Reducing the Wing Body Join (In-Tank Systems) Cycle Time

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Abstract *— Due to increased demand, The Boeing Company decided to reduce the cycle time of the 777/777x Airplane Program from 10-day to 7-day. This project impacts the position of the Wing Body Join (In-Tank Systems). The goal was to have a bar chart with zero conflicts and correct precedence and duration time; these would positively improve bar load and jobs completed on time. The D.M.A.I.C. methodology was used in this project. A workshop was performed as a starting point to build the new bar chart with the personnel related to the process. Time studies were conducted, starts and completes were eliminated, and the job's time duration was adjusted, increasing the bar load by 22% and reducing by 50% jobs with more than two hours. After the time studies, analysts worked on two champion recipes to minimize conflicts between sealers and in-tank mechanics and reduce inspections. These efforts increased the jobs completed on time by 16%, comparing the last airplane used with a 10-day cycle and the third airplane on a 7-day cycle.*

Key Terms *— D.M.A.I.C., Do What's Due (D.W.D.), Bar chart load, Precedence, Bar chart, In-Tank, Budget, Bar time, Time Studies, Champion Recipes.*

INTRODUCTION

This project was developed at The Boeing Company (Everett, WA Site), a leading global aerospace industry. It was performed at the 777/777x Wing Body Join Position, specifically in the In-Tank Systems, where the hydraulics are installed.

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The D.M.A.I.C. (Define, Measure, Analyze, Control) methodology was followed. First, the problem was defined, followed by a workshop. Second, analysts started the measuring phase by performing time studies and identifying jobs that needed to be adjusted. Then, the analyze phase started by discussing the findings, working on champion recipes, and presenting the bar chart to leadership. Finally, in the improvement phase, mechanics used the new bar chart with three pilot airplanes. The analysts were able to observe and keep track of the critical metrics of this project during the pilots and following airplanes.

LITERATURE REVIEW

The Indian Aircraft Overhaul Company performed an analysis of the outsourcing process for performance improvement at XYZ limited. XYZ is one of Asia's largest aerospace companies, under the management of the Indian Ministry of Defense. The complete outsourcing process starts from the projection of requirements of components and ends with payment to vendors on receipt of the components as per purchase order details [1]. The company was experiencing high cycle time of the outsourcing process, material issues, long process time for purchase orders, and shortages of components. The study is conducted with the following objectives:

- To realize a 40 to 45% reduction in Purchase Order (PO) awarding process time and therefore to achieve the target of 65 days PO cycle time.
- To bring a 35 to 40% reduction in average in-house outsourcing process cycle time and therefore to achieve the target of 140 days

average in-house outsourcing process cycle time.

The company followed steps in analyzing the issues under consideration. They analyze the existing outsourcing system and it was determined the average cycle time was 361 days for the outsourcing process. Then, they performed a simulation of the existing purchase order utilizing ARENA to measure performance. They set up the parameters of the model, the model was run for 35 days. They collected data for the outsourcing process on 650 random parts. They validated the model testing the hypothesis, the result was that the model resembles the real system. After that, a waiting time analysis and identification of the bottleneck were performed.

Analysis of the existing system reveals that inadequate infrastructure, inefficient workplace organization, wide variation in batch size, the improper composition of batch size, lack of computerization and online approval mechanism, under-utilization of resources, inadequate training/skills, etc. were the major causes for a high cycle time of in-house outsourcing [1]. The results of the simulation study indicate that the average cycle time of purchase order placement is reduced to 69 days (close to the target), i.e., an improvement of 33.65% over the present 104 days. The corresponding in-house outsourcing process cycle time is reduced to 145 days and the total outsourcing process cycle time became 290 days [1].

Recommendations were made.

- Demand projection should be done based on a priority-wise sequence. Ensure strict monitoring of the suggested performance indices for the PO awarding process.
- Vendors should be encouraged to bid submission through the e-system, reducing the PO cycle time to 69 days.
- Training in functional areas, computer operations, and process planning.

The approach proposed provides the decision-maker with the means for a detailed evaluation of their outsourcing process with a special focus on the PO awarding system and helps understand the key bottlenecks in their processes [1]. Further analysis of the particulars of the bottleneck process/station and help streamline the production process is needed.

DEFINE PHASE

Problem Statement

Due to an increase in demand, the company decided to change the 777/777x Airplane Program cycle time from 10-day to 7-day.

Goal

The goal was to have zero conflicts in the process to perform the schedule with no delays. Also, they wanted to maximize labor utilization based on the budget given.

Objectives

The objectives of this project were:

- Increase Do What's Due Metric
- Increase bar chart load to 85%
- Reduce the number of conflicts in the process

Workshop

The Wing Body Join Team successfully did a workshop. All support departments were involved in this process. Mechanics were able to create the bar chart with the correct precedence. The supporting departments also helped during this process to minimize conflicts. Jobs with more than two hours duration and starts and completes were identified. Having this workshop also helped identify other conflicts between sealers and in-tank mechanics. They work in the same area (tank), and it has limited space.

MEASURE PHASE

In this phase, analysts performed time studies on eight jobs. These jobs had a 10% difference between the bar chart time and the historical data.

Analysts ran the conflict check giving thirteen conflicts at the time. Also, twenty S.A.T.s were

created to split twenty jobs to eliminate starts and completes.

In Table 1, the budget time has been identified as 7,680 minutes. Currently, the bar time is 4,860 minutes with a total of three mechanics, giving a bar load percentage of 63% out of 85%, which is the goal. The In-Tank Systems Bar charts had twenty jobs identified with starts and completes. On the other hand, analysts identified ten jobs with more than two hours of duration. In Figure 1, jobs marked as peach were the jobs identified with more than two hours of duration.

Table 1
In-Tank Systems 10-Day Cycle Time

Total Jobs	7-day budget (min)	Bar time (min)	Bar load (%)	# Starts / Completes	# Jobs >2hrs
20	7680	4860	63%	20	10

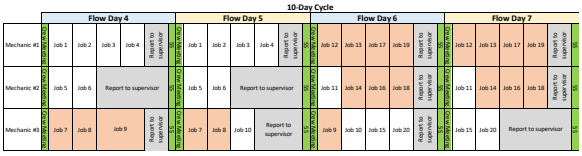

Figure 1
In-Tank Systems 10-Day Cycle Bar Chart

After the workshop, twenty jobs were split, eliminating starts and completes and reducing the number of jobs with more than two hours to five. Also, the bar time for the 7-day cycle is 6,500 minutes, with a bar load of 85%, as shown in Table 2. In Figure 2, the workdays for the In-Tank Systems bar chart remained at four days. However, the number of mechanics increased by one, with four in the In-Tank Systems area.

Table 2
In-Tank Systems 7-Day Cycle Time

Total Jobs	7-day budget (min)	Bar time (min)	Bar load (%)	# Starts / Completes	# Jobs with >2hrs
40	7680	6500	85%	0	5

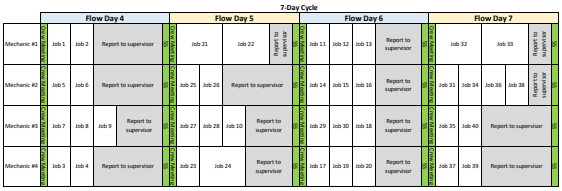

Figure 2
In-Tank Systems 7-Day Cycle Bar Chart

ANALYZE PHASE

Analysts discussed findings with the personnel involved in the workshop. Analysts shared the champion recipes for the eight-time studies, comparing the bar chart time, historical data, and new duration. Analysts and managers could adjust the time for the jobs without impacting the bar chart load and the budget. Industrial Engineering Managers prioritized the Champion Recipes; two worked, and managers will re-evaluate the rest for the 4-day cycle time starts.

Champion Recipes

After performing time studies, areas of improvement were identified. The analysts created champion recipes to capture the problems they observed during the studies. Here are the two champion recipes:

- **Conflicts reduction between Seal and In-Tank Systems bar chart due to limited space in the tank:** Sealers were able to identify the jobs performed inside the tank and the jobs that have direct precedence with the in-tank systems jobs. This helped reduce the conflicts and manage the number of mechanics working per day in the tank without impacting space requirements.
- **QA Process Inspection:** The analysts worked with the Quality Assurance team to identify when the process inspections were required.

Present to Leadership

To use the new bar chart when the 7-Day cycle starts, team leads, managers, and senior managers needed to sign the bar chart. Analysts presented to the leaders the before and after, sharing data to validate what they did during this process.

IMPROVE PHASE

The following information covers details about utilizing the new bar chart.

Pilot

The company selected three specific airplanes as pilots of the project. The first airplane was the one starting the new bar chart. The analysts observed the building of the airplane, identifying any conflicts or areas of improvement. On the first airplane, analysts identified four conflicts in the schedule. These conflicts were about space constraints with mechanics and sealers in the tank. Analysts solved those conflicts and captured them on the next airplane. The same happened with airplanes two and three.

Do What's Due (D.W.D.)

The metric that was measured in this project was the Do What's Due. D.W.D. metrics are the jobs completed on time.

On airplane LN1700, D.W.D. was 63.2%, and on airplane LN1701, 71.7%. This represents an increase of 8.5% between the last airplane using a 10-day cycle and the first airplane using a 7-day cycle, refer to table 3. On the other hand, airplane LN1702 had a D.W.D. of 74.3%, and airplane LN1703 had 79.3%. The DWD between airplane LN1701 and airplane LN1703 increased by 7.6%.

This confirms an improvement in the D.W.D., which was impacted by the changes during this project. Also, analysts considered the learning curve because of new mechanics on the team, which would affect the D.W.D.

Table 3
Do What's Due Progress

Cycle	Airplane/Line Number	D.W.D.
10-Day Cycle	LN1700	63.2%
7-Day Cycle	LN1701	71.7%
	LN1702	74.3%
	LN1703	79.3%

CONTROL PHASE

In this phase, the analyst will only keep track of the D.W.D because of the projected changes in the demand. Analysts are currently attending Tier 2 meetings with manufacturing managers to discuss D.W.D. In the case of the D.W.D. being less than 80%, managers need to explain why that happened and perform a root cause analysis if required.

CONCLUSION

The project was completed following the D.M.A.I.C. methodology. The new bar chart met the objectives by increasing the bar load to 85% and D.W.D. to 79.3% on the LN1703 airplane. Jobs with starts and completes were eliminated, and 50% of the jobs with more than two hours duration were eliminated. The future expectations are to keep track of the DWD considering the learning curve and be able to meet at least 95% D.W.D. Also, this project should work as a precedence baseline for future cycle time changes.

REFERENCES

[1] Jha, K.K., Thakkar, J.J. & Thanki, S.J. “Cycle time reduction in outsourcing process case of an Indian aerospace industry” International Journal of Advanced Manufacturing Technology 106, 4355-4373 (2020). https://doi.org/10.1007/s00170-019-04909-2