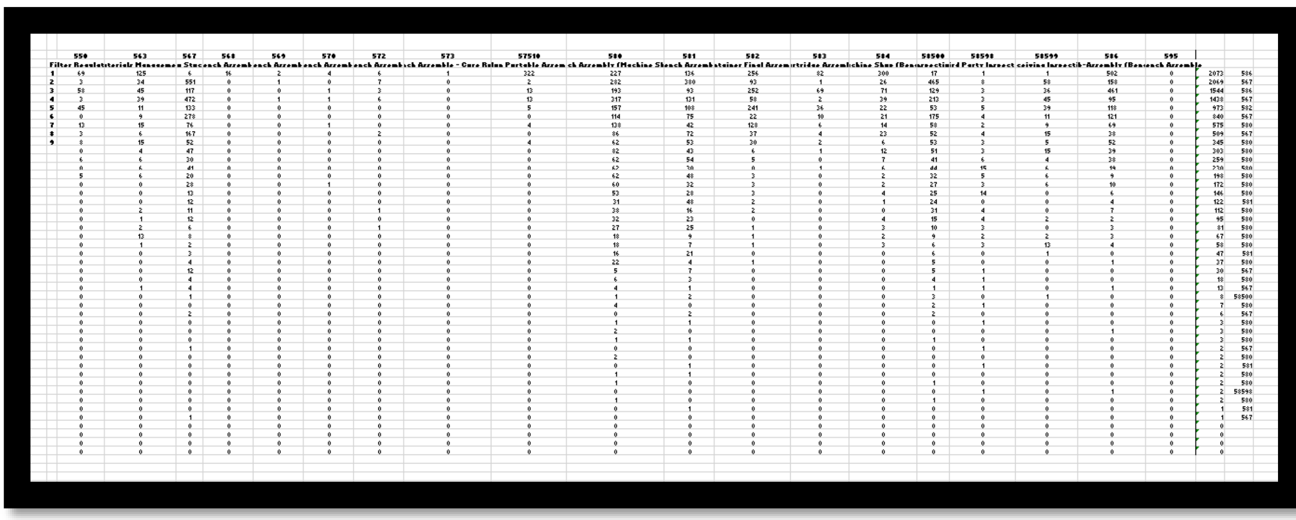

Figure 8: Manufacturing Part Matrix

Using these skills learned in ISEN 230 allowed me to optimize and speed up gathering information and sorting data about our routers, saving time that the I would have had to spend manually sorting and reviewing each of the more than 2875 routers. Since this process took less time, I was able to identify issues with the routers that led us to our next step of prework.

Part Families

In ISEN 210 and 281, students are taught about how to use a matrix to identify part families. A part family is a series of manufactured pieces that follow the same or similar steps throughout the door-to-door manufacturing process. Engineers can use part families to help divide lines of manufacturing and set-up specific layouts that allow each family to use the one-piece flow methodology through its production life cycle.

While sorting through the routers, we discovered that some of the routers were outdated, displaying incorrect steps, or had steps in the wrong order. This not only exposed the need to review all the routers, but the inability to trust the routers causing the Industrial Engineer and I to sit down with subject matter experts that knew the progression of the steps and confirm the data we had organized. After reviewing the cartridge facilities routers and correcting any wrong information, we started to develop a part family matrix that would enable us to identify which cartridges followed similar steps as seen in Figure 9. This information in the future will allow us to organize and optimize lines that use the same equipment and process to build these cartridges into the one-piece flow methodology, saving money, manufacturing time, and increasing yield.

part number	Precleaning SA parts	Mark Stamp	Mark Vibro Etch	Wash Bodies & Pins	Install Bridge insulator	Lathe	gritblast	ring (small)	apply encapsulant	phenolic insulator	install interface seal	install O ring	weld terminal	meg test
	WI.CT.G.501		WI.CT.G.502 PS.CT.G.001	WI.CT.G.501	WI.CT.G.503	WI.CT.G.504 PS.CT.G.002	WI.CT.G.505 PS.CT.G.003	WI.CT.G.509						
	Oven	583-047 (Greenard Press)	583-014 (Styliner Vibroetch)	Oven	460-5110-052 (Scale) & Oven	583-046	583-015			460-5110-052 (Scale)				460-5100-834
491022	x		x	x	x	x	x	x	x	x	x	x		x
446517	x		x	x	x	x	x	x	x	x	x	x		x
535939	x		x	x	x	x	x	x	x	x	x			x
535940	x		x	x	x	x	x	x	x	x	x			x
536309	x		x	x	x	x	x	x	x	x	x			x
536210	x		x	x	x	x	x	x	x	x	x			x
535390	x		x	x	x	x	x	x	x	x	x			x
570037	x		x	x	x	x	x	x	x	x	x			x
878560	x		x	x	x	x	x	x	x	x	x			x
446736	x		x	x	x	x	x		x	x				x
445375	x		x	x	x	x	x	x	x	x		x		x
DOD472381	x		x (has to have gov lot number)	x	x	x	x	x	x	x	x	x		x
446517	x		x	x	x	x	x	x	x	x	x	x		x
446841	x		x	x	x	x	x	x	x	x	x	x		x
A805123	x		x	x	x	x	x		x	x				x
446239	x		x	x	x	x	x	x	x	x	x	x		x
449382	x		x	x	x	x	x	x	x	x	x	x		x
440393	x		x	x	x	x	x	x	x	x		x		x
876223	x		x	x	x	x	x		x	x				x
447231	x		x	x	x	x	x	x	x	x	x	x		x
262433	x		x	x	x	x	x	x	x	x	x	x		x
446543	x		x	x	x	x	x	x	x	x	x	x		x

Figure 9: Part Families Matrix

Next Steps and Conclusion

Future Value-Stream Transformation

On April 11th, project stakeholders and Collins manufacturing leadership met with the lead Industrial Engineer and I to discuss the first area of attack in this transformation project. It was decided that the Cartridge Facility is the best place to start since it holds the third most overdue in FireX, is self-contained for production, and relies on only one other cell to complete production steps. On May 23rd through 25th we are holding a Value-Stream kickoff and conference with the Director and Assistant Directors of Manufacturing, Environmental, Health, and Safety personnel (EH&S), Manufacturing Engineers, Industrial Engineers, and production cell line leaders and supervisors, to work together in developing the transformation plan for the cartridge facility. This will involve reviewing the layout, identifying manufacturing steps that can be condensed, combined, and improved, and developing a plan to reduce scrap and waste.

Conclusion

Collins Aerospace is a leading research, design, and manufacturer in the American aerospace industry responsible for projects such as designing the next generation of spacesuits and reporting to the largest international aerospace manufactures, Boeing and Airbus. After spending three and a half months with Collins, I have had the opportunity to learn practical industry lessons while getting to watch how a multi-billion-dollar organization functions. Additionally, I have had the privilege to work and contribute to a plant-wide project that will affect production methods and capacity in the coming years.

Through this experience I have learned the necessity of clean and transparent documentation of previous work done in order to leave the next person with a clear understand of your progress and thought process. Had this been done with the layout, this would have allowed the project engineer and I to better understand where the previous engineer left off and what locations were up to date instead of us having to review each area in the plant. Another key lesson learned was the importance of not putting the solution before the problem. Throughout the pre-work process there were many times that I had ideas to solve specific issues, yet these solutions may not be tackle the whole problem or consider other factors we have yet to see. Therefore, learning to slow down, keep an open mind, and wait until all the information was gathered was an important lesson to learn and to bring forward into approaching future problems.

Spending time at Collins Aerospace has broadened my view of production facilities, and deepened my understanding of types of projects that Industrial Engineers complete. This internship, while at a production facility that is not the most efficient, has allowed me to learn and gain unparalleled experience that other internships may not provide.

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