Modelling Expansion Options at Cristallo Motorbikes

A Business Analysis Report

<u>Developing Dynamic Simulation Models for Electric Motorcycle Production using the Simul8 suite and Analysing Results</u>

By

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EXECUTIVE SUMMARY

This Business Analysis report is based on the observations and insights reflecting on the real-world implementation of Cristallo Motorcycle's production line. Recommendations have been provided in this report to assist management in addressing quality issues, preparing the company for expansion, and managing the anticipated rising production demand. To do so, the company's current situation with regard to various production processes has been modelled using simulation. The model has been built, tested, and validated in an endeavour to use it to investigate potential future prospects for the company. This report includes an analysis of an estimate of the upper (production using 4 workers per process per shift) and lower (production using 2 workers per process per shift) limits of production over the period of a year, also throwing light on what may be done to improve the situation. According to the management's estimations, 4000 models should be produced annually to accommodate sustainable factory changes. Notwithstanding, if this production exceeds 4500, new investments could be made as an expansion strategy to increase sales. The practical accomplishment of these objectives has been scrutinised suggesting possible amendments, and maximum production efficiency.

The analysis revealed that due to problems in Build Frame and Install Power System 2 processes and associated resource constraints (improper staff utilisation causing disbalance in production), the orders were not getting processed as desired and were getting accumulated as backlogs in the Order Book, decreasing production efficiencies to 44% (1762 motorcycles out of 3987 orders received while using 4 workers per process) and 29.5% (1176 motorcycles out of 3987 orders while using 2 workers per process) respectively. A special emphasis has been placed on the suggested adjustments to the number of workstations that a specific activity requires and the number of resources allocated per activity every shift, which may be implemented to support future demands of over 4500 orders per year. These strategies can be used as recommendations for capacity growth to meet rising demand and as proof that management should act on these ideas.

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1. INTRODUCTION

This Business Analysis report is an extension of the analysis of the Cristallo Motorcycle and includes an investigation of highlighting existing bottlenecks and various development options for the company using Dynamic Simulation with the Simul8 software package. The same dataset has been used to extract key parameters like the Average and Standard Deviation of the time taken for each individual process in the manufacturing process to incorporate in the Simul8 model. The management team was given a variety of solutions in the previous analysis report to address the production quality problems, enhance order throughput, and boost factory profitability. Few of these predictions have been confirmed and implemented through simulations, and recommendations have been provided for management to enable better analytical decision-making.

Despite having well-thought-out processes and resources in place, Cristallo Motorcycles was compelled to shift to a 24/7 weekly production cycle because of the continuously rising demand for motorcycles. The activity stations in this established arrangement have queues before them with a capacity to keep 30 motorcycles (acting as a buffer) and resources allotted for all 6 shifts. There were still issues with the management of predicted production figures, and it was necessary to find the root causes of these issues and fix them by developing simulation models that could be used in real-world settings while remaining sustainable.

2. MAIN OBJECTIVES

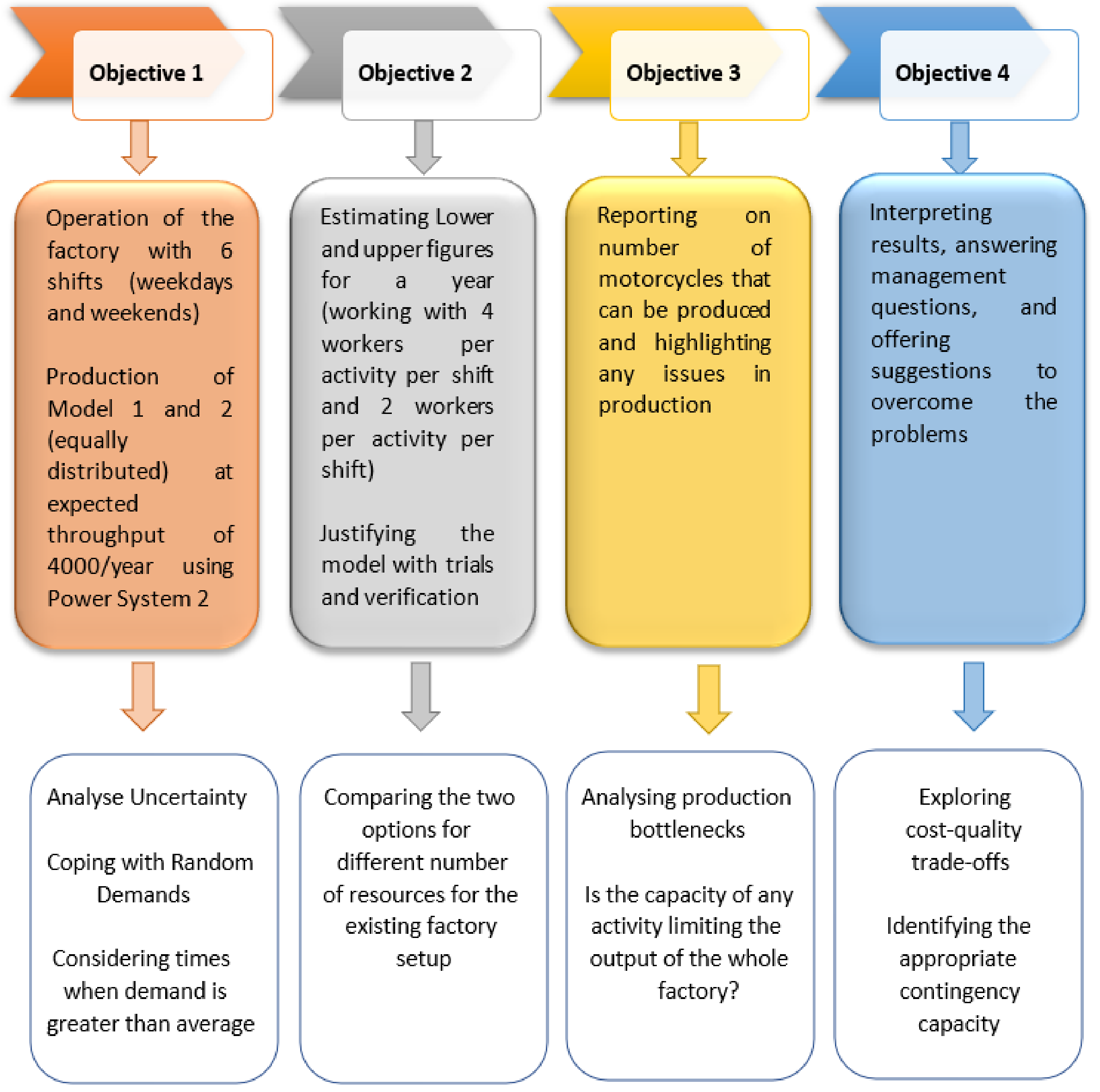

Figure 1: Main Objectives for the Analysis

The consequences of uncertainty about the motorcycle orders received, workflows and subsequent motorcycles that could be manufactured in Cristallo Motorcycle factory setting have been examined and emphasised on how they can be improved. Using Simul8, a micro-world has been created which provided a good representation of the reality that was used to develop a better understanding of the flows and experiment with options to enhance them.

3. EXISTING PRODUCTION SETUP

As mentioned in the assignment 1 case study, the following number of workstations corresponding to each activity have been used in the Simul8 model:

Stage	Number of workstations	Time	Utilisation
Build frame	5	7.9	87%
Power system 1	5	12.5	99%
Power system 2	3	----	80%
Steering & suspension	3	5.0	89%
Fittings	2	3.0	82%
Quality check & fix	1	1.6	82%

Figure 2: Details of various Activities and Workstations

The following production process has been integrated into the model:

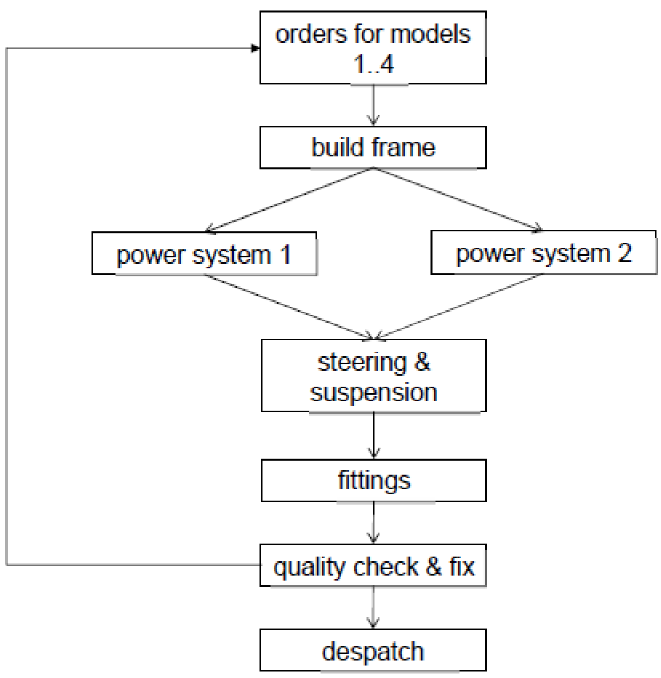

Figure 3: Production Process

The average time taken for individual processes:

Table 1: Average Time for Individual Processes

Model	Average Frame Time	Average Power Time	Average Steering Time	Average Fittings Time	Average Quality Time
Model 1	7.81	12.61	4.90	2.96	1.51
Model 2	7.83	12.80	4.77	2.93	1.49

The standard deviation of time taken for individual processes:

Table 2: Standard Deviation of Time for Individual Processes

Model	Standard Deviation Frame Time	Standard Deviation Power System 2 Time	Standard Deviation Steering Time	Standard Deviation Fittings Time	Standard Deviation Quality Time
Model 1	2.02	3.30	1.23	0.78	0.44
Model 2	1.98	3.19	1.23	0.76	0.42

The average and standard deviation of time for Power System 2:

Table 3: Average and Standard Deviation of Time for Power System 2

Power System	Average Time	Standard Deviation Time
Power System 2	14.40	3.75

As per the recommendations of the production and marketing managers, the production of the most popular models, 1 (Comici) and 2 (Delgard) have been explored using Power System 2 in their construction, since it causes lesser production difficulties despite being expensive. The anticipated production of motorbikes in a year using 4 workers per workstation for each shift has been compared with the estimated figures using 2 workers per workstation to understand the lower and upper limits. Then the model was modified, to solve existing production issues and prepare the factory to meet the anticipated demands of 4500 motorcycles per year.

4. DEVELOPING THE SIMUL8 MODELS AND ANALYSING THE SIMULATION RESULTS

4.1 Specifications and Elements

4.1.1 Key Initial Options

- Hours were chosen as the unit of time
- Result collection period was 8760 hours (1 year = 365*24 hours)

4.1.2 Building Blocks

Table 4: Building Blocks Used in the Simul8 Model

Building Block	Name of the Element	Description
Work Items	Orders	Orders for Comici and Delgard bike models simulated. Labels created for both bike models specifying the average and standard deviation of individual process times.
Start Point	Comici Orders	Orders for both bike models arrive in the system. Different sources of demand having different characteristics have been reflected. Both orders have an exponential distribution pattern of arrival.
	Delgard Orders	
Activity	Plan Motorcycle Manufacture	This has zero duration and has been used just to direct the orders to the first manufacturing process. This also has incoming orders which require Rework. The priority for orders requiring Rework is set to be higher than those of processing new orders.
	Build Frame	The 1st stage in the manufacturing motorcycle process. It has 5 parallel workstations, and the timing distribution is set to be normal with specific values for average and standard deviation depending upon the bike model.
	Install Power System 2	The 2nd stage in the manufacturing motorcycle process. It has 3 parallel workstations, and the timing distribution is set to be normal with specific values for average and standard deviation for Power System 2.
	Steering and Suspension	The 3rd stage in the manufacturing motorcycle process. It has 3 parallel workstations.
	Fittings	The 4th stage in the manufacturing motorcycle process. It has 2 parallel workstations.
	Quality Check and Fix	The last stage in the manufacturing motorcycle process. It has 1 workstation. It does a final check to approve the motorcycles to be despatched to

		customers or rejected, scrapped, and reworked from the start. There are two outputs from this process. Criteria are set for 97% of orders to be despatched and 3% to fail Quality Checks and go for Rework.
	Despatch Sort	This has zero duration and has been used just to direct the orders to the endpoint, i.e., distributing motorcycles to customers depending on the Bike model. Comici and Delgard models have two different endpoints and are distributed separately.
Queue	Order Book	It is a queue for incoming orders. It receives orders for both Bike models and keeps a track of their numbers.
	Frame Queue	These queues hold bikes before corresponding workstation activities (while waiting to be processed) until a space becomes available with one of the workers. The maximum capacity of each queue is 30 (bikes).
	Power System 2 Queue	
	Steering and Suspension Queue	
	Fittings Queue	
	Quality Check and Fix Queue	
	Rework Queue	It takes bikes that require Rework after failing Quality Checks and passes them to all manufacturing stages again.
End	Despatch Comici	The respective bike models leave the system and are despatched to customers through this endpoint.
	Despatch Delgard	
Resources	Frame Build Staff	All the manufacturing processes involved have been assigned specific resources depending on their skills. These resources (specific staff) have been made available (as per mentioned times and days) for each activity depending upon their shift patterns.
	Power System 2 Install Staff	
	Steering and Suspension Staff	
	Fittings Staff	
	Quality Check and Fix Staff	

4.1.3 Shifts

Six shifts were introduced to have a 24/7 work pattern:

Table 5: Six Shifts used in the Simul8 Model

Shift Name	Days Operational	Time
Weekdays Day Shift	Monday to Friday	0700-1500
Weekdays Swing Shift		1500-2300
Weekdays Night Shift		2300-0700
Weekends Day Shift	Saturday and Sunday	0700-1500
Weekends Swing Shift		1500-2300
Weekends Night Shift		2300-0700

4.1.4 Variability and Random Effects

To incorporate a high degree of variability and randomness similar to real systems, two types of uncertainty have been considered, random demand (Orders for Comici and Delgard models arrive at an exponential rate) and random timing of activities (Time taken for each process has been accommodated with normal distribution using average and standard deviation). These practices introduced stochasticity in the model.

4.1.5 Labels

To deal with the 2 motorcycle models with different timings on each workstation, the following labels were created:

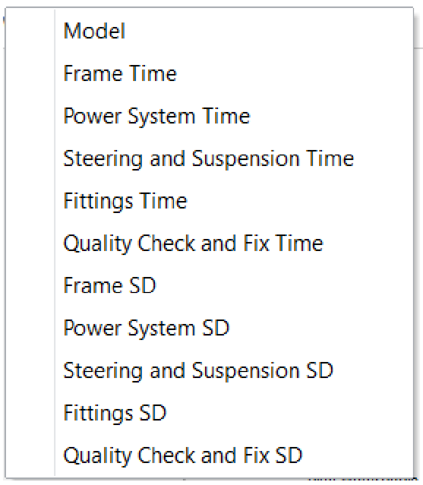

Figure 4: Labels used in the Simul8 Model

Initially, two identical models were created, the only difference being in the number of workers per workstation for each shift (4 and 2 respectively).

4.2 Simul8 Model with 4 workers per workstation for each shift

Anticipated Demand – 4000 orders per year (2000 for each bike model)

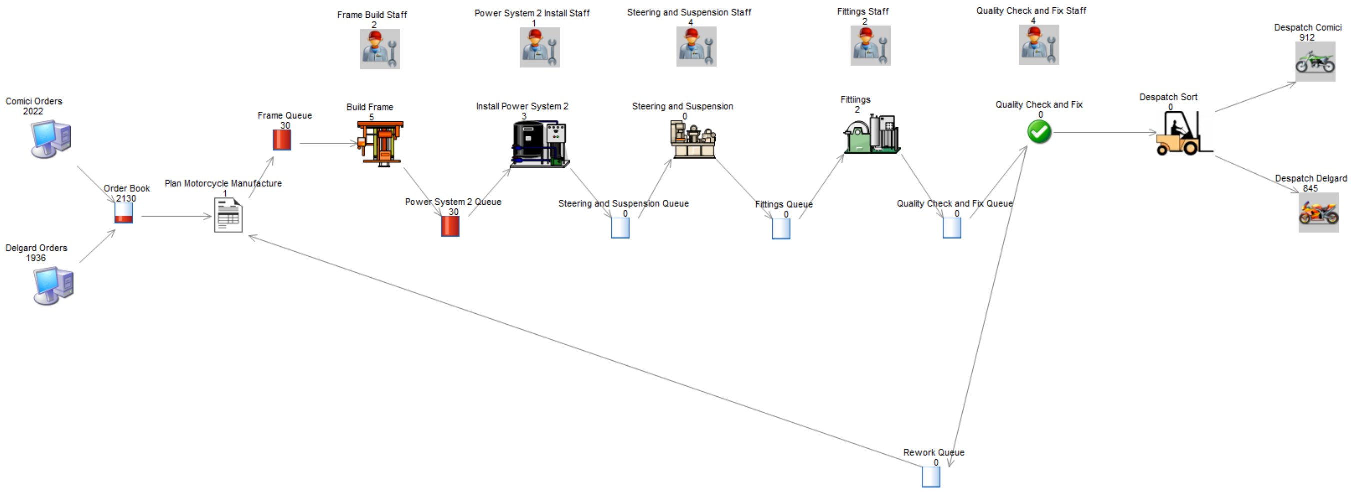

Figure 5: Simul8 Model using 4 workers per workstation per shift

4.2.1 Key Performance Indicators (KPIs)

To check the behaviour of the model reflecting similar real-world characteristics and draw insights, various KPIs were selected from simulation trials results:

- Number of Orders received
- Number of Orders despatched
- Number of Orders in various queues
- Staff Utilisation for each process
- Average time motorcycle stayed in the system

4.2.2 Trials and Validation

20 simulation trials were run, each using a different set of random numbers to represent a different possible combination of demand and timing. Since it is difficult to foresee the future with accuracy, these analyses still provide a perspective of the range of potential outcomes, as shown by the variable ranges of KPI values.

These results provided a mean based on the 20 sets of results and also the 95% confidence interval:

Table 6: Simulation Results for Model using 4 workers

Simulation Object	Performance Measure	-95%	Average	95%
Comici Orders	Number Entered	1972.2664	1994.9	2017.5336
Delgard Orders	Number Entered	1972.14971	1992.1	2012.05029
Order Book	Current Contents	2120.89404	2153.5	2186.10596
Frame Queue	Current Contents	30	30	30
Power System 2 Queue	Current Contents	30	30	30
Steering and Suspension Queue	Current Contents	0	0	0
Fittings Queue	Current Contents	0	0	0
Quality Check and Fix Queue	Current Contents	0	0	0
Frame Build Staff	Utilization %	41.31462	41.52764	41.74066
Power System 2 Install Staff	Utilization %	74.89145	74.89875	74.90605
Steering and Suspension Staff	Utilization %	24.97887	25.07808	25.17729
Fittings Staff	Utilization %	15.17371	15.25055	15.32739
Quality Check and Fix Staff	Utilization %	7.73409	7.76752	7.80095
Despatch Comici	Number Completed	874.45842	884.75	895.04158
	Average Time in System (1)	2414.51324	2449.09628	2483.67932
Despatch Delgard	Number Completed	867.94231	877.6	887.25769
	Average Time in System (2)	2406.25241	2436.63195	2467.01149

Observations based on average values of trials:

- Order Book backlogs = **2154** (almost 54%; half of orders)

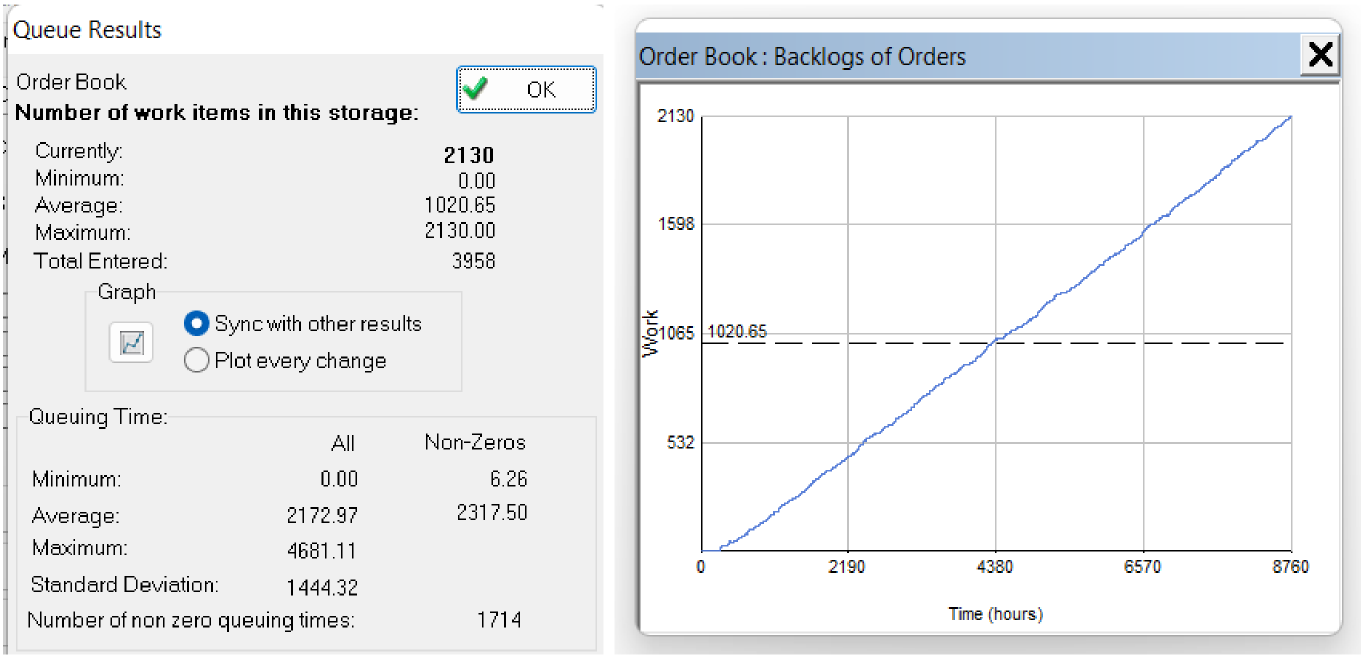

Figure 6: Order Book for Model using 4 workers

- The Order Book always has a high number of orders in backlog. The mean waiting time for an order waiting in the Order Book queue is 2173 hours, which is a very high value. Customers have to wait a lot (almost 90 days) for their orders to be processed.

- Frame Queue and Power System 2 Queue are causing significant backlogs

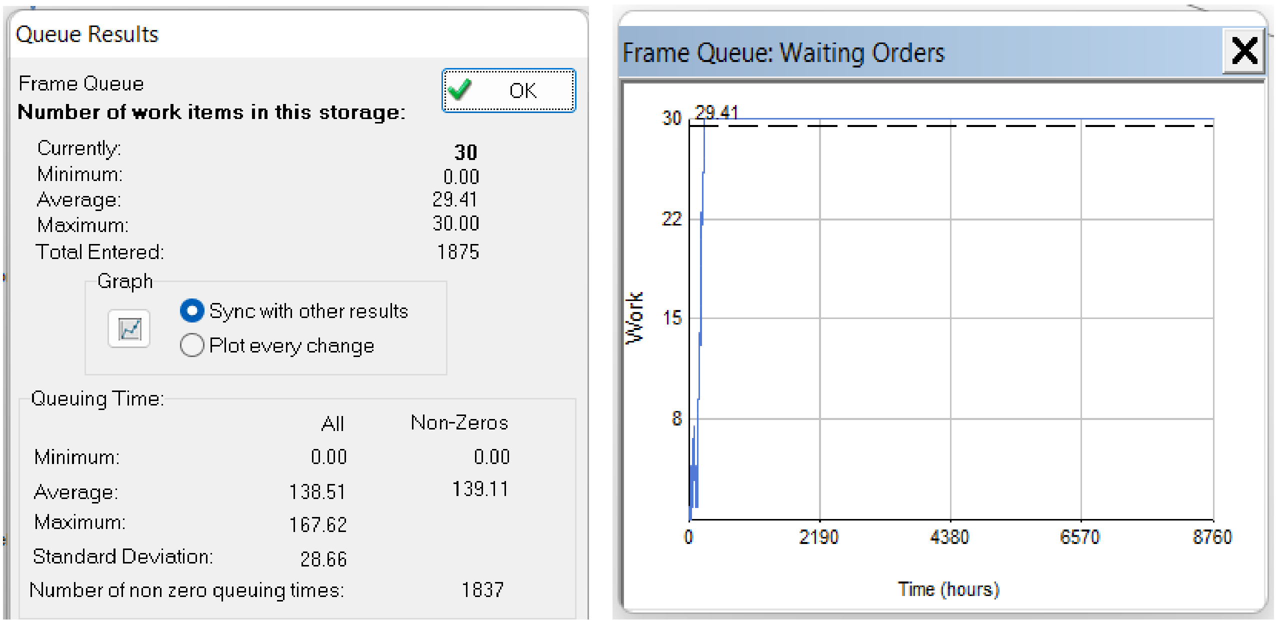

Figure 7: Frame Queue for Model using 4 workers

- Frame Queue is occupied fully all the time, and orders have to wait approximately 139 hours before going to the Build Frame workstation.

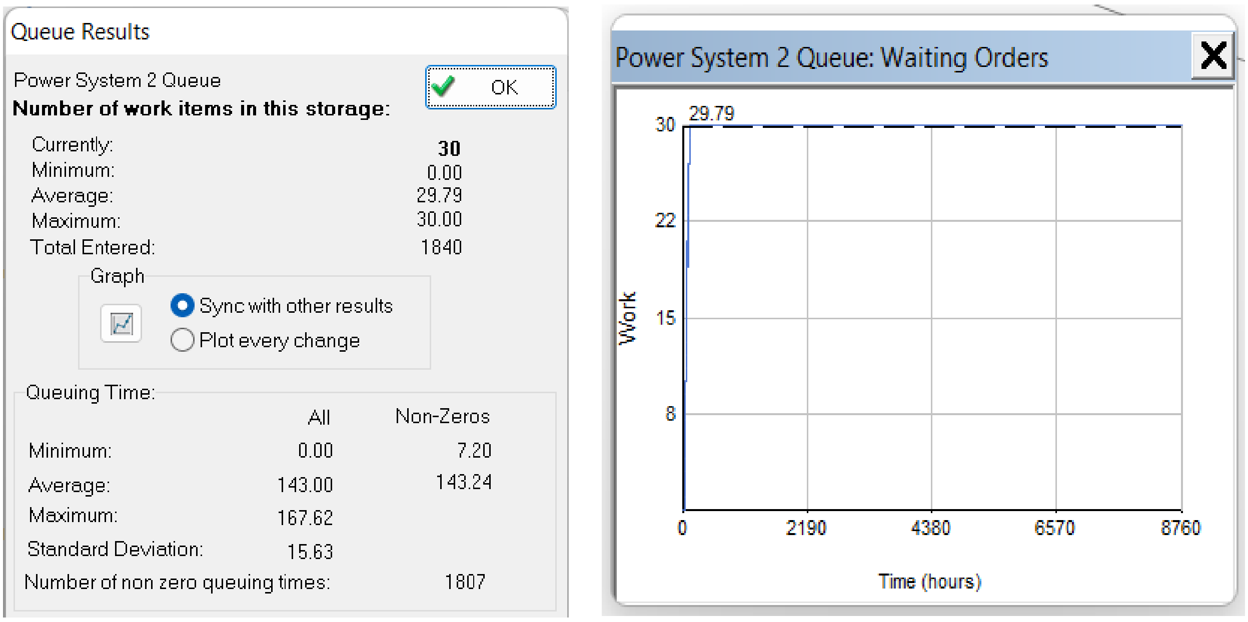

Figure 8: Power System 2 Queue for Model using 4 workers

- Power System 2 Queue is also occupied fully all the time, and orders have to wait approximately 143 hours before going to the Install Power System 2 workstation

- Only Power System 2 Install staff are utilised the maximum (75%), and the rest of the staff are underutilised

Table 7: Resource Utilisation for Model using 4 workers

Resource	Utilisation Percentage
Frame Build Staff	41.52 %
Power System 2 Install Staff	74.89 %
Steering and Suspension Staff	25.07 %
Fittings Staff	15.25 %
Quality Check and Fix	7.76 %

Certainly, there are serious issues in production. *Only **1762** motorcycles (44% efficiency) out of **3987** orders received could be produced. The production cannot match the forecasted demand for 4000 motorcycles per year. Queues representing the backlog of orders account for the majority of orders. Mean staff utilisation varies considerably between 7 % and 75%, suggesting a major imbalance in production. The average time in system is quite high.*

In further experiments with lower demands, the following was observed on average:

Table 8: Production Experiments for Model using 4 workers

Demands per year (Set Exponentially)	Orders Received	Bikes Produced and Despatched	Backlogs of Orders	Efficiency of Production
1600 (800 for each motorcycle model)	1585	1574	0	99.30 %
2000 (1000 for each motorcycle model)	1990	1758	161	88.34 %
2200 (1100 for each model)	2188	1761	356	80.48 %

<u>The company can only handle the demands of approximately 2000 motorcycles per year.</u>

4.3 Simul8 Model with 2 workers per workstation for each shift

Anticipated Demand – 4000 orders per year (2000 for each bike model)

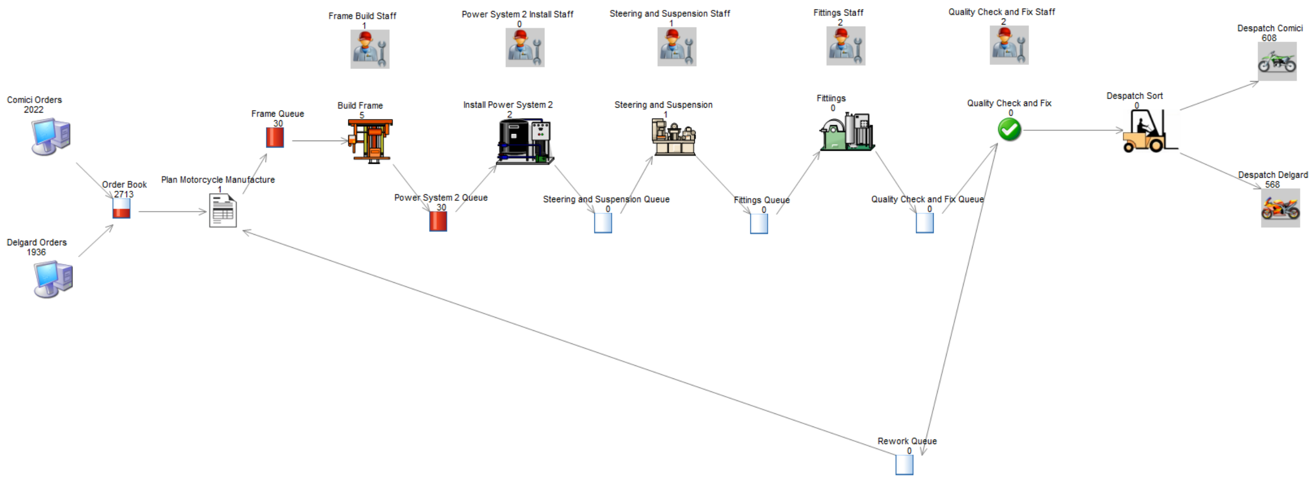

Figure 9: Simul8 Model using 2 workers per workstation per shift

The simulation provided average values based on the 20 trials including the 95% confidence interval.

Table 9: Simulation Results for Model using 2 workers

Simulation Object	**Performance Measure**	**-95%**	**Average**	**95%**
Comici Orders	Number Entered	1972.2664	1994.9	2017.5336
Delgard Orders	Number Entered	1972.14971	1992.1	2012.05029
Order Book	Current Contents	2709.61422	2741.95	2774.28578
Frame Queue	Current Contents	30	30	30
Power System 2 Queue	Current Contents	30	30	30
Steering and Suspension Queue	Current Contents	0	0	0
Fittings Queue	Current Contents	0	0	0
Quality Check and Fix Queue	Current Contents	0	0	0
Frame Build Staff	Utilization %	55.68908	55.98125	56.27342
Power System 2 Install Staff	Utilization %	99.87072	99.87979	99.88886
Steering and Suspension Staff	Utilization %	33.29971	33.43934	33.57897
Fittings Staff	Utilization %	20.19831	20.32228	20.44626
Quality Check and Fix Staff	Utilization %	10.33719	10.38956	10.44193
Despatch Comici	Number Completed	577.57036	587.15	596.72964
	Average Time in System (1)	3052.77681	3086.64763	3120.51844
Despatch Delgard	Number Completed	581.09969	588.85	596.60031
	Average Time in System (2)	3071.78655	3103.87143	3135.95631

Observations:

- Order Book backlogs = **2742** (approximately 69% of orders)

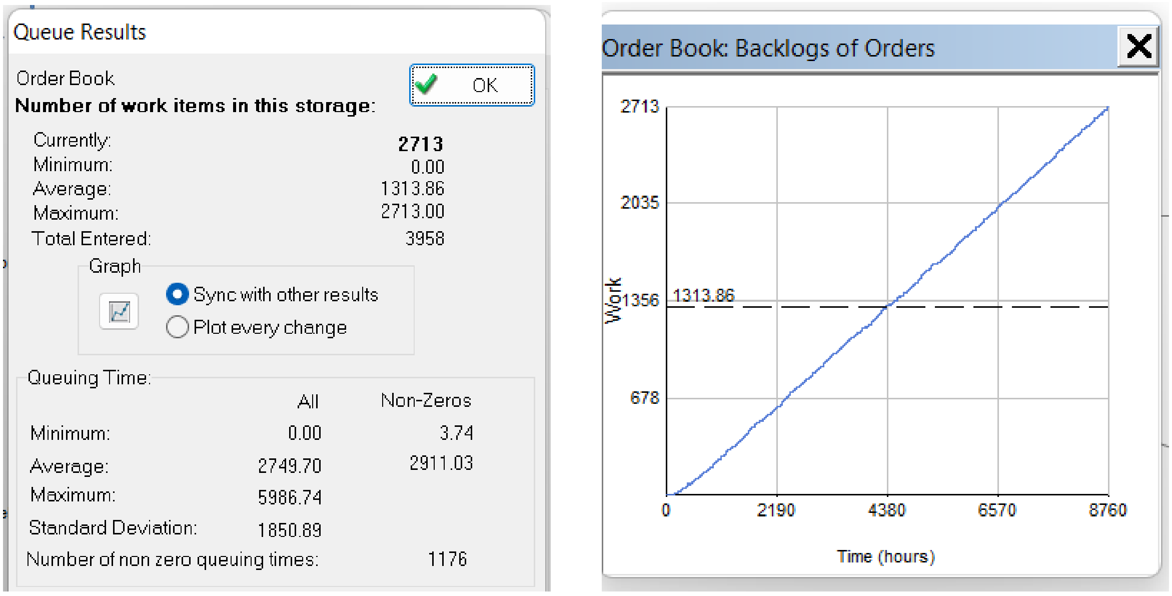

Figure 10: Order Book for Model using 2 workers

- Often a large number of orders are backlogged in the Order Book. The average order waiting period in the Order Book backlog is 2750 hours, which is a very prolonged time period. For approximately 115 days, customers must wait until their orders are processed.

- Substantial backlogs are being generated by the Frame Queue and the Power System 2 queue.

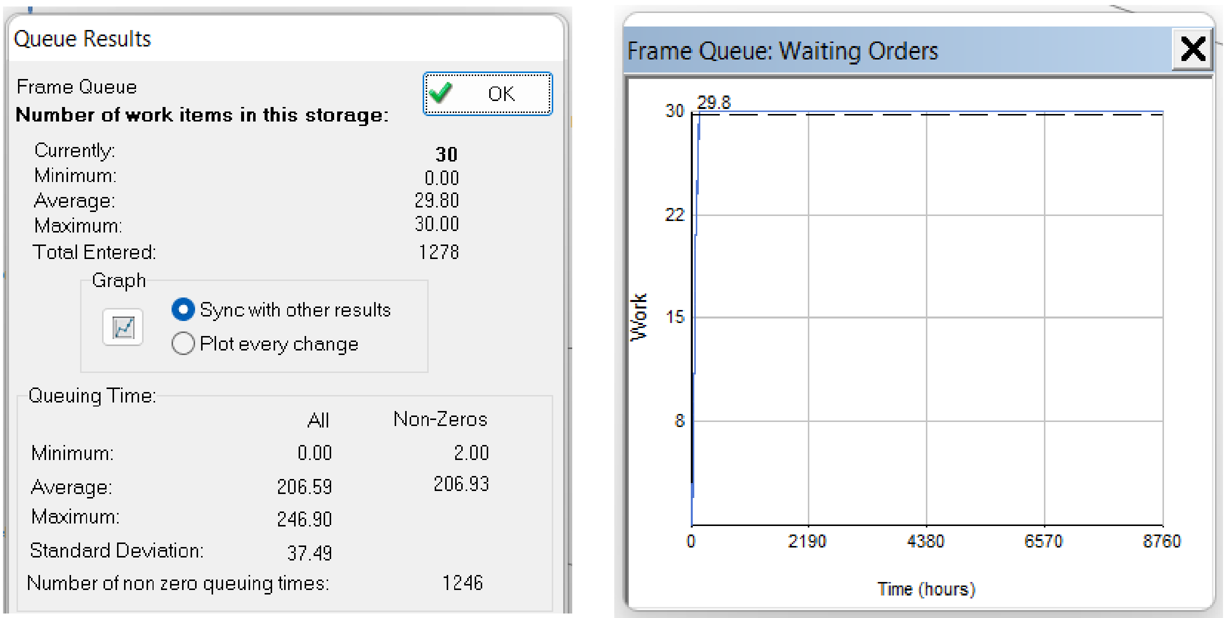

Figure 11: Frame Queue for Model using 2 workers

- Orders must wait about 207 hours before being sent to the Build Frame workstation due to the Frame Queue's constant full occupancy.

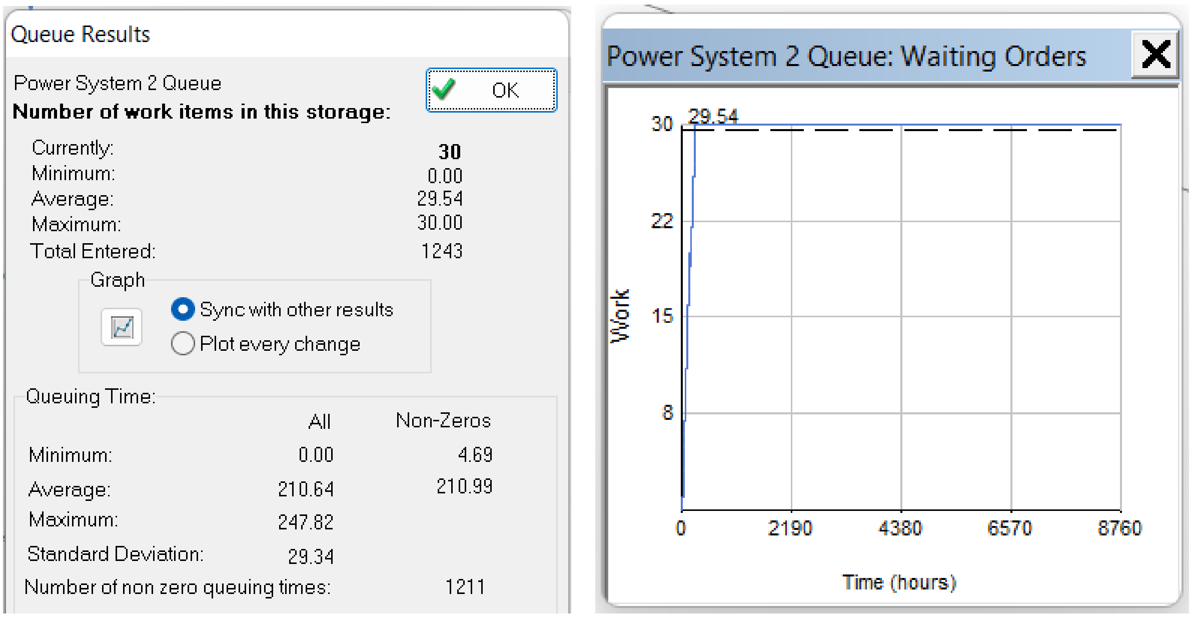

Figure 12: Power System 2 Queue for Model using 2 workers

- Orders must wait roughly 211 hours before being sent to the Install Power System 2 workstation since the Power System 2 Queue is also constantly completely full.

- Power System 2 Install staff are over-utilised (99.87%), and the rest of the staff are underutilised.

Table 10: Resource Utilisation for Model using 2 workers

Resource	Utilisation Percentage
Frame Build Staff	55.98 %
Power System 2 Install Staff	99.87 %
Steering and Suspension Staff	33.43 %
Fittings Staff	20.32 %
Quality Check and Fix	10.38 %

There are definitely significant problems affecting production. *Out of the **3987** orders received, only **1176** motorcycles (**29.5% efficiency**) might be manufactured. The predicted demand for 4,000 motorcycles per year cannot be satisfied by capacity. The most of orders are in queues that represent the backlog of orders. The broad range of mean staff utilization - between 10% and 99% - indicates a considerable production unbalance. The average duration in the system is rather long.*

Additional experiments with reduced demands revealed the following findings on average:

Table 11: Production Experiments for Model using 2 workers

Demands per year (Set Exponentially)	Orders Received	Bikes Produced and Despatched	Backlogs of Orders	Efficiency of Production
1200 (600 for each motorcycle model)	1186	1154	0	97.30 %
1400 (700 for each motorcycle model)	1386	1173	144	84.63 %
1600 (800 for each model)	1585	1174	341	74.06 %

The factory can only meet the demand for about 1400 motorcycles annually.

4.4 Modified Simul8 Model to achieve set Targets (Producing more than 4500 bikes/year)

The model described in previous subsections was observed to be realistic and options have been explored to improve its performance and enhance its capacity to meet the demands of producing more than 4500 motorbikes per year.

Emphasis was laid on the following aspects:

4.4.1 Rebalancing the Production Line

In the previous subsections, the staff utilisation % was calculated for 4 workers and 2 workers respectively per activity per shift. Staff utilisation should be equally distributed for all activities. To do so, various combinations of the number of resources were tried and tested to determine the best combination.

Table 12: Rebalanced Production Line for Modified Proposed Model

Resource	Number of Resources/Activity	Utilisation Percentage
Frame Build Staff	5	84.28 %
Power System 2 Install Staff	9	86.10 %
Steering and Suspension Staff	3	86.55 %
Fittings Staff	2	78.97 %
Quality Check and Fix Staff	1	80.53 %

4.4.2 Modifying the number of workstations for different activities

As discussed, the current capacity cannot cater for higher production numbers. Hence, there was a need to increase the capacity. Since the queues before Build Frame and Install Power System 2 processes were creating the most backlogs, different combinations of the number of workstations for these processes were experimented with to find out the best possible combination.

Table 13: Number of Workstations for Different Activities for Modified Proposed Model

Activity	Number of Workstations Required
Build Frame	5
Install Power System 2	9
Steering and Suspension	3
Fittings	2
Quality Check and Fix	1

4.4.3 Increasing or decreasing the capacity of intermediate storage

After trying the above-mentioned parameters, no queue was observed to be full. Hence the capacity of each queue was set to 15 and the model was tested. The model was able to fulfil the required demands effectively even with each queue having a **capacity of storing 15 motorcycles**.

4.4.4 Trials and Validation

Expected Demand – 4600 orders per year (2300 for each bike model)

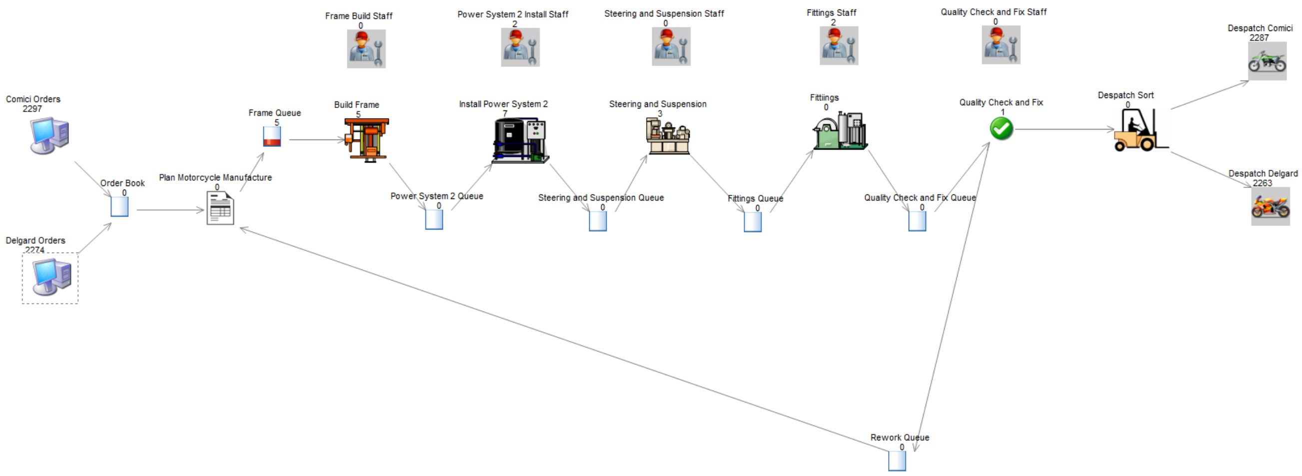

Figure 13: Modified Proposed Simul8 Model

Table 14: Simulation Results for Modified Proposed Model

Simulation Object	Performance Measure	-95%	Average	95%
Comici Orders	Number Entered	2270.1704	2290.9	2311.6296
Delgard Orders	Number Entered	2269.88432	2292.75	2315.61568
Order Book	Current Contents	0	0	0
Frame Queue	Current Contents	0.69952	2.3	3.90048
Power System 2 Queue	Current Contents	0.09599	1.05	2.00401
Steering and Suspension Queue	Current Contents	0.39261	0.95	1.50739
Fittings Queue	Current Contents	0.07996	0.3	0.52004
Quality Check and Fix Queue	Current Contents	0.1439	0.5	0.8561
Frame Build Staff	Utilization %	83.67349	84.28291	84.89234
Power System 2 Install Staff	Utilization %	85.38335	86.10602	86.82868
Steering and Suspension Staff	Utilization %	85.84868	86.55744	87.26621
Fittings Staff	Utilization %	78.45769	78.97506	79.49242
Quality Check and Fix Staff	Utilization %	79.94538	80.53065	81.11593
Despatch Comici	Number Completed	2258.93868	2279.9	2300.86132
	Average Time in System (1)	41.03163	42.03978	43.04793
Despatch Delgard	Number Completed	2259.65081	2282	2304.34919
	Average Time in System (2)	40.83055	41.82918	42.82781

Observations:

- No backlog of orders in the Order Book, negligible backlogs of orders in other queues
- Very High Utilisation of all the resources
- Average time in the system has significantly reduced for both motorcycle models (approximately equal to historical values provided in the dataset)

- Frame Queue and Power System 2 Queue now had very few orders anytime (less than 15)

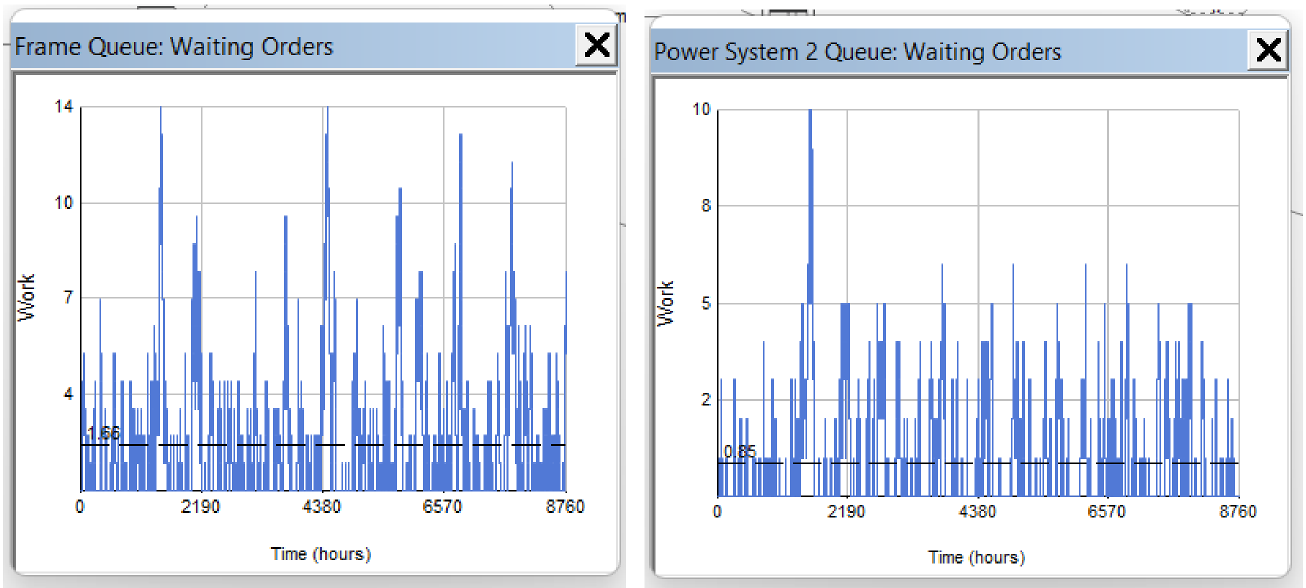

Figure 14: Frame Queue and Power System 2 Queue for Modified Proposed Model

Outstanding improvement has been observed in production numbers and the efficiency of various processes and resources. ***4562** motorcycles (99.52 % efficiency) out of **4584** orders received could now be produced. The production capacity exceeded the predicted demand for more than 4500 motorcycles per year. No queue has any backlog of orders. Mean staff utilisation now varies between 78% and 87%, demonstrating a balanced production line. The average time in system has reduced drastically.*

5. PROVIDING SOLUTIONS AND RECOMMENDATIONS

Exploiting the 24/7 production cycle using 6 shifts (3 weekdays and 3 weekends shifts), the operation of the Cristallo Motorcycle was simulated for a year, to determine the number of motorcycles that could be produced for Comici and Delgard at expected throughput of 4000/year using Power System 2.

5.1 4 Workers per activity per shift

The Upper limit of production: **1762 motorcycles** (at an Estimated Demand of 4000 orders)

The number of orders that the factory can accommodate: **2000 orders**

5.2 2 Workers per activity per shift

The Lower limit of production: **1176 motorcycles** (at an Estimated Demand of 4000 orders)

The number of orders that the factory can accommodate: **1400 orders**

These two setups had many severe issues in existing processes which decreased productivity and caused an imbalance in the production line. Due to the Build Frame and Power System 2 Install processes and their queues, many orders were getting accumulated as backlogs, and the predicted demand could not be met with the existing setup even when using 4 workers or 2 workers per activity per shift.

The Simul8 model was validated by conducting simulation trials in an effort to use it to research potential future prospects for the company. It was then redeveloped by trying and testing different possible combinations of workstations, number of resources per activity, % staff utilisation, and storage capacities of queues for different levels of anticipated demands. Finally, the results were obtained for a demand of 4582 motorcycle orders per year, being able to manufacture 4562 motorcycles with an efficiency of 99.52%, with no order backlogs and optimum staff utilisation.

5.3 Recommended Production Setup

The following combination is recommended for the factory setup (this is capable to manufacture more than 4500 motorcycles/year):

Table 15: Recommended Setup for Modified Proposed Model

Process	Number of Workstations Required	Number of Resources per Activity	Staff Utilisation Percentage	Queue Storage Capacity
Build Frame	5	5	84.28 %	15
Power System 2 Install	9	9	86.10 %	15
Steering and Suspension	3	3	86.55 %	15
Fittings	2	2	78.97 %	15
Quality Check and Fix	1	1	80.53 %	15

Hence, the following modifications may be done to the existing setup:

- Number of workstations of Power System 2 to be increased from 5 to 9
- Number of Resources per activity per shift may be allocated as per the number observed during the analysis
- Storage capacities of all queues may be decreased to 15

Additional experiments with higher demands for the proposed model yielded the following results on average:

Table 16: Production Experiments for Modified Proposed Model

Demands per year (Set Exponentially)	Orders Received	Bikes Produced and Despatched	Backlogs of Orders	Efficiency of Production
4800 (2400 for each motorcycle model)	4784	4758	0.10	99.46 %
4900 (2450 for each motorcycle model)	4883	4854	0.00	99.40 %
5000 (2500 for each model)	4985	4951	0.30	99.31 %

Beyond a demand of 5000 orders/year, the production efficiency remained high and there were no pending orders as backlogs in the Order Book, however, the following parameters were observed to be problematic:

- Staff utilisation % increased heavily beyond 92% for Frame Build, Power System 2 Install, and Steering and Suspension Staffs
- Average Time in System increased to approximately 55 hours

*As a result, according to the proposed modified setup, the factory can only meet the demand for roughly **5000** motorcycles per year.*

Monitoring Staff Utilisation as a performance measure on individual manufacturing processes ensures optimal balance in the production line and can be adjusted depending upon the shift requirements. The suggested sustainable changes can be made with minimum effort. Also, there is a scope for new investments as an expansion strategy to increase further sales of any other motorcycle model in future. The same Simul8 model can be modified to incorporate other motorcycle models (including Rossi and Torre) and both Power Systems (including Power System 1) to explore further feasibility.

The practical accomplishment of the set objectives has been demonstrated successfully using simulation to maximise production efficiency, and also to tackle such bottlenecks if they arise in future. Simulation software like Simul8 used by numerous organisations worldwide beneficially provides enhancement alternatives through their modelling capabilities to analyse workflows and bottlenecks in systems. When analysing systems that must deal with uncertainty, manufacturing companies typically seek suggestions for enhancing workflows through production lines and establishing the most cost-effective ways to increase output.