



Proposed Improvement Of Work-Center Capacity In Aerospace Industry: A Case Study Of AMC's Aircraft Ramp-Up

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ABSTRACT

An aerospace manufacturing company faced significant capacity overload challenges while ramping up narrow-body aircraft aerostructure production from 6 to 10 units per month. This study utilized a Capacity Requirements Planning (CRP) framework and mixed methods, combining qualitative analysis through Current Reality Tree (CRT) and Focus Group Discussions (FGDs), with quantitative analysis of capacity utilization. The findings reveal critical bottlenecks in work centers such as "Work Center A" and "Work Center B," which initially operated above optimal load (165% and 119%, respectively). After implementing solutions such as workload redistribution, predictive spare part planning, and integrated scheduling, simulations showed utilization dropping to 73% and 65%, respectively. This paper recommends adopting predictive planning systems and cross-functional collaboration for sustainable production efficiency.

INTRODUCTION

The aerospace industry in Indonesia, represented by an aerospace manufacturing company (AMC), is undergoing a significant transformation driven by increasing global demand. AMC has been appointed as a key supplier of narrow-body aircraft aerostructure components, prompting a ramp-up in production from 6 to 10 units per month. This change presents both an opportunity and a challenge. While the ramp-up offers the potential to increase monthly revenue significantly, it also creates bottlenecks within production facilities, particularly in critical work centers such as "Work Center A" and "Work Center B."

The company's initial operational setup was optimized for a stable production rate of 6 units, and the sudden increase to 10 units introduces capacity imbalance, excessive workload, scheduling conflicts, and the risk of reduced product quality. Recognizing the risk of operational

delays, customer dissatisfaction, and reputational damage, this study explores how AMC can optimize its production planning and execution through a structured capacity analysis. This research aims to analyze the root causes of capacity overload, evaluate the current load distribution, and propose practical, scalable solutions that support sustainable ramp-up while maintaining high efficiency and quality standards.

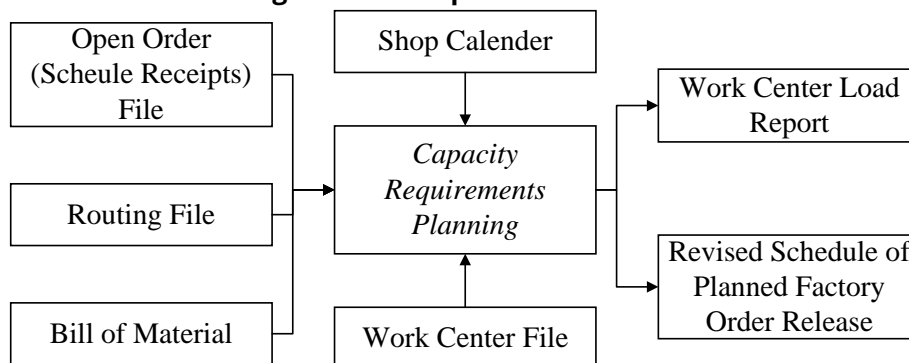
LITERATURE REVIEW

This study draws on several established theories to analyze and resolve capacity issues in production environments, particularly during ramp-up phases. The Current Reality Tree (CRT), part of the Theory of Constraints (TOC), is a diagnostic tool that maps undesirable effects (UDEs) back to their root causes. This method is effective in clarifying interdependencies within a system and focusing managerial attention on leverage points. In this study, CRT helps identify systemic issues affecting work center performance at AMC. Colledani et al. (2018) emphasize the importance of early detection of quality and performance problems during ramp-up by designing robust systems and employing continuous monitoring. These measures help manage risks typically associated with increased production volume.

Terwiesch and Bohn (2001) contribute a learning-curve perspective, showing that knowledge accumulation through experimentation and feedback loops can improve operational performance during transition phases. Their findings justify the incorporation of structured learning initiatives and quality control at early ramp-up stages. Lean manufacturing principles, as discussed by Aditia & Sardjono (2020), stress that before considering capital investment, manufacturers should optimize internal efficiencies through better scheduling, setup reduction, and workload balancing. These insights are aligned with the needs of AMC. Lee et al. (2014) propose Intelligent Resource Allocation frameworks, in which real-time decision-making systems dynamically allocate resources. These systems use tools such as RFID and fuzzy logic to adapt operations to changing demands ideal for environments experiencing rapid scale-up.

Agile Ramp-Up methods introduced by Heraud et al. (2023) promote a management model that embraces quick iterations, real-time planning, and collaboration across departments. This study incorporates aspects of these methods into its proposed solutions. Finally, Capacity Requirements Planning (CRP), as codified by APICS (2002), serves as a foundation for calculating load versus capacity across work centers. Unlike RCCP, which is more general, CRP enables detailed scheduling and load management, making it highly relevant for AMC’s operational planning.

Figure 1. Conceptual Framework



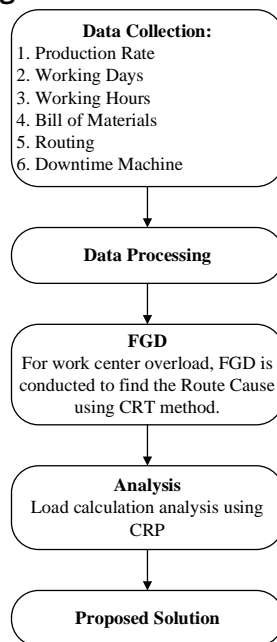
The conceptual framework of Capacity Requirements Planning (CRP) shows how key inputs such as open orders, routing, BOM, work center data, and the shop calendar are processed to generate outputs like work center load reports and revised factory schedules. This system

enables planners to detect overload early and adjust production plans accordingly, making it highly relevant for managing ramp-up challenges at AMC.

METHODS

This study uses a mixed-method approach that integrates qualitative diagnosis and quantitative analysis. Qualitative data were gathered through Focus Group Discussions (FGDs) with operations, engineering, and planning personnel. The CRT method was then applied to construct a cause-effect model linking symptoms such as overload and rework to underlying issues in planning, resource allocation, and communication. Quantitative data include production routing, machine availability, manpower, calendar schedules, and work order durations. These were input into a Capacity Requirements Planning (CRP) simulation to identify which work centers were over utilized and to what extent.

Figure 2. Research Design



The steps are as follows:

1. Identification of production targets and current resource capacities.
2. CRT construction to detect root problems.
3. CRP load simulation and validation of overload levels.
4. Proposal and simulation of solutions.

Rated capacity, often referred to as calculated capacity, is widely used in Capacity Requirements Planning (CRP), particularly in job shop settings. Utilization, as defined by APICS (2002), reflects how efficiently a resource is used, expressed as a percentage of actual productive time over total available time. This metric typically includes both run and setup time, and excludes downtime due to factors like machine or labor unavailability.

In essence, machine utilization indicates the proportion of scheduled operating hours during which the machine is actively producing. This can be quantified using the following formula:

$$Utilization\ Factor = \frac{Production\ Time\ Available}{Total\ Clock\ Hours\ Available} \times 100\%$$

RESULTS

The results of this study are presented in two main parts: qualitative findings from the Current Reality Tree (CRT) analysis and quantitative findings from the Capacity Requirements Planning (CRP) simulation. Together, these results provide a comprehensive understanding of the capacity overload problem and the potential impact of the proposed solutions.

Findings from Current Reality Tree (CRT) Analysis

Through Focus Group Discussions (FGDs) with cross-functional stakeholders including production planning, engineering, and shopfloor supervisors the CRT was constructed to identify the root causes of observed production challenges. The major Undesirable Effects (UDEs) identified were:

1. Frequent backlog in the production queue.
2. Delayed shipment to customers.
3. Increased overtime and worker fatigue.
4. Frequent machine downtime.

From these UDEs, three core root causes were revealed:

1. Fragmented and manual planning systems
Different departments used inconsistent planning tools, leading to misalignment.
2. Lack of predictive spare part management
Breakdown and unavailability of critical parts delayed operations.
3. Low acceptance of scheduling improvements
Resistance among floor-level employees to adopt updated planning systems hindered change implementation.

These root causes created a reinforcing loop that exacerbated delays and overloading, particularly in the two most critical work centers.

Findings from Capacity Requirements Planning (CRP)

Quantitative data including routing times, working hours, machine availability, and monthly production targets were processed using the CRP methodology to determine actual versus available capacity for each key work center.

Before Implementation:

1. Work Center A showed a utilization rate of 165%, indicating that the work center required significantly more time than was available to meet monthly targets.
2. Work Center B showed a utilization rate of 119%, suggesting moderate overcapacity, but still posing a risk to timely output.

This capacity overload was a major barrier to achieving the ramp-up target of 10 units per month.

Proposed Solutions and Simulated Improvements: The following strategies were simulated and evaluated:

1. Redistribution of sub-processes to alternative work centers with lower utilization.
2. Implementation of a predictive spare part ordering system based on historical usage and lead time.
3. Revisions to shift scheduling and addition of short daily maintenance buffers.

After Simulation:

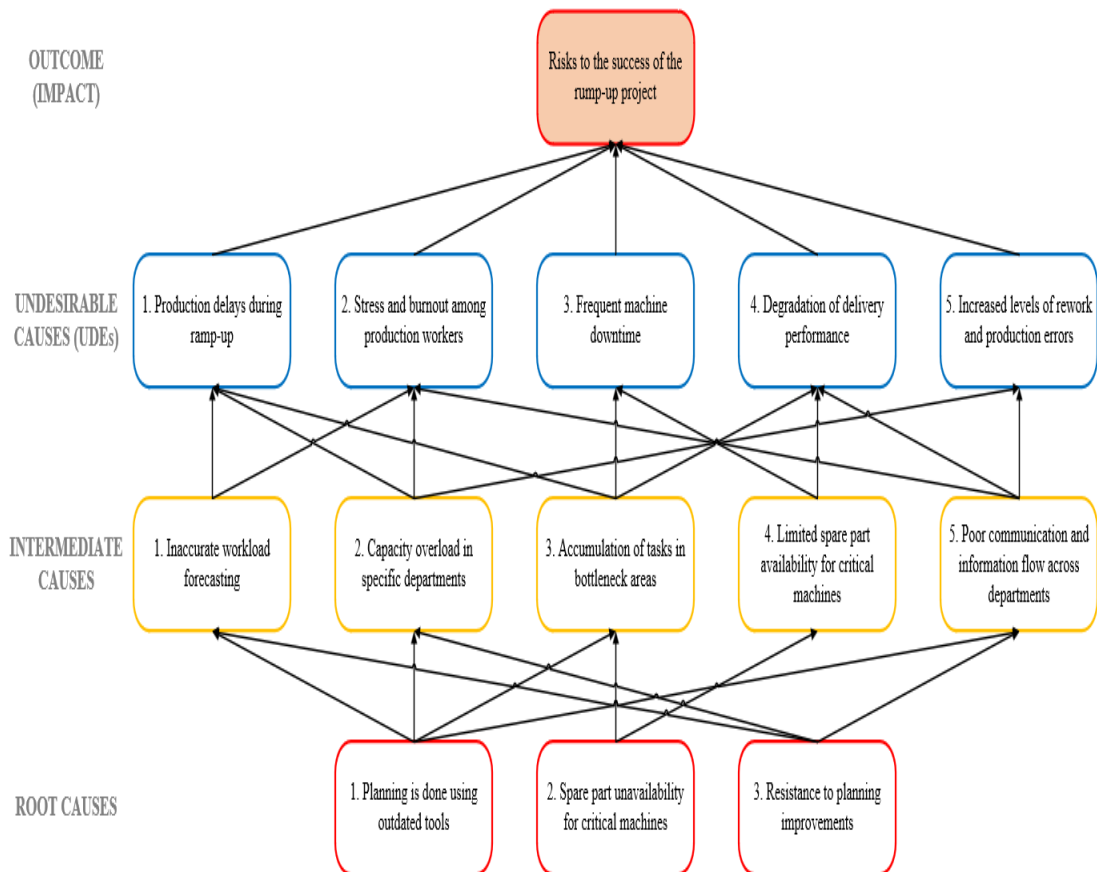
1. Work Center A utilization dropped to 73% and Work Center B utilization decreased to 65%.

Table 1. Summary Table of Capacity Utilization

No.	Work Center	Before	After
1	Work Center A	165%	73%
2	Work Center B	119%	65%
3	Work Center C	112%	76%
4	Work Center D	175%	78%
5	Work Center E	102%	68%
6	Work Center F	105%	58%
7	Work Center G	98%	54%
8	Work Center H	113%	65%
9	Work Center I	122%	79%
10	Work Center J	115%	61%
11	Work Center K	101%	57%

Source: Data Processed, 2025

Figure 3. Current Reality Diagram



DISCUSSION

The results of this study confirm that production ramp-up challenges in complex manufacturing environments like aerospace are multifactorial in nature. It is not solely a question of whether equipment or manpower is sufficient, but rather whether the entire system from planning to execution is harmonized. The use of the Current Reality Tree (CRT) in this research has helped reveal that many observable problems, such as capacity overload and production delays, were symptoms of deeper root causes, including poor integration across departments and resistance to planning tools.

These systemic issues often go unnoticed in traditional planning reviews but can become critical bottlenecks during a scale-up. When production is ramped up without addressing the underlying causes, the result is not just operational stress, but also risks to quality, timeliness, and customer satisfaction.

The application of Capacity Requirements Planning (CRP) allowed for a precise quantification of work-center loads, which provided critical insights into where resource gaps were most severe. It became evident that Work Center A and Work Center B were the limiting factors in the entire workflow. The proposed solutions such as reallocation of workloads, improved shift design, and the introduction of predictive spare part planning were effective in simulations because they addressed both operational and managerial dimensions.

One notable implication is that AMC does not require large capital investments to solve these problems. Instead, the results suggest that optimization through better planning, data utilization, and communication offers a more efficient and sustainable route. This aligns with lean and agile principles, reinforcing the idea that flexibility and continuous learning are more valuable than fixed expansion strategies in dynamic environments.

Moreover, this study highlights the importance of internal stakeholder engagement. Resistance to new planning tools was one of the main obstacles, suggesting that any technical solution must be paired with organizational change management, training, and cultural adaptation. Without buy-in from the ground level, even the most well-designed system will fail to deliver optimal results.

CONCLUSION

This research provides strong evidence that a structured analytical approach, combining CRT and CRP, is effective for identifying and resolving capacity overload during production ramp-up in the aerospace industry. AMC, through simulation-based decision-making, has shown that substantial improvements in efficiency and utilization can be achieved without additional capital investment.

The findings support a shift in perspective from reactive firefighting to proactive planning. By addressing the core issues of disconnected planning, lack of predictive control, and poor workload distribution, AMC has created the conditions necessary for successful scaling. The broader implication of this study is that capacity challenges during ramp-up can often be resolved through smarter use of existing resources, especially when supported by cross-functional collaboration and strong data analysis tools. Companies facing similar challenges are encouraged to adopt a systems-thinking approach and invest in capability development, rather than immediately defaulting to purchasing new assets.

In conclusion, effective capacity improvement is not merely a technical exercise but also an organizational one. Strategic alignment between planning, execution, and people development will be key to sustaining operational excellence in ramp-up scenarios.

Table 2. Proposed Business Solution

No.	Proposed Solution	Purpose	Expected Impact
1	Addition of Production Shifts	Increase man-hours and extend machine operation time	50–70% capacity increase per work center
2	Additional Manpower	Fill labor shortages and support new shifts	Improved execution of added shifts and reduced delays
3	Investment	Expand permanent capacity for persistent overload areas	Structural capacity improvement; long-term relief
4	Outsourcing	Offload non-critical or repetitive processes to third parties	20–30% load reduction at internal work centers

LIMITATION

The simulation assumes a stable demand pattern and does not account for real-time disruptions such as absenteeism or urgent rework. The CRT analysis was also based on qualitative input from a limited set of stakeholders, which might introduce bias. Future research could expand the analysis to include multiple aircraft models, incorporate stochastic variables into CRP models, and assess the impact of digital integration tools like Manufacturing Execution Systems (MES) and IoT on dynamic capacity planning.

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