Integrated Master Production Scheduling Dashboards Combining Workforce and Capacity Metrics in Assembly Manufacturing Environments

Sai Prasad Ravulapally

Independent Researcher
Shakopee, Minnesota, USA
prasadsai328@gmail.com

Abstract:
Manufacturing companies are having difficulties dealing with demand that changes quickly, which means that they need to quickly match production capacity with the availability of workers. Traditional Master Production Scheduling (MPS) methods often rely on the planner's experience and separate analytical tools, which makes it harder for organizations to respond quickly and make the right decisions. This study discusses the creation and use of a Master Production Scheduling dashboard that brings together customer demand, production capacity, and workforce needs in a labor-intensive assembly manufacturing setting that makes outdoor power equipment. The dashboard combines takt-time standards, workforce modeling, line capability constraints, and operational calendars into one decision-support platform using a design science research methodology and an industrial case study. The results demonstrate that planning for the workforce is more transparent, staffing choices are made more rapidly, cross-functional planning is more consistent, and more visible to leaders. The results show how engineering-driven analytical dashboards can help businesses make small changes to their digital systems without having to spend a lot of money on new systems.

Keywords: Master Production Scheduling, Capacity Planning, Workforce Analytics, Manufacturing Dashboards, Industrial Engineering Analytics, Decision Support Systems, Production Planning, Digital Manufacturing Transformation.

1. INTRODUCTION

Modern manufacturing systems are under more pressure to meet changing customer needs while working with limited resources. Master Production Scheduling (MPS) is an important planning step that turns demand forecasts into manufacturing plans that can be carried out while making sure that resources are available (Vollmann et al., 2005).

Even though enterprise resource planning systems have come a long way, many businesses still have trouble planning because they have data sources that are not connected and planners have to rely on their gut feelings. Assembly jobs that take a lot of labor are especially at danger since the quantity of workers available has a direct effect on how much work can be done.

In these types of scenarios, employment decisions might be delayed, output can be unsteady, or workers can be employed incorrectly if the quantity of workers needed is not guessed correctly.

This research investigates the use of an Integrated Master Production Scheduling dashboard developed in a plant for producing outdoor power equipment. The research investigates the enhancement of organizational planning efficacy through the integration of workforce modeling and capacity analysis.

2. LITERATURE REVIEW

2.1 Master Production Scheduling

Master Production Scheduling is the link between demand management and shop-floor execution (Jacobs & Chase, 2020). Effective MPS systems make guarantee that production is achievable by matching demand with restrictions on materials, labor, and capacity. But conventional MPS deployments focus more on planning materials than on making sure the workforce is available (Stevenson et al., 2005).

2.2 Capacity Planning in Labor-Intensive Manufacturing

Capacity planning examines how well an organization can meet demand with the resources it has (Slack et al., 2019). In assembly manufacturing environments, labor availability frequently emerges as the principal production restriction. Hopp and Spearman (2011) show that changing how workers are assigned to tasks may have a large effect on how fast the system runs and how stable it is.

2.3 Integration of Workforce Planning

Workforce planning links the number of workers who are available to the goals of the organization. According to Becker and Huselid (1998), disconnected workforce planning leads to poor staffing choices and delayed operational responses. Integrated planning systems help departments collaborate better, such as production, HR, and engineering.

2.4 Manufacturing Decision Support Systems

Decision Support Systems turn data from operations into useful information for managers (Power, 2002). Visualization dashboards help people understand things better and make decisions faster (Few, 2013). Spreadsheet-based systems are still widely used because they are flexible, even though they can't handle large amounts of data (Panko, 2008).

2.5 Research Gap

The current literature focuses on optimization algorithms and ERP implementations. There is a lack of empirical research on effective industrial engineering dashboard solutions that incorporate workforce and capacity planning in actual production settings.

3. RESEARCH METHODOLOGY

3.1 Research Approach

This study relies on a Design Science Research (DSR) methodology to examine the enhancement of workforce and capacity decision-making through an analytically integrated planning dashboard in manufacturing Master Production Scheduling settings. Design science research is especially suitable when organizational issues necessitate the development of a functional artifact aimed at addressing genuine operational challenges while concurrently enhancing academic understanding (Hevner et al., 2004).

3.2 Case Study Environment

The research was carried out via an embedded industrial case study in a labor-intensive assembly manufacturing facility that produces outdoor power equipment. The facility has five assembly lines that can make about 7,200 units per month. It works with a lot of different products, with over 100 SKUs. A weekly timetable, monthly demand predictions, and daily operational monitoring all help with production planning.

3.3 Challenges with Planning Before Implementation

Before implementation, planning activities depended a lot on the planner's knowledge and had to be done by hand to coordinate conversations across departments. Instead of adopting an integrated analytical framework, the personnel needs, production feasibility, and capacity limits were evaluated at one at a time. This disorganized approach resulted in delayed personnel choices, inaccurate planning assumptions, and diminished organizational visibility.

The research focuses on evaluating the extent to which the development of an integrated analytical artifact can reliably improve planning transparency, coordination, and decision-making effectiveness.

4. DASHBOARD ARCHITECTURE AND SYSTEM DESIGN

4.1 Data Architecture

The developed dashboard combines variables from operations, workforce, and production planning into a single analytical structure that can turn customer demand into assessments of manufacturing capabilities that can be put into action. Planning is mostly based on how many customers there are each month. It is integrated with standard industrial engineering data, such normal workforce needs, constraints on manufacturing line capacity, and takt time.

4.2 Modeling the Needs of the Workforce

Required labor hours were calculated as:

$$Required\ Hours = \frac{Demand}{Units\ Per\ Hour} \times Standard\ Headcount$$

The suggested approach includes manpower modeling right in the logic for capacity evaluation, which is different from standard planning tools that include labor availability as a second thought. To find out how many hours of work are needed, take the demand and use time-study data to transform it into a standard quantity of production labor. After that, the needs for all eligible production lines are added together to find out how the overall workload is spread out.

4.3 Capacity Modeling

Available capacity calculated from:

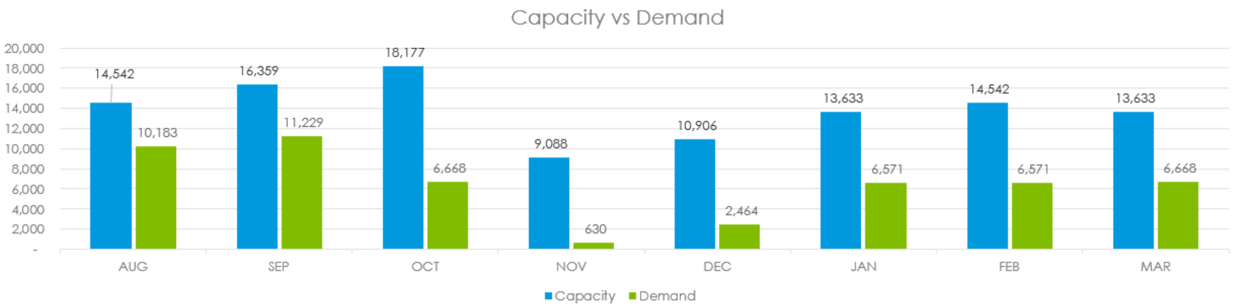
$$Available\ = Working\ Days \times Hours \times Efficiency$$

To find out how much production capacity is available, you can utilize working calendars that show anticipated downtime, preventative maintenance plans, efficiency assumptions, and variables that affect absenteeism. It is easy to see straight away if there is too much or too little production capacity by comparing the needed workload to the available capacity.

Figure 1. Capacity vs Demand Dashboard

Lines	AUG		SEP		OCT		NOV		DEC		JAN		FEB		MAR	
	Capacity	Demand	Capacity	Demand	Capacity	Demand	Capacity	Demand	Capacity	Demand	Capacity	Demand	Capacity	Demand	Capacity	Demand
1	15,860	14,560	16,500	12,000	16,920	12,305	3,560	3,200	13,506	3,520	20,356	15,230	20,356	15,230	16,920	12,305
2	14,542	10,183	16,359	11,229	18,177	6,668	9,088	630	10,906	2,464	13,633	6,571	14,542	6,571	13,633	6,668
3	16,506	15,300	16,320	14,560	12,540	14,260	5,620	5,633	12,036	2,364	1,235	6,780	1,235	6,780	12,540	14,260
4	21,463	14,287	24,146	10,709	26,829	10,416	13,414	1,152	16,097	2,746	20,121	12,519	21,463	12,519	20,121	10,416
5	23,690	25,300	24,560	23,602	23,420	23,000	6,320	230	12,365	14,523	25,300	1,248	25,300	1,248	23,420	23,000
	16		18		20		10		12		15		16		15	

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Capacity	14,542	16,359	18,177	9,088	10,906	13,633	14,542	13,633
Demand	10,183	11,229	6,668	630	2,464	6,571	6,571	6,668



4.4 Framework for Visualization

It's extremely important to use visualization tools to make excellent choices. Management dashboards use common graphical indications to demonstrate how feasible demand is, where there are gaps in the workforce, and how ready the business is to operate. This makes it possible for executives from diverse departments to rapidly comprehend the consequences of difficult planning. During planning meetings, scenario simulation functionality also helps decision-makers look at different ways to run things, such adjusting work schedules or establishing targets for how efficient things should be.

5. IMPLEMENTATION STRATEGY

It took four months to build the dashboard using an iterative, engineering-driven process. The first step in development was to build a prototype using only a small amount of operational data to test the logic of the calculations and the assumptions made in the models. Pilot deployment allowed for the verification of analytical accuracy by comparing it to the results of manual planning and actual production.

After validation, structured training sessions were held for production planners, operations managers, human resources staff, and engineers. Stakeholders immediately adopted the system because they realized how it could bring together planning activities that had been isolated into one decision-making platform. The industrial engineering department was in charge of making sure that the system's integrity was maintained, which included making sure that standard production data kept in accordance with changing manufacturing circumstances. The company was able to use the new technology by making dashboard outputs the major source of information for planning choices during weekly Master Production Scheduling meetings.

6. RESULTS

6.1 Planning Decision Improvements

The integrated dashboard changed the way planning decisions were made in the facility in a big way. Hiring needs for the workforce, which were once based on experience-based judgment, became outcomes that could be measured and supported by standardized analytical logic. Leadership could now assess the feasibility of production as soon as they got demand forecasts, which greatly reduced uncertainty during planning meetings.

6.2 Organizational Alignment

Having all the information about the workforce and capacity in one place made it easier to respond to changes in demand and make staffing changes ahead of time. Planning meetings changed from exercises for combining data to discussions for making strategic decisions about how to improve operations.

6.3 Scenario-Based Planning Capability

The dashboard also made it easy to keep an eye on production by making sure that all departments utilized the same way of looking at the data. This got rid of a lot of the planning assumptions that used to be at odds between the engineering, operations, and human resources departments.

7. DISCUSSION

The results show that structured analytical integration, rather than large-scale enterprise technology deployment, can lead to real operational change. The study supports the idea that digital transformation in manufacturing often happens through small steps in analytics adoption that are led by industrial engineering projects.

By putting workforce modeling right into production planning, the dashboard makes sure that operational execution skills are in alignment with strategic demand goals. This integration decreases the organization's reliance on the expertise of individual planners and encourages decision-making processes that are the same across the board.

The results of this study strengthen decision-support system theory, indicating that visualization-based analytics enhance managerial cognitive abilities and expedite the evaluation of complex decisions. The developed artifact shows how easy-to-use tools like spreadsheet-based platforms can bring a lot of value to an organization when they are based on stringent engineering methods.

8. Managerial Implications

From a management point of view, the study shows how important it is to include workforce analytics in production planning. Companies that use labor-intensive assembly systems often don't realize how important manpower allocation is for reaching their production goals.

The dashboard that was put in place shows that cross-functional transparency makes it possible for operational planning, hiring strategy, and production execution to all work together. Leaders may progress from making personnel decisions based on what they see to creating plans based on what they know.
Figure 2. The table shows how many workers are needed each month and when operators are available in important manufacturing departments. It compares the current operator strength with projected operational needs, highlighting workforce gaps that indicate potential shortages affecting production capacity and resource planning.

Department	Current	AUG		SEP		OCT		NOV		DEC		JAN		FEB		MAR	
		Need	GAP	Need	GAP	Need	GAP	Need	GAP	Need	GAP	Need	GAP	Need	GAP	Need	GAP
Assemblers	2560	3260	700	2560	0	2500	60	2562	2	2300	260	1500	1,060	2530	30	2360	200
Quality	15	16	1	15	0	15	0	15	0	16	1	10	5	14	1	16	1
Materials	25	29	4	25	0	25	0	25	0	25	0	20	5	25	0	25	0
Operations Support	8	9	1	8	0	8	0	8	0	9	1	3	5	8	0	8	0
Engineering Support	26	30	4	26	0	26	0	26	0	23	3	19	7	26	0	25	1
TOTAL	**2634**	**3,344**	**710**	**2,634**	**0**	**2,574**	**60**	**2,636**	**2**	**2,373**	**261**	**1,552**	**1,082**	**2,603**	**31**	**2,434**	**200**

9. LIMITATIONS

While the implementation offers clear benefits, several limitations should also be acknowledged. The dashboard relies on regularly updated production data rather than real-time data streams, which limits its

ability to respond to operational changes occurring throughout the day. Additionally, the spreadsheet-based structure may become challenging to manage as data volume and organizational complexity increase.
The accuracy of the analysis also depends heavily on the quality of standardized time-study data and demand forecasts. To maintain reliability, engineering standards must be continuously updated as production methods and product designs evolve. Furthermore, the current solution lacks advanced predictive and optimization capabilities commonly available in dedicated business analytics platforms.

10. FUTURE RESEARCH DIRECTIONS

Future research may enhance this study by incorporating enterprise resource planning or manufacturing execution systems that facilitate automated data acquisition. Future improvements could include the use of predictive analytics and machine learning models to better estimate workforce requirements under uncertain demand conditions. Expanding this approach across multiple facilities would also help evaluate its scalability and broader applicability. Additionally, integrating factors such as quality performance, equipment utilization, and financial metrics could support the development of more comprehensive and connected operational decision-making systems.

11. CONCLUSION

This research demonstrates that Master Production Scheduling can be significantly more effective in assembly manufacturing environments with a high number of employees when analytical displays are integrated. Through the systematic integration of customer demand, workforce availability, and production capacity within a single decision-support framework, the developed system transitions planning from estimating based on experience to coordinating based on data.

This research highlights an important yet often overlooked aspect of factory planning—the critical role of workforce capability in determining achievable production capacity. Traditional scheduling approaches frequently consider labor availability as a secondary factor; however, the findings from this case study show that directly incorporating workforce analytics into planning processes significantly enhances decision-making accuracy and operational flexibility. The implementation also represents a meaningful step toward digital transformation. Instead of relying on large-scale technology investments, the organization achieved measurable improvements in planning performance through the effective use of industrial engineering principles and structured data integration, supporting both operational efficiency and organizational growth. These results support the idea that digital transformation is primarily a process of improving organizational capabilities, rather than a technological project.

This research contributes to both academic knowledge and industrial practice by showing that widely accessible analytical tools, when supported by sound engineering principles, can serve as effective decision-support systems. Integrated planning dashboards provide organizations with a practical and user-friendly approach to improving strategic decision-making, strengthening collaboration across teams, and increasing operational adaptability in response to fluctuating demand and workforce constraints commonly faced in modern manufacturing environments.

REFERENCES:

1. Becker, B., & Huselid, M. (1998). High performance work systems. *Academy of Management Journal*, file:///C:/Users/prasa/Downloads/1998ResearchinPHRMPaperReducedSize.pdf.
2. Few, S. (2013). *Information dashboard design*. Analytics Press, file:///C:/Users/prasa/Downloads/Information_dashboard_design_The_effecti.pdf.
3. Hevner, A. R., et al. (2004). Design science in information systems research. *MIS Quarterly*, https://wise.vub.ac.be/sites/default/files/thesis_info/design_science.pdf.
4. Hopp, W. J., & Spearman, M. L. (2011). *Factory physics*. Waveland.

5. Jacobs, F. R., & Chase, R. B. (2020). *Operations management*. McGraw-Hill.
6. Panko, R. (2008). Spreadsheet errors. *Journal of End User Computing*, file:///C:/Users/prasa/Downloads/0802.3457.pdf
7. Power, D. J. (2002). *Decision support systems*. Greenwood.
8. Slack, N., Brandon-Jones, A., & Johnston, R. (2019). *Operations management*. Pearson.
9. Stevenson, M., et al. (2005). Planning and control. *IJOPM*.
10. Vollmann, T. E., et al. (2005). *Manufacturing planning and control systems*. McGraw-Hill.
11. Yin, R. K. (2018). *Case study research*. Sage.