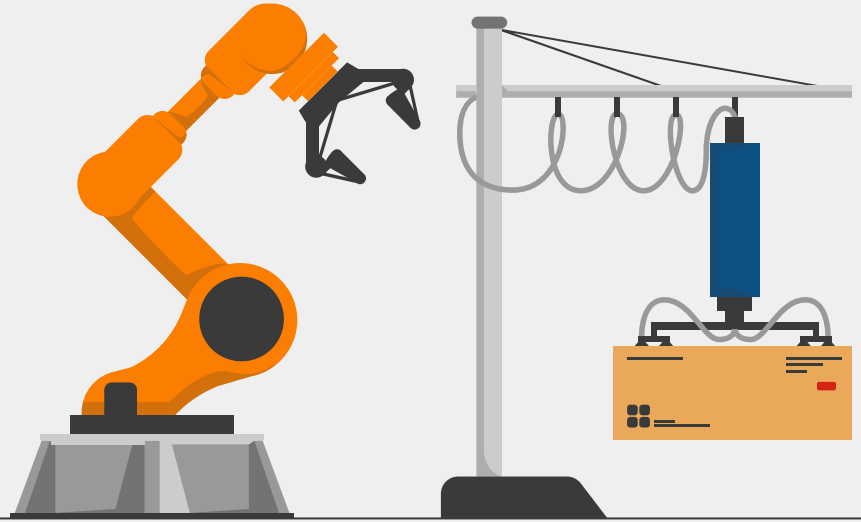
PROFIT AND LEAD TIME IMPROVEMENT FOR TANK PRODUCTION PROCESS AT PT. X : A DISCRETE-EVENT MODELLING SIMULATION APPROACH



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Introduction & Business Issue

Introduction

PT X embarks its journey as a body maker company, a business that is focusing on body vehicle manufacturing based in Sidoarjo, Indonesia. Specializing in transport and storage tanks, PT. X ensures the production of high-quality products that meets customer specifications and expectations. The firm has been established since 2003 with 1,000 employees and 3 workshops. PT X has served both local market across Indonesia such as Java, Sumatra, Kalimantan, Sulawesi, Bali, NTT, NTB, Lombok, and Papua.

As a verified tank builder of Pertamina

Its main customer is Pertamina, which is an Indonesian state-owned enterprise that primarily operates in the oil and gas sector, to supply their needs of body vehicle to fulfill oil and gas demand both from customers, corporations, and projects. Their manufacturing capability is not merely a measure of scale; it's a testament to our dedication to delivering reliable, durable, and tailor-made solutions based on qualified certification. The firm offers a range of high-quality solutions that meet industry standards.

Business Issue

With high development of logistics and transportation across Indonesia as a government initiative, PT Pertamina has made an order to PT X, with a timeline and details as follows:

Total number of ordered tanks (as per contract)	**: 90 tanks**
The average number of arrival tank orders	**: 7 tanks in a week (Monday-Friday in working days)**
Product Volume	**: 32 KL**
Duration to be finished as per the contract	**: 90 days (calender days) for 1 tank**
Penalty	**: 7.5% (per month) for 1 tank***

Note:
*Due to actually, in general, the lead time (also meaning flow time in our case) for 1 tank is around 75 calendar days, yet Pertamina gave us the additional time of 2 weeks or 15 days lead time (for issuing the certification) to be 90 days in order to prepare the product completely on the road after the certification issue.

Currently, the average production capacity of PT X each week is around 7 units with an average lead time of 90 days for 1 tank (counted from the order entered the production processes until being the finished product) as per the contract with the client (Pertamina). However, the firm's production capacity is lower than the number of orders from Pertamina. The average lead time is currently longer than the expected duration from Pertamina. Hence, with the limitation of production capacity and speed, the firm fails to deliver all finished products to Pertamina on time. As a result, it decreases its revenue and profit. In addition, the firm has to pay a penalty fee for lateness in fulfilment on this project.

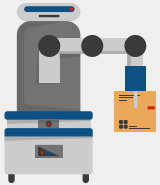
The actual final result shows that within 90 calendar days, 87 tanks have entered into the production process; the output for 29 tanks is completed, while 58 tanks are backlog (uncompleted). With this situation, the current profit (came from the current outputs) so far (Rp. 803,275,640) is not optimal for the company due to the backlogs being higher than the output.

02

Objectives

Objectives

The objective of this project is to model and analyze the operation of complex systems **to support management decision-making, and optimize production processes by improving the company's revenue, profit, efficiency, and reducing manufacturing costs, backlogs, and lead time.**

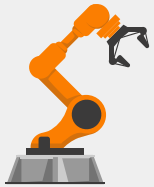


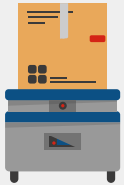
Identify Bottleneck

Analyse areas in the production line where there is delay

Proposed new scenario and analyse the impact of proposed changes

Strategy Scenario Analysis



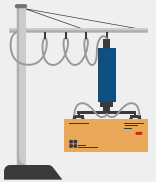


Profit Maximization

Allocate resources to avoid overloading or underutilized machinery and workers.

Reduce Manufacturing Cost, Backlogs, and Lead Time

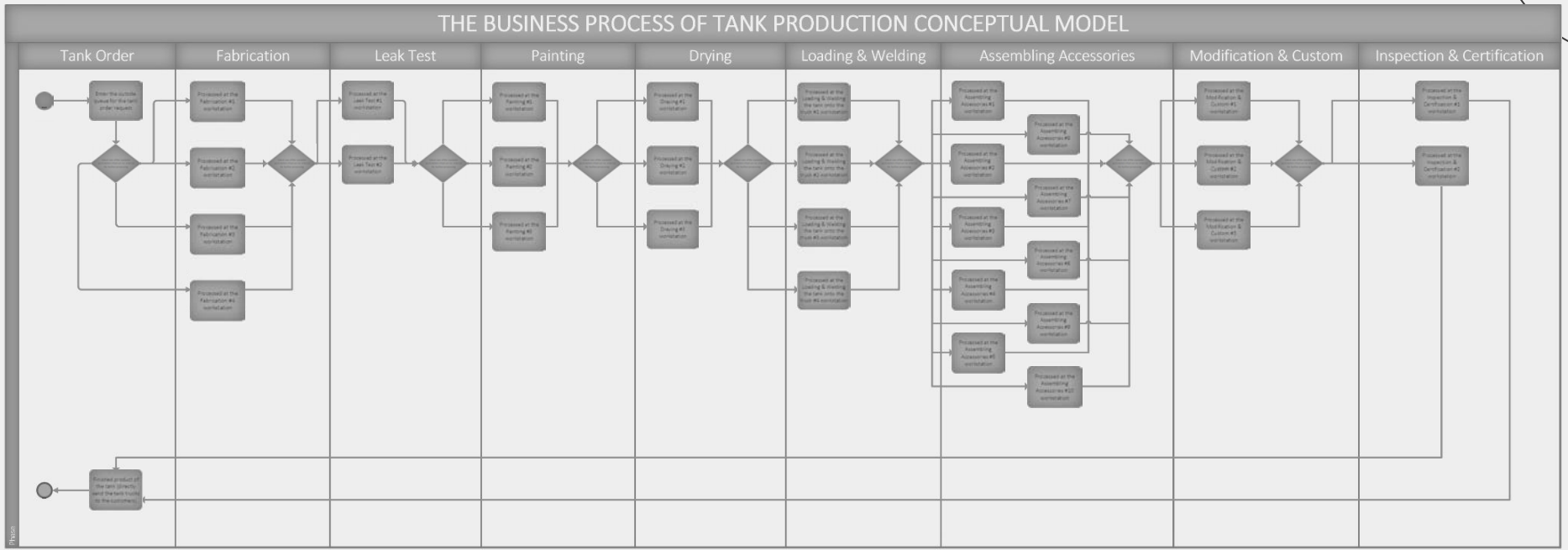
Efficiency



03

Conceptual Model

The Business Process of Tank Production Conceptual Model



04

Data & Specifications

Breakdown of Production Time

NO	PRODUCTION ACTIVITIES	PRODUCTION TIME FOR 1 TANK (DAY)		
		THE FASTEST	AVERAGE	THE LONGEST
1	Fabricating (starting rolling the plates by using the rolling machines)	6	7	8
2	Leak Test (Hydrotest)	1	2	3
3	Painting	3	4	5
4	Drying	3	4	5
5	Loading onto the truck, then welding it	1	2	3
6	Assembling Accessories (box, bumper, side guard, mud guard, dll)	4	5	6
7	Modification & Custom (Pneumatic, stickering, lamp)	1	2	3
8	QC Inspection & Certification (testing, leak test, spesification)	4	5	6
9	Directly sending the tank trucks to the customers as the finished product (the tank) without any delay to avoid the penalty from the customer.			

Breakdown of Production Capacity

NO	PRODUCTION ACTIVITIES	Number of Labour / Workstation (Worker)	Total Machine for Production (Qty)
1	Fabricating (starting rolling the plates by using the rolling machines)	4	4
2	Leak Test (Hydrotest)	2	2
3	Painting	4	3
4	Drying	2	2
5	Loading onto the truck, then welding it	3	4
6	Assembling Accessories (box, bumper, side guard, mud guard)	3	10
7	Modification & Custom (Pneumatic, stickering, lamp)	4	3
8	QC Inspection & Certification (testing, leak test, spesification)	3	2
9	Directly sending the tank trucks to the customers as the finished product (the tank) without any delay to avoid the penalty from the customer.		

Breakdown of Costs

NO	DESCRIPTION	PRODUCTION COST (IDR)	REMARKS
1	5 KL Tank	IDR 118.450.255	Price / Tank
2	8 KL Tank	IDR 143.225.800	Price / Tank
3	10 KL Tank	IDR 167.355.300	Price / Tank
4	16 KL Tank	IDR 213.425.400	Price / Tank
5	24 KL Tank	IDR 523.450.750	Price / Tank
6	**32 KL Tank**	**IDR 535.250.700**	Price / Tank **(ordered unit by Pertamina)**
7	40 KL Tank	IDR 645.750.500	Price / Tank

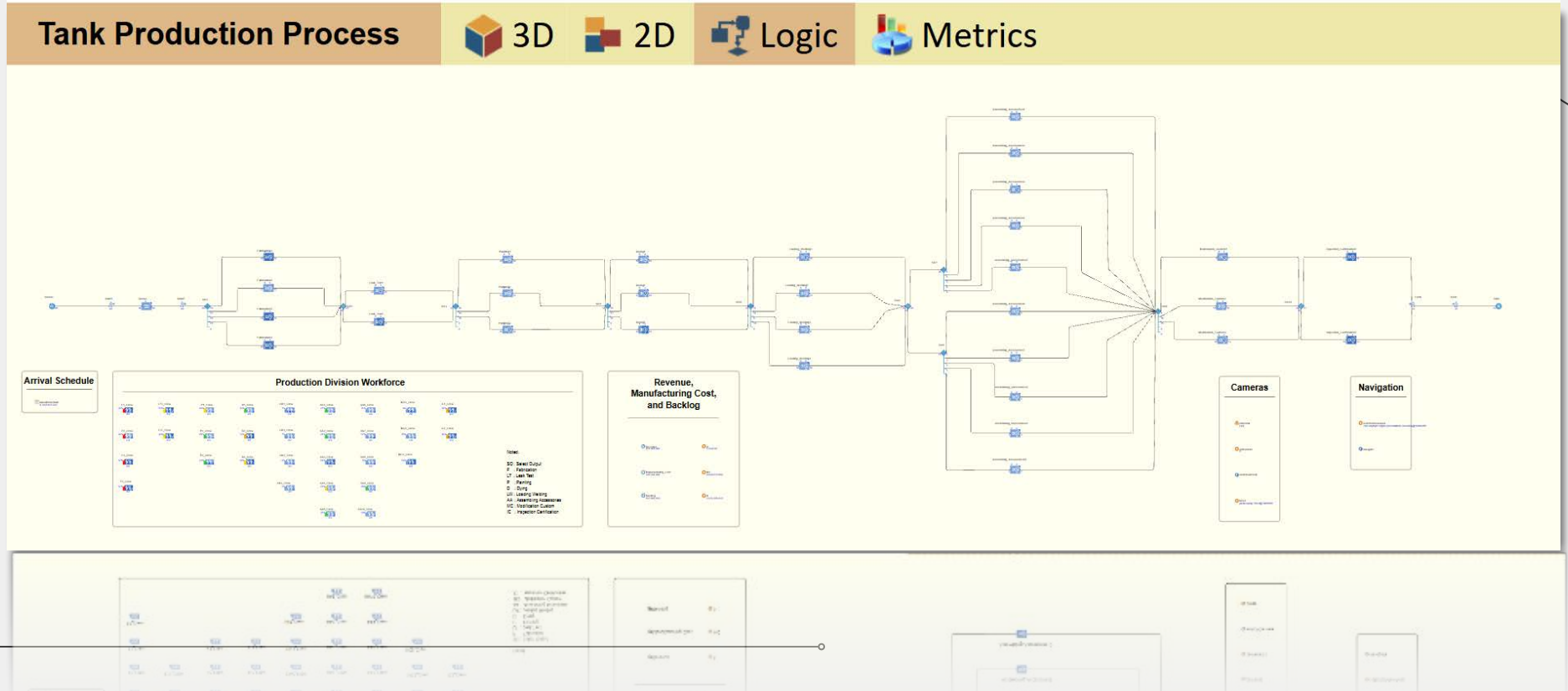
Breakdown of Revenue

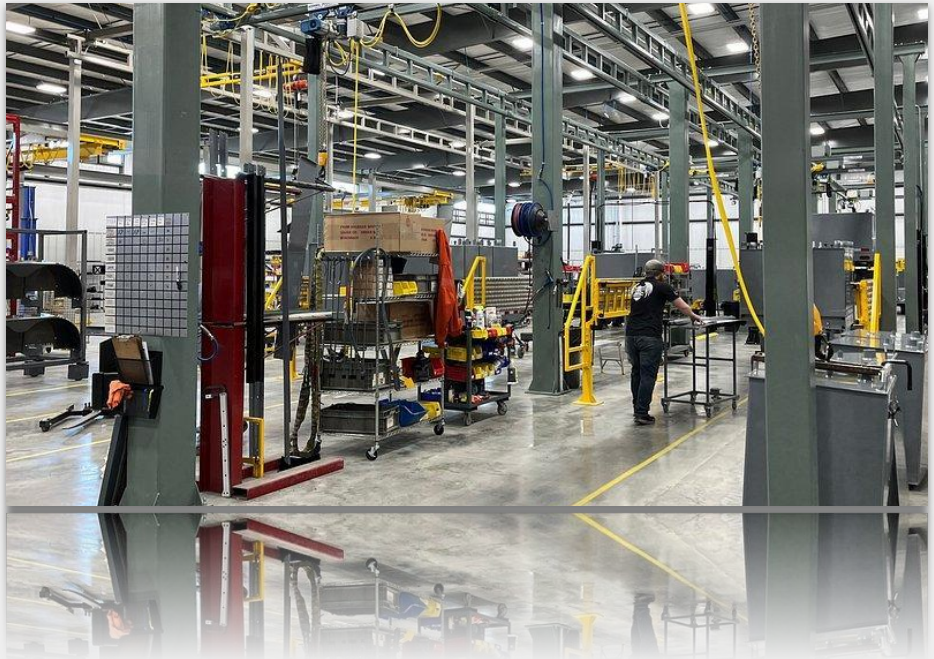
NO	DESCRIPTION	REVENUE (IDR)	REMARKS
1	5 KL Tank	IDR 135.000.000	Price / unit
2	8 KL Tank	IDR 160.000.000	Price / unit
3	10 KL Tank	IDR 185.000.000	Price / unit
4	16 KL Tank	IDR 240.000.000	Price / unit
5	24 KL Tank	IDR 585.000.000	Price / unit
6	**32 KL Tank**	**IDR 670.000.000**	Price / Tank **(ordered unit by Pertamina)**
7	40 KL Tank	IDR 720.000.000	Price / unit

05

Computational Model

Wireline Diagram (Logic) on AnyLogic





06

Verification

Verification

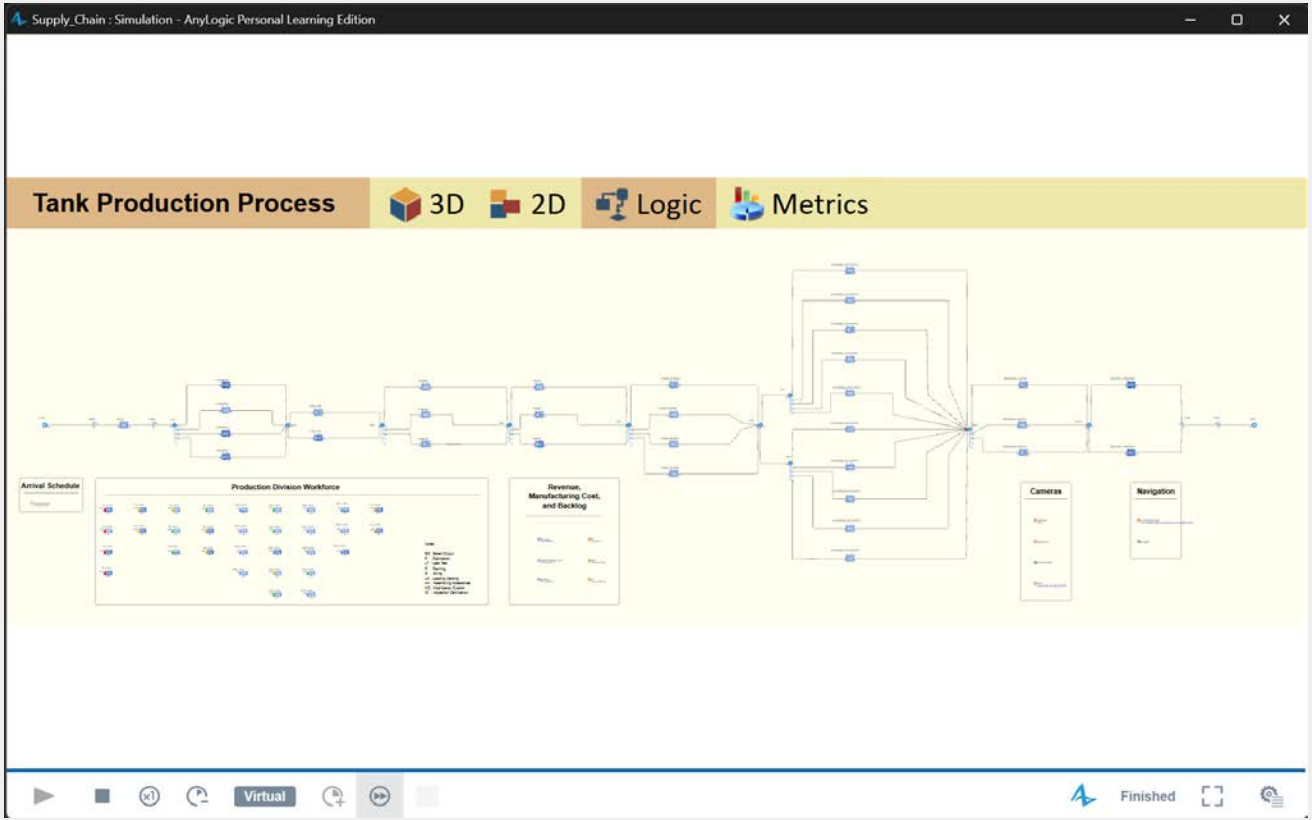
The simulation model includes all parameters, agents, functions, variables, and processes needed, such as the following:

- **Processes:** Fabrication, Leak Test, Painting, Drying, Loading & Welding, Assembling Accessories, Modification Custom, and Inspection & Certification.
- **Resource Pool (Production Division Workforce):** Fabricator Crew (4 workstations with 4 workers each), Leak Tester (2 workstations with 2 workers each), Painter (3 workstations with 4 workers each), Dryer (3 workstations with 2 workers each), Loader & Welder (4 workstations with 3 workers each), Assembling Accessories (10 workstations with 3 workers each), Modification & Custom (3 workstations with 4 workers each), and Inspection & Certification (2 workstations with 3 workers each).
- **Agents:** Main, Tank, Fabricator, LeakTester, Painter, Driyer, Loader_Welder, AccessoriesAssembler, CustomModificator, and CertificationInspector.
- **Schedule:** Arrival Schedule (Weekday on Monday-Friday by average of 7 ordered tanks a week)
- **Parameters:** Revenue, Manufacturing Cost, and Backlog.
- **Functions:** Switch-Camera, and Navigate.
- **Variables:** R (Revenue), MC (Manufacturing Cost), B (Backlog), Camera, Timer, and Selected View Area.

Verification

The simulation model could run well without any bugs or errors until the simulation finished running, such as in the following examples:

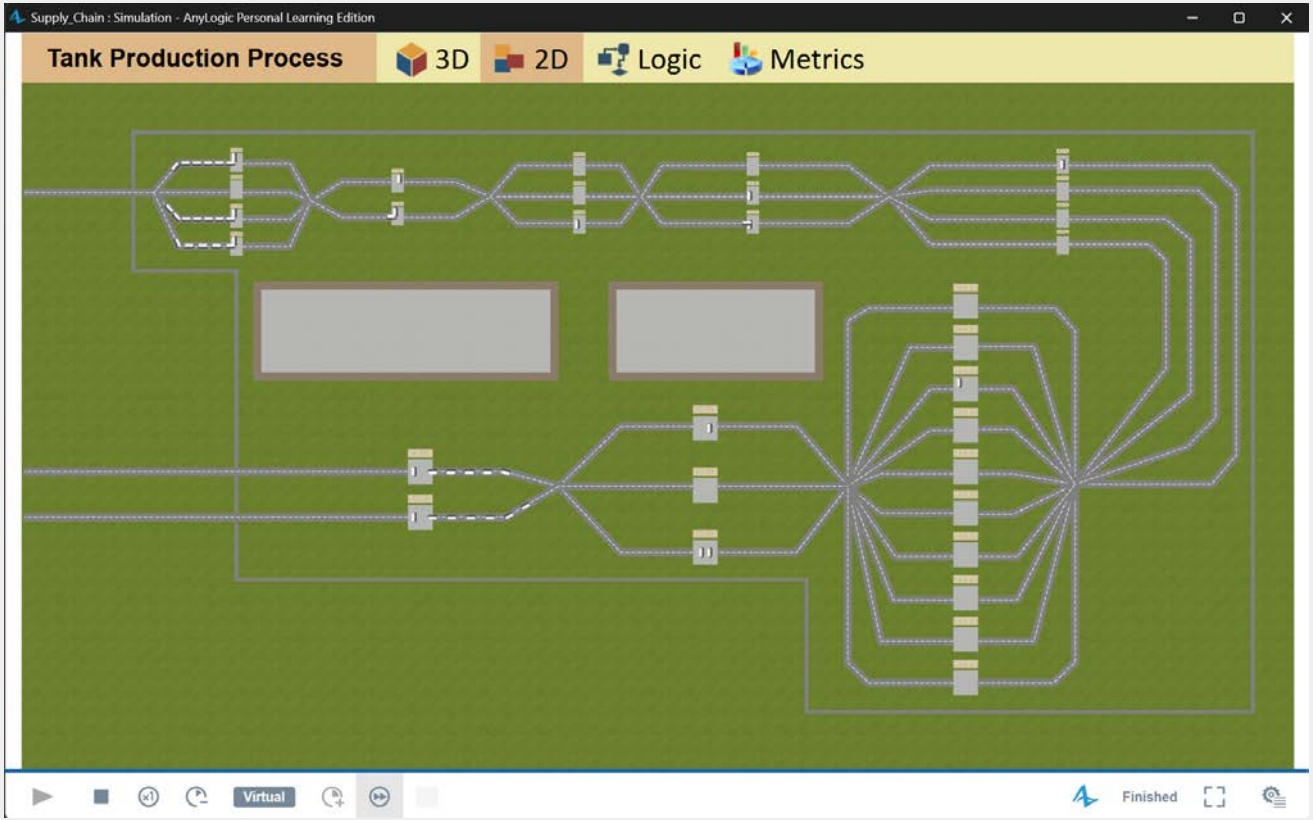
Logic



Verification

The simulation model could run well without any bugs or errors until the simulation finished running, such as in the following examples:

2D



Verification

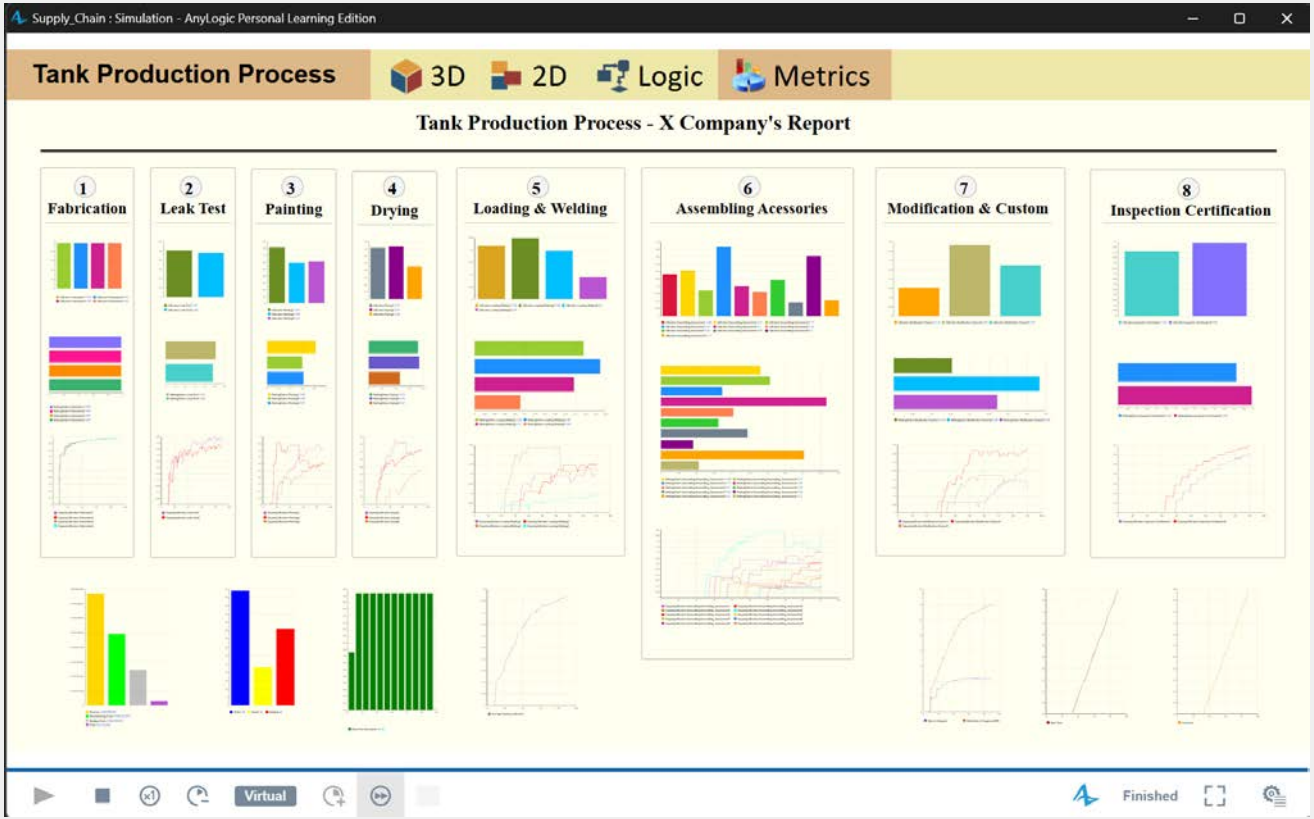
The simulation model could run well without any bugs or errors until the simulation finished running, such as in the following examples:

3D

Verification

The simulation model could run well without any bugs or errors until the simulation finished running, such as in the following examples:

Metrics (Analysis)



07

Validation

Validation

We're running by the model time unit based on daily as per the real one from the case with the real time scale 1 as the execution mode by the stop at specified time 90 calendar days. The following is the result (for the initial condition without any strategy scenario intervention) after we compared by the face validation (asking people knowledgeable / experienced system under study) at the workshop:

- The simulation model generated revenue, manufacturing costs, backlog costs, and profit almost exactly almost like in the company's real situation at the moment.
- The simulation model generated total order, backlogs, and outputs almost exactly almost like in the company's real situation at the moment.
- The simulation model generated flow time, and lead time almost exactly almost like in the company's real situation at the moment.

We've processed the detail output data validation and compared them between the actual and the simulation data (for the initial condition that without any strategy scenario intervention) in order to get the minimum % confidence level result >= 75% or approach 80%. So, according to the following table result of % of confidence level, our model could be said to be valid.

Description	Average of Lead time	Number of Outputs	Number of Backlogs	Revenue	Manufacturing Costs	Backlog Costs	Profit
Real Condition	75 Days	29	58	Rp. 19,430,000,000	Rp. 12,417,816,240	Rp. 6,208,908,120	Rp. 803,275,640
Simulation	59 Days	24	46	Rp. 15,410,000,000	Rp. 9,849,000,000	Rp. 4,924,000,000	Rp. 637,100,000
% of Confidence Level	78.667%	82.759%	79.310%	79.310%	79.313%	79.310%	79.313%

08

Experiment Scenario / Design

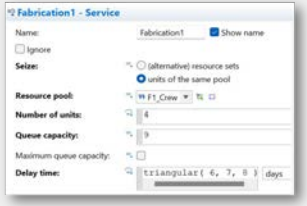
The Current Initial (Default) Condition Simulation (No Strategy Intervention)

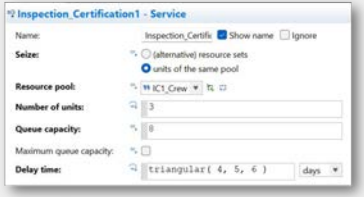
This simulation dashboard is for the tank production process at PT. X to track various stages of production with no interference strategy with corresponding metrics resulted that **after 90 days,** only a total 69 tanks went into production; **23 tanks are completed**, **while 46 tanks are backlog (uncompleted)**. The total profit and revenue were only Rp. 637,100,000 and Rp. 15,410,000,000, while the total manufacturing costs and the backlog costs were Rp. 9,849,000,000 and Rp. 4,924,000,000. This simulation result aligned with the real condition (see the previous chapter). Thus, we need to conduct some experiments (strategy scenario) to improve the optimal profit and the lead time. Please see the result from this strategy scenario in the next chapter.

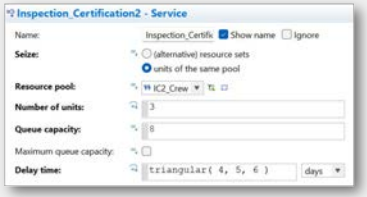
THE #1 STRATEGY SCENARIO (EXPERIMENT #1)

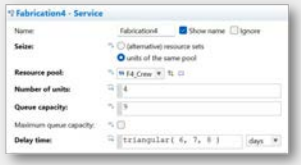
For the first experiment, we setup the following data:

BEFORE





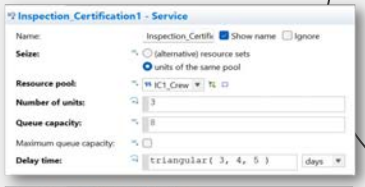


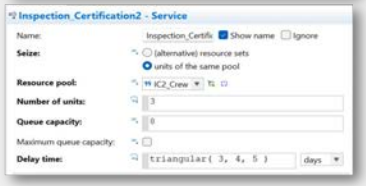


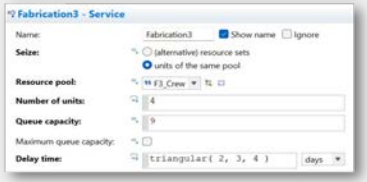
Fabrication 1-4
Number of units : 4
Queue Capacity : 9
Delay time: triangular (6,7,8)

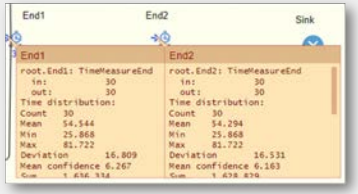
Inspection Certification 1-2
Number of units : 3
Queue Capacity : 8
Delay Time :triangulars (4,5,6)

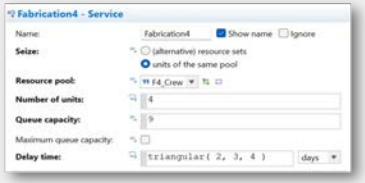
AFTER











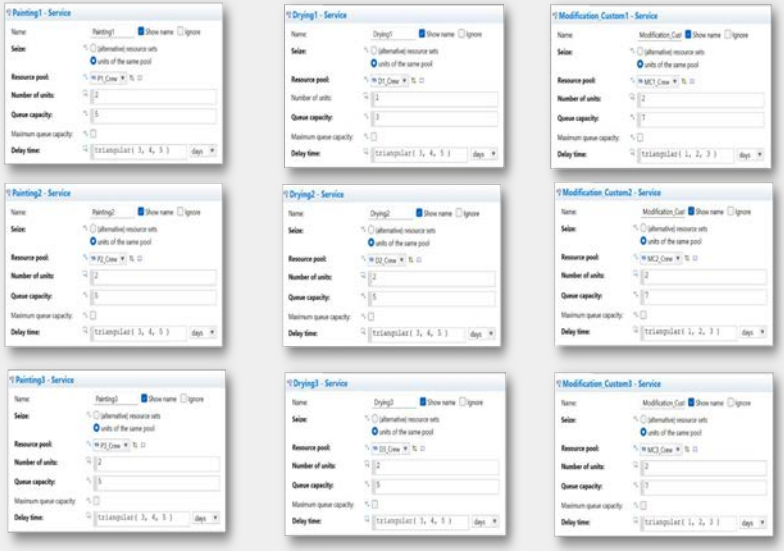
Fabrication 1-4
Number of units : 4
Queue Capacity : 9
Delay time: triangular (2, 3, 4)

Inspection Certification 1-2
Number of units : 3
Queue Capacity : 8
Delay Time :triangulars (3,4,5)

THE #2 STRATEGY SCENARIO (EXPERIMENT #2)

For the second experiment, we setup the following data:

BEFORE



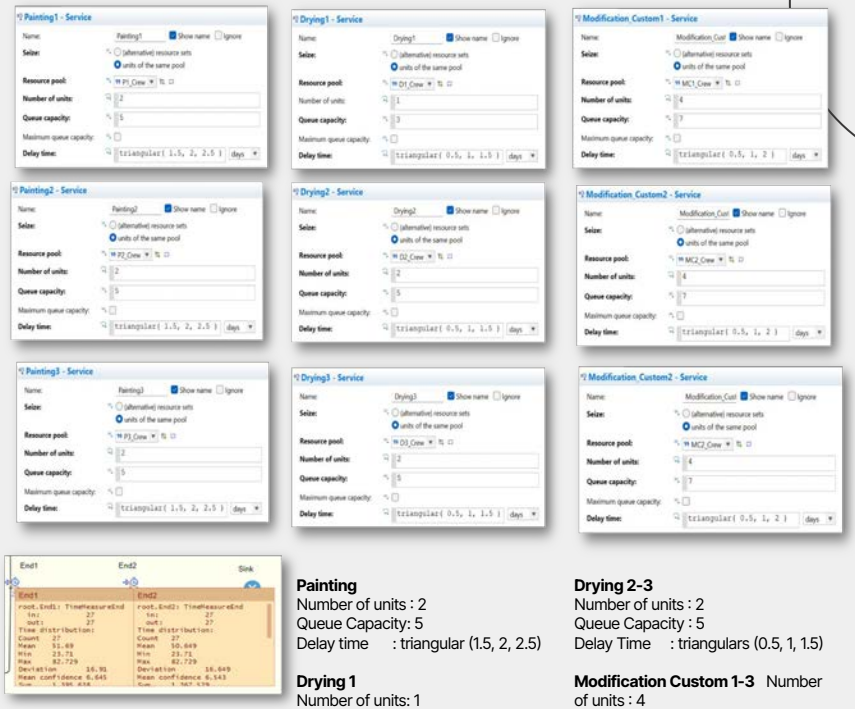
Painting 1-3
Number of units : 2
Queue Capacity: 5
Delay time : triangular (3,4,5)

Drying 1
Number of units : 1
Queue Capacity : 3
Delay Time : triangulars (3,4,5)

Drying 2-3
Number of units : 2
Queue Capacity : 5
Delay Time : triangulars (3,4,5)

Modification Custom 1-3 Number of units : 2
Queue Capacity : 7
Delay Time : triangulars (1,2,3)

AFTER



Painting
Number of units : 2
Queue Capacity: 5
Delay time : triangular (1.5, 2, 2.5)

Drying 1
Number of units: 1
Queue Capacity : 3
Delay Time :triangulars (0.5, 1, 1.5)

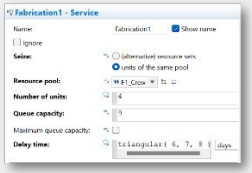
Drying 2-3
Number of units : 2
Queue Capacity : 5
Delay Time : triangulars (0.5, 1, 1.5)

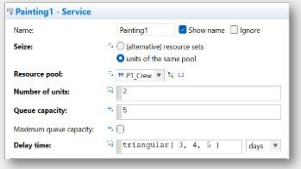
Modification Custom 1-3 Number of units : 4
Queue Capacity : 7
Delay Time : triangulars (0.5, 1, 2)

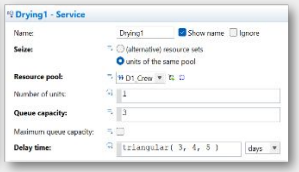
THE #3 STRATEGY SCENARIO (EXPERIMENT #3)

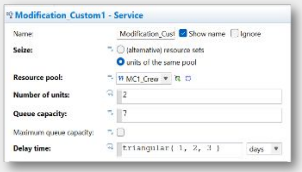
For the third experiment, we setup the following data:

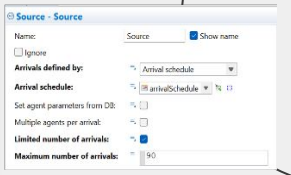
BEFORE

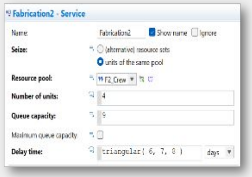


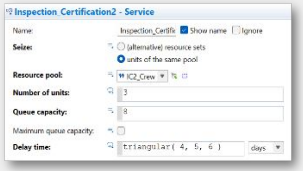


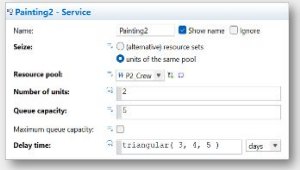


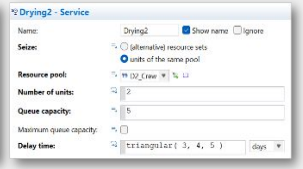


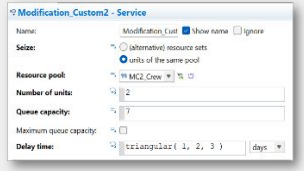


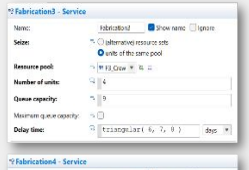


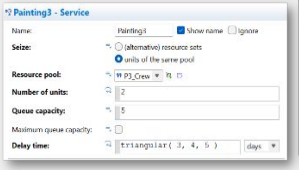


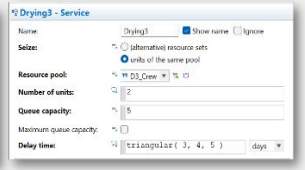


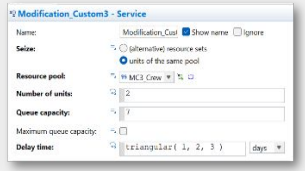


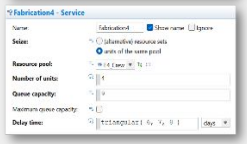












Fabrication 1-4
Number of units : 4
Queue Capacity : 9
Delay time : triangular (6,7,8)

Inspection Certification 1-2
Number of units : 3
Queue Capacity : 8
Delay Time :triangulars (4,5,6)

Painting 1-3
Number of units : 2
Queue Capacity: 5
Delay time : triangular (3,4,5)

Drying 1
Number of units : 1
Queue Capacity : 3
Delay Time : triangulars (3,4,5)

Drying 2-3
Number of units : 2
Queue Capacity : 5
Delay Time : triangulars (3,4,5)

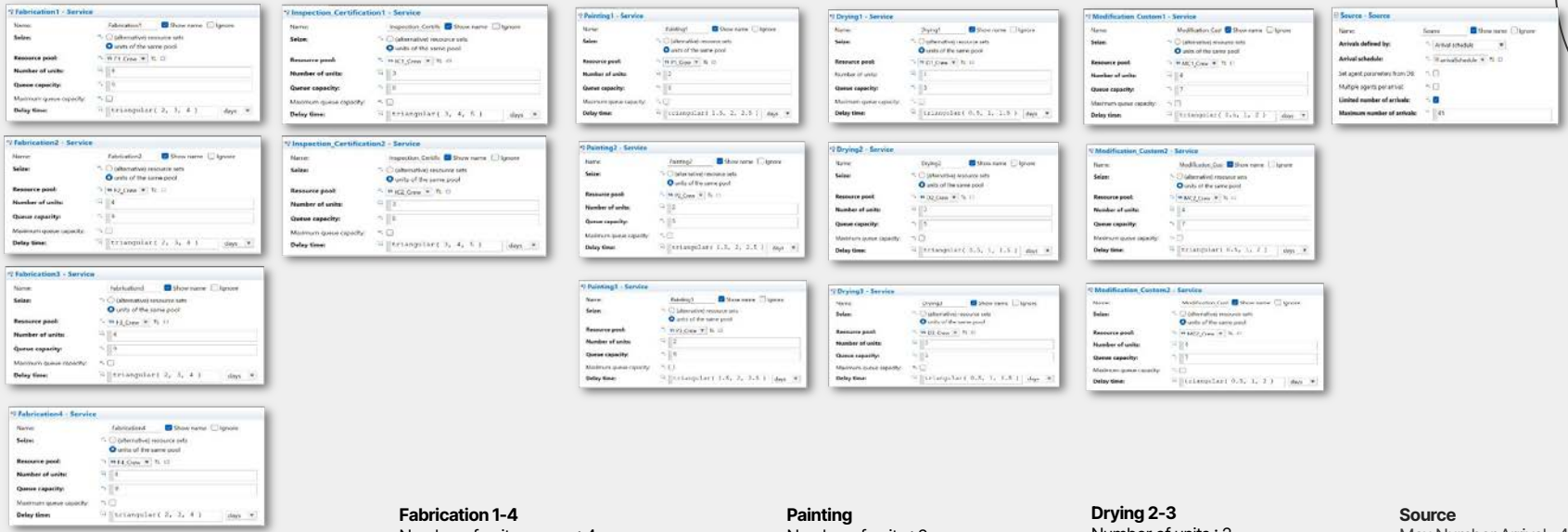
Modification Custom 1-3
Number of units : 2
Queue Capacity : 7
Delay Time : triangulars (1,2,3)

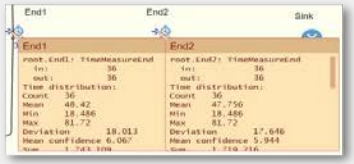
Source
Max Number Arrival: 90

THE #3 STRATEGY SCENARIO (EXPERIMENT #3)

For the third experiment, we setup the following data:

AFTER





Fabrication 1-4
Number of units : 4
Queue Capacity : 9
Delay time : triangular (2, 3, 4)

Inspection Certification 1-2
Number of units : 3
Queue Capacity : 8
Delay Time :triangulars (3,4,5)

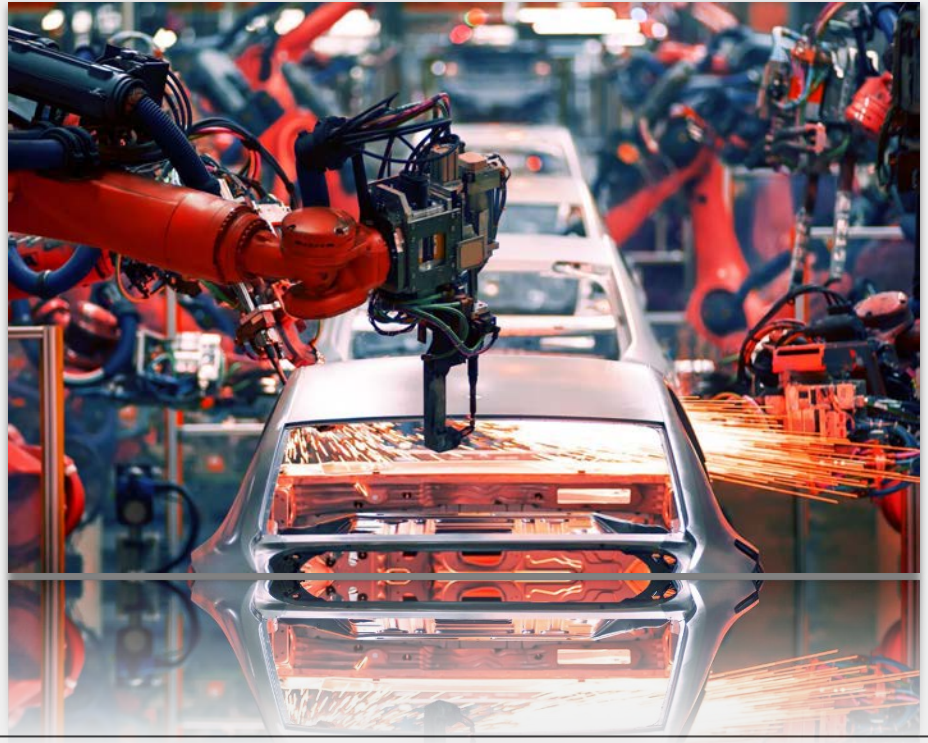
Painting
Number of units : 2
Queue Capacity: 5
Delay time : triangular (1.5, 2, 2.5)

Drying 1
Number of units: 1
Queue Capacity : 3
Delay Time :triangulars (0.5, 1, 1.5)

Drying 2-3
Number of units : 2
Queue Capacity : 5
Delay Time : triangulars (0.5, 1, 1.5)

Modification Custom 1-3
Number of units : 4
Queue Capacity : 7
Delay Time : triangulars (0.5, 1, 2)

Source
Max Number Arrival: 45



09

Results

Results

Comparison KPIs for financial and operational performance

KPI	DEFAULT (NO INTERFERENCE STRATEGY SCENARIO)	THE 1st STRATEGY SCENARIO (EXPERIMENT #1)	CHANGE (GAP) #1	THE 2nd STRATEGY SCENARIO (EXPERIMENT #2)	CHANGE (GAP) #2	THE 3rd STRATEGY SCENARIO (EXPERIMENT #3)	CHANGE (GAP) #3
Revenue	**Rp15,410,000,000.00**	**Rp20,100,000,000.00**	**30.435%**	**Rp18,090,000,000.00**	**-10.000%**	**Rp24,120,000,000.00**	**-10.00%**
Manufacturing Costs	Rp9,849,000,000.00	Rp12,850,000,000.00	30.470%	Rp11,560,000,000.00	-10.039%	Rp15,420,000,000.00	-10.04%
Backlog Costs	Rp4,924,000,000.00	Rp4,389,000,000.00	-10.865%	Rp3,426,000,000.00	-21.941%	Rp3,104,000,000.00	-21.94%
Total Costs	**Rp14,773,000,000.00**	**Rp17,239,000,000.00**	16.693%	**Rp14,986,000,000.00**	**-13.069%**	**Rp18,524,000,000.00**	**-13.07%**
Profit	**Rp637,100,000.00**	**Rp2,865,000,000.00**	**349.694%**	**Rp3,103,000,000.00**	**8.307%**	**Rp5,600,000,000.00**	**8.31%**
Customer Orders	69	71	2.899%	59	-16.901%	65	-16.90%
Output (orders)	23	30	30.435%	27	-10.000%	36	-10.00%
Backlog (orders)*	46	41	-10.870%	32	-21.951%	29	-21.95%
Service Level, %	**33.33%**	**42.25%**	**26.761%**	**45.76%**	**8.305%**	**55.38%**	**3.51%**
Unit Costs	**Rp642,304,347.83**	**Rp574,633,333.33**	**-10.536%**	**Rp555,037,037.04**	**-3.410%**	**Rp514,555,555.56**	**-3.41%**
Unit Profit	**Rp27,700,000.00**	**Rp95,500,000.00**	**244.765%**	**Rp114,925,925.93**	**20.341%**	**Rp155,555,555.56**	**20.34%**
Mean Capacity Utiliza-tion,% : Average	**45.535%**	**52.96%**	**7.429%**	**37.75%**	-0.152	**51.98%**	-0.152
Fabrication1	0.974	0.974	0.000	0.973	-0.001	0.969	-0.001
Fabrication2	0.973	0.598	-0.375	0.968	0.370	0.946	0.370
Fabrication3	0.973	0.961	-0.012	0.973	0.012	0.969	0.012
Fabrication4	0.974	0.973	-0.001	0.965	-0.008	0.965	-0.008
Leak Test1	0.508	0.912	0.404	0.530	-0.382	0.943	-0.382
Leak Test2	0.480	0.415	-0.065	0.394	-0.021	0.720	-0.021
Painting1	0.818	1.056	0.238	0.446	-0.610	0.539	-0.610
Painting2	0.594	0.801	0.207	0.270	-0.531	0.713	-0.531
Painting3	0.615	0.835	0.220	0.266	-0.569	0.425	-0.569
Drying1	0.718	0.822	0.104	0.148	-0.674	0.216	-0.674
Drying2	0.734	0.873	0.139	0.247	-0.626	0.205	-0.626
Drying3	0.454	0.742	0.288	0.114	-0.628	0.381	-0.628

Results

Comparison KPIs for financial and operational performance

KPI	DEFAULT (NO INTERFERENCE STRATEGY SCENARIO)	THE 1st STRATEGY SCENARIO (EXPERIMENT #1)	CHANGE (GAP) #1	THE 2nd STRATEGY SCENARIO (EXPERIMENT #2)	CHANGE (GAP) #2	THE 3rd STRATEGY SCENARIO (EXPERIMENT #3)	CHANGE (GAP) #3
Loading Welding1	0.216	0.294	0.078	0.218	-0.076	0.236	-0.076
Loading Welding2	0.249	0.293	0.044	0.200	-0.093	0.484	-0.093
Loading Welding3	0.197	0.230	0.033	0.234	0.004	0.525	0.004
Loading Welding4	0.091	0.141	0.050	0.118	-0.023	0.147	-0.023
Assembling Accessories1	0.280	0.170	-0.110	0.159	-0.011	0.280	-0.011
Assembling Accessories2	0.307	0.231	-0.076	0.295	0.064	0.402	0.064
Assembling Accessories3	0.173	0.216	0.043	0.345	0.129	0.403	0.129
Assembling Accessories4	0.466	0.511	0.045	0.148	-0.363	0.609	-0.363
Assembling Accessories5	0.204	0.394	0.190	0.288	-0.106	0.422	-0.106
Assembling Accessories6	0.162	0.386	0.224	0.065	-0.321	0.502	-0.321
Assembling Accessories7	0.244	0.277	0.033	0.425	0.148	0.321	0.148
Assembling Accessories8	0.091	0.108	0.017	0.251	0.143	0.241	0.143
Assembling Accessories9	0.403	0.210	-0.193	0.364	0.154	0.193	0.154
Assembling Accessories10	0.107	0.262	0.155	0.231	-0.031	0.681	-0.031
Modification Custom1	0.153	0.309	0.156	0.199	-0.110	0.298	-0.110
Modification Custom2	0.383	0.306	-0.077	0.090	-0.216	0.315	-0.216
Modification Custom3	0.272	0.399	0.127	0.266	-0.133	0.466	-0.133
Inspection Certification1	0.612	0.701	0.089	0.767	0.066	0.797	0.066
Inspection Certification2	0.691	0.672	-0.019	0.747	0.075	0.802	0.075

Results

Comparison KPIs for financial and operational performance

KPI	DEFAULT (NO INTERFERENCE STRATEGY SCENARIO)	THE 1st STRATEGY SCENARIO (EXPERIMENT #1)	CHANGE (GAP) #1	THE 2nd STRATEGY SCENARIO (EXPERIMENT #2)	CHANGE (GAP) #2	THE 3rd STRATEGY SCENARIO (EXPERIMENT #3)	CHANGE (GAP) #3
Average Waiting Cus-tomer Orders	0.974	0.877	-0.097	0.970	0.093	0.962	0.093
Average WIP **Total**	**10.222**	**12.566**	**0.229**	**7.825**	**-4.741**	**12.266**	**-4.741**
Leak Test1	0.508	0.912	0.404	0.530	-0.382	0.943	-0.382
Leak Test2	0.480	0.415	-0.065	0.394	-0.021	0.720	-0.021
Painting1	0.818	1.056	0.238	0.446	-0.610	0.539	-0.610
Painting2	0.594	0.801	0.207	0.270	-0.531	0.713	-0.531
Painting3	0.615	0.835	0.220	0.266	-0.569	0.425	-0.569
Drying1	0.718	0.822	0.104	0.148	-0.674	0.216	-0.674
Drying2	0.734	0.873	0.139	0.247	-0.626	0.205	-0.626
Drying3	0.454	0.742	0.288	0.114	-0.628	0.381	-0.628
Loading Welding1	0.216	0.294	0.078	0.218	-0.076	0.236	-0.076
Loading Welding2	0.249	0.293	0.044	0.200	-0.093	0.484	-0.093
Loading Welding3	0.197	0.230	0.033	0.234	0.004	0.525	0.004
Loading Welding4	0.091	0.141	0.050	0.118	-0.023	0.147	-0.023
Assembling Accessories1	0.280	0.170	-0.110	0.159	-0.011	0.280	-0.011
Assembling Accessories2	0.307	0.231	-0.076	0.295	0.064	0.402	0.064
Assembling Accessories3	0.173	0.216	0.043	0.345	0.129	0.403	0.129
Assembling Accessories4	0.466	0.511	0.045	0.148	-0.363	0.609	-0.363
Assembling Accessories5	0.204	0.394	0.190	0.288	-0.106	0.422	-0.106
Assembling Accessories6	0.162	0.386	0.224	0.065	-0.321	0.502	-0.321
Assembling Accessories7	0.244	0.277	0.033	0.425	0.148	0.321	0.148
Assembling Accessories8	0.091	0.108	0.017	0.251	0.143	0.241	0.143
Assembling Accessories9	0.403	0.210	-0.193	0.364	0.154	0.193	0.154
Assembling Accessories10	0.107	0.262	0.155	0.231	-0.031	0.681	-0.031

Results

Comparison KPIs for financial and operational performance

KPI	THE 1st STRATEGY SCENARIO (EXPERIMENT #1)	CHANGE (GAP) #1	THE 2nd STRATEGY SCENARIO (EXPERIMENT #2)	CHANGE (GAP) #2	THE 3rd STRATEGY SCENARIO (EXPERIMENT #3)	CHANGE (GAP) #3
Modification Custom1	0.309	0.156	0.199	-0.110	0.298	-0.110
Modification Custom2	0.306	-0.077	0.090	-0.216	0.315	-0.216
Modification Custom3	0.399	0.127	0.266	-0.133	0.466	-0.133
Inspection Certification1	0.701	0.089	0.767	0.066	0.797	0.066
Inspection Certification2	0.672	-0.019	0.747	0.075	0.802	0.075
Lead Time, days**		-4.535 Days		-3.895 Days		-2.229 Days
Average	**54.544**	**-7.676%**	**50.649**	**-7.141%**	**48.420**	**-7.141%**
Min	25.868		23.710		18.486	
Max	81.722		82.729		81.720	
Deviation	16.809		16.649		18.013	
Flow Time, days**		-4.535 Days		-3.895 Days		-2.229 Days
Average	**54.544**	**-7.676%**	**50.649**	**-7.141%**	**48.420**	**-7.141%**
Min	25.868		23.710		18.486	
Max	81.722		82.729		81.720	
Deviation	16.809		16.649		18.013	

Note:

**In this process, the Lead Time and the Flow Time are the same. Because in reality at the company, there is no waiting time between the processing phases and shipping (the goods moves to the next available workstation process as soon as they are done from the previous workstation phase in order to speed up the production process and also to avoid the penalty from the customer if the goods are not done to be sent to them on time without any delay).

10

Analysis & Discussion

1st Strategy Analysis

Step	Number of Units		Queue		Delay Time	
	S0	S1	S0	S1	S0	S1
Fabrication1	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Fabrication2	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Fabrication3	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Fabrication4	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Inspection_Certification1	3	3	8	8	triangular(4,5,6)	triangular(3,4,5)
Inspection_Certification2	3	3	8	8	triangular(4,5,6)	triangular(3,4,5)

Delay time improvement

The significant improvement in delay times in S1 requires a process optimisation effort such as:

- Improved workflow efficiency (e.g., better scheduling or enhanced worker productivity).
- Reduction of non-value-adding delays (e.g., waiting times, setup times, or rework).
- Streamlined processes to shorten the time required per tank at both fabrication and inspection stages.

Number of Units and Queue Size: The capacity (number of units) and the queue size remain unchanged between S0 and S1, meaning no additional equipment or resources were added, and the production bottleneck was not addressed by increasing throughput capacity.

The delay time (time required to complete each step) is modelled using triangular distributions (minimum, mode, and maximum values), showing the range and likelihood of time taken at each step:

S0 (Current Condition):

- Fabrication Steps: triangular distribution of (6, 7, 8) days.
- Inspection/Certification Steps: triangular distribution of (4, 5, 6) days.

S1 (1st Scenario):

- Fabrication Steps: **Reduced** delay times of (2, 3, 4) days, indicating a substantial improvement in process efficiency.
- Inspection/Certification Steps: **Reduced** delay times of (3, 4, 5) days, further accelerating the inspection process.

THE #1 STRATEGY SCENARIO (EXPERIMENT #1)

The simulation results for experiment #1 are depicted in the pictures. In this scenario, the intervention is changing the process of production time (delay time) in the fabrication process and the inspection certification process in their workstation because the comparison of in and out is large.

2nd Strategy Analysis

Step	Number of Units		Queue		Delay Time	
	S0	S2	S0	S2	S0	S2
Painting1	2	2	5	5	triangular(3,4,5)	triangular(1.5,2,2.5)
Painting2	2	2	5	5	triangular(3,4,5)	triangular(1.5,2,2.5)
Painting3	2	2	5	5	triangular(3,4,5)	triangular(1.5,2,2.5)
Drying1	2	1	5	3	triangular(3,4,5)	triangular(0.5, 1, 1.5)
Drying2	2	2	5	5	triangular(3,4,5)	triangular(0.5, 1, 1.5)
Drying3	2	2	5	5	triangular(3,4,5)	triangular(0.5, 1, 1.5)
Modification_Custom1	2	4	7	7	triangular(1,2,3)	triangular(0.5, 1, 2)
Modification_Custom2	2	4	7	7	triangular(1,2,3)	triangular(0.5, 1, 2)
Modification_Custom3	2	4	7	7	triangular(1,2,3)	triangular(0.5, 1, 2)

Delay Time Improvement

S0 (Current Condition):

- Painting Steps: Delay times are (3, 4, 5) days.
- Drying Steps: Delay times are (3, 4, 5) days.
- Modification Steps: Delay times are (1, 2, 3) days.

S2 (2nd scenario):

- Painting Steps: Delay times are reduced to (1.5, 2, 2.5) days, reflecting a 50% improvement.
- Drying Steps: Delay times are significantly reduced to (0.5, 1, 1.5) days, achieving a much faster turnaround.
- Modification Steps: Delay times are shortened to (0.5, 1, 2) days, streamlining the process further.

Painting Steps
Reduced by 50%, cutting task times nearly in half. This improvement accelerates the overall painting process, reducing bottlenecks.

Drying Steps
The most significant improvement, with times reduced to 16%-33% of S0 values. This change can contribute to a major enhancement in drying technology or workflow efficiency, which could improve production speed.

Modification Steps
Reduction of about 50% in task times, optimizing the customization stage and enabling tanks to progress more quickly through the final stages.

THE #2 STRATEGY SCENARIO (EXPERIMENT #2)

The simulation results for experiment #2 are depicted in the pictures. In this scenario, the production time (delay time) of the painting process, drying, and modification custom process. Please see the result from this strategy scenario in the next chapter.

3rd Strategy Analysis

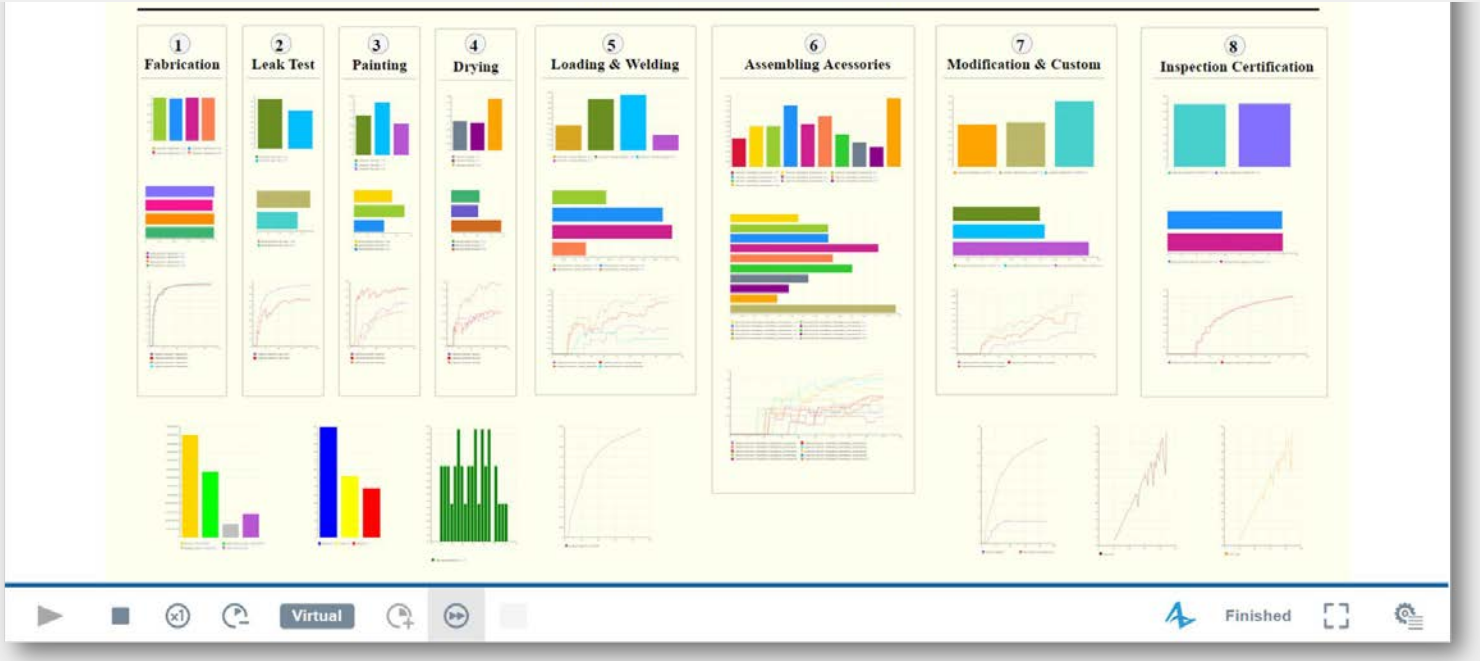
Step	Number of Units		Queue		Delay Time	
	S0	S3	S0	S3	S0	S3
Fabrication1	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Fabrication2	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Fabrication3	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Fabrication4	4	4	9	9	triangular(6,7,8)	triangular(2,3,4)
Inspection_Certification1	3	3	8	8	triangular(4,5,6)	triangular(3,4,5)
Inspection_Certification2	3	3	8	8	triangular(4,5,6)	triangular(3,4,5)
Painting1	2	2	5	5	triangular(3,4,5)	triangular(1.5,2,2.5)
Painting2	2	2	5	5	triangular(3,4,5)	triangular(1.5,2,2.5)
Painting3	2	2	5	5	triangular(3,4,5)	triangular(1.5,2,2.5)
Drying1	2	1	5	3	triangular(3,4,5)	triangular(0.5, 1, 1.5)
Drying2	2	2	5	5	triangular(3,4,5)	triangular(0.5, 1, 1.5)
Drying3	2	2	5	5	triangular(3,4,5)	triangular(0.5, 1, 1.5)
Modification_Custom1	2	4	7	7	triangular(1,2,3)	triangular(0.5, 1, 2)
Modification_Custom2	2	4	7	7	triangular(1,2,3)	triangular(0.5, 1, 2)
Modification_Custom3	2	4	7	7	triangular(1,2,3)	triangular(0.5, 1, 2)

Step	Maximum Number of Arrival	
	S0	S3
Source	90	45

Essentially, the 3rd strategy is a mixture between S1 & S3, and it's added by an improvement in the source step from the maximum number of arrivals of 90 to 45, which means:

- The maximum arrival is limited to 45 tanks at a time to avoid long queues at the initial phase before entering the first production stage.
- The total contract requires producing 90 tanks, with an average of 7 tanks arriving per week.
- If the limit is set too low (e.g., 7 tanks arriving simultaneously), fewer orders can be completed, leaving workers idle and reducing efficiency.
- The 45-tank limit doesn't restrict the total number of tanks in the contract (90); it only limits how many can enter the queue at a time.
- Once a tank is completed, the next tank in the sequence (e.g., tank #46 onwards) can enter the queue, maintaining the flow.
- The objective is to achieve optimal profit by ensuring that output exceeds backlogs within the 90-day production cycle (given the lead time for 1 tank is 90 days under normal conditions).
- If the arrival limit is too small, revenue and profit will decrease due to underutilized capacity.
- Conversely, if the arrival limit is too high, backlogs will increase, leading to higher manufacturing and backlog costs, which will also reduce profit.

THE #3 STRATEGY SCENARIO (EXPERIMENT #3)



The 3rd scenario objective is to achieve optimal profit, therefore output > backlogs. The previous condition was more orders received in the production process, impacting more manufacturing costs and WIP costs, so the profit is getting smaller. The intervention applied in scenario 3 maximises the capacity to receive the order from 90 to 45 (reducing 50%) for the beginning to avoid the long queue at the beginning stages (when the tank orders are coming) before the first stage (fabrication). Please see the result from this strategy scenario in the next chapter.

COMPARATIVE SUMMARY

Scenario	Revenue (Rp)	Manufacturing Costs (Rp)	Backlog Costs (Rp)	Profit (Rp)	Profit Growth (%)
Current	15.4 billion	9.8 billion	4.9 billion	637 million	-
1st Strategy	20.1 billion	12.8 billion	4.3 billion	2.8 billion	+64.4%
2nd Strategy	18.9 billion	11.5 billion	3.4 billion	3.1 billion	+84.4%
3rd Strategy	24.1 billion	15.4 billion	3.1 billion	5.6 billion	+110.9%

From the experiment results toward three strategies that have been shown in the previous part, we can conclude that:

Default Scenario (No Interference Strategy):

- High backlog due to 46 tanks remaining incomplete due to limited capacity, incurring substantial penalty costs.
- Profit margins are the lowest across all scenarios due to a combination of inefficiencies and penalties.
- The inability to scale production to meet the order results in underutilised revenue potential.

The 1st Strategy:

- Revenue increases significantly due to improved delivery of tanks.
- While manufacturing costs rise slightly, profitability improves drastically due to lower backlog penalties.

The 2nd Strategy:

- Higher revenue and reduced penalties result in a substantial profit increase.
- The strategy reflects a balanced trade-off between cost increases and efficiency gains.

The 3rd Strategy:

- The highest revenue and lowest backlog penalties across all scenarios.
- While manufacturing costs increase significantly, profitability more than doubles compared to the default scenario.

STRATEGY SCENARIO ANALYSIS

The graph shows the financial outcomes of four production scenarios aimed at optimizing profits for PT X's backlog challenge. The initial true condition has the lowest revenue, high manufacturing costs, and high backlog costs. The first strategy shows a noticeable increase in revenue due to improved scheduling or capacity adjustments, while manufacturing costs slightly increase due to higher production activity. Backlog costs decline, signalling progress in addressing delays. Profit rises significantly, showcasing the positive financial impact of operational changes. The second strategy shows revenue continues to climb while manufacturing costs rise further, indicating continued success in reducing penalties. The third strategy shows revenue peaking, manufacturing costs are highest, backlog costs reach their lowest point, and profit is the highest across all scenarios, demonstrating the success of aggressive capacity expansion.

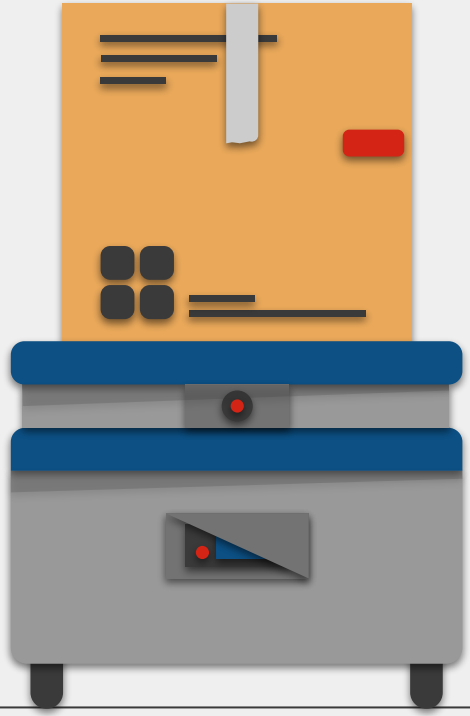
Therefore, according to the chart, the optimal best strategy scenario to be implemented is the third strategy scenario due to the total number of outputs (36) > the total number of backlogs (29), which impact the company's profit (Rp. 5600000000) > the backlog costs (Rp. 3104000000).

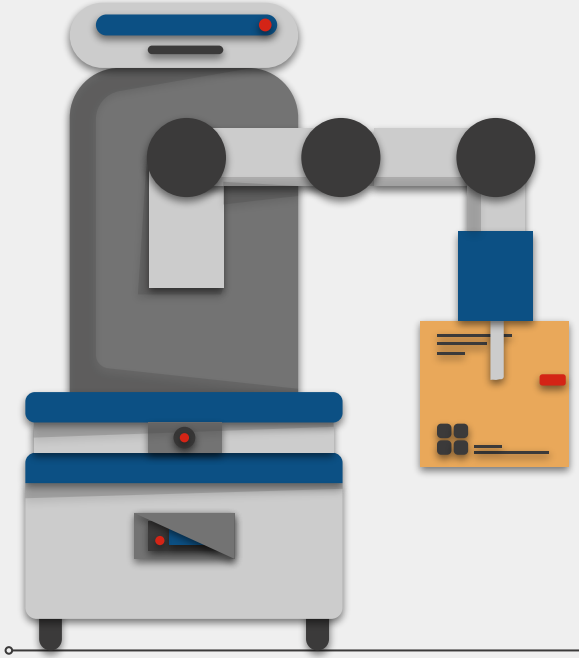
11

Suggestion

Suggestion

1. We suggest that it's necessary to add at least 1 more workstation for the leak test area to speed up the production process in the future.
2. We suggest that it's necessary to use automation from the spray booth for painters to speed up work in the painting area so that it can cut the delay time.
3. We suggest that it's necessary to upgrade from a small oven to a large oven equipped with a drying automation feature from the spray booth oven for the dryer to speed up work in the drying area so that it could cut the delay time.
4. Currently, production is carried out in 5 working days a week, namely Monday-Friday. We suggest that to speed up the process, overtime could be provided for employees on Saturdays.





"Hard work beats talent when talent doesn't work hard."

- Tim Notke -

"You don't have to be great to start, but you have to start to be great."

- Zig Ziglar -

"The difference between ordinary and extraordinary is that little extra."

- Jimmy Johnson -

Thanks!

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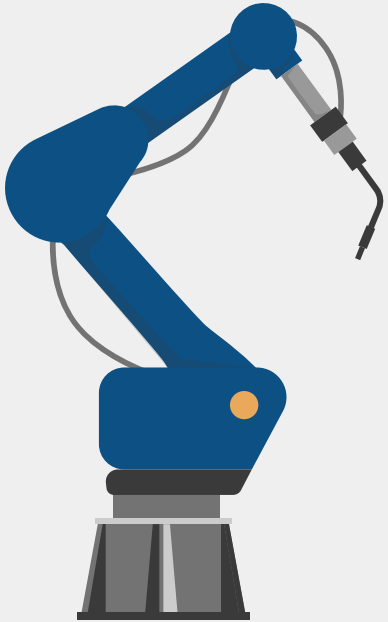

The Modelling for Business

2024