

## Digital Twins and their Ability to Drive Adaptation

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# Agenda

Manufacturing and Supply Chain Challenges

The "Intelligent" Supply Chain Game

What is a "real" Digital Twin?

►Q&A



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## Today's Manufacturing & Supply Chain Challenges



Manufacturing has become the response buffer for supply chains as companies become leaner and the order behavior of the market changes

Customers demand increased product variety and configurability with smaller minimum order quantities, and shorter product life cycles requiring manufacturing agility

Facilities are handling increasingly complex operations with semi-flexible manufacturing resources to increase manufacturing agility also dealing with more complex supply chains

End customers are demanding shorter lead times and increased transparency into the supply chain performance with predictable delivery times



Adapting to the VUCA world as global variability and uncertainty has increased while supply chains became more **complex** and available information more **ambiguous**.



## The Silent Supply Chain "Killers"





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# Imagine.....

### An "enterprise system" that.....

- 1. Represents your **end-to-end** manufacturing supply chain
- 2. Runs the supply chain across all time horizons and all supply chain functions in a continuous timeline in a single constraint model of the process
- 3. Allows you to make changes to the processes, business rules and decision logic
- 4. Contains dynamic dashboards and reports with key business KPIs and process specific results for detail analysis to support all stakeholders
- 5. Provides full **3D visualization** of the supply chain for presentation and validation
- Provides a platform that can accurately replicate the end-to-end process
  behavior for business optimization based on agreed KPIs and performance metrics



# The "Intelligent" Supply Chain Game

Let's visualize this new "*enterprise system*" as if it is a computer game?

- This is *game changing* so please bear with me for the next 30 min....
  - The game will entail a lot of detail
  - It might feel overwhelming
  - It might even feel somewhat repetitive
  - It might also be hard to follow all the game results

So please hang in there, at the end you will clearly see what is possible with this new Intelligent Adaptive Process Digital Twin technology to take your business to the next level



## The Intelligent Supply Chain Game Concepts

#### ▶ The game will consist of 5 levels of progression

- 2 levels in the operational timeframe
- 1 level in the Demand Driven S&OP timeframe
- 2 levels in the Adaptive S&OP timeframe ("impeding" and "what-if" strategical)
- Each level will have a specific business challenge to complete
- Some levels might require adjustments in game setting to improve business performance (Gross profit)

#### Evaluate the supply chain performance

- Production Schedules
- Inventory positions and cost
- Resource utilization and cost
- Warehouse utilization
- Constraint analysis
- Delivery performance
- Sales revenue
- Gross profit







### Supply Chain Map View





### Game Configuration: Factory Layout



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### Game Level 1 (operational)

### The **Level 1** challenge: *Traditional MRP base case*

- Sales orders for all products with 25% day to day variation
- Demand spike of 20% in week 3
- Reorder point/reorder quantity replenishment policy for RM & FG
- Run the operations very lean and cost effective
- Run the game for 30 days
  - Stating the 26<sup>th</sup> of January 2025

Analyze & understand the business performance of the base case using the standard *Reorder point/reorder quantity* replenishment method



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#### Level 1 Results: Gantt charts







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#### Level 1 Results





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#### Level 1 Results: Inventory and Utilization Dashboards







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#### Level 1 Results: Financial and Service Level Dashboards





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#### **Level 1 Results**





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## Game Level 2 (operational)

### The Level 2 challenge: *Operational DDMRP*

- Sales orders for all products with 25% day-to-day variation
- Demand spike of 20% in week 3
- Implement DDMRP replenishment policy for all RM and FG
- Run the game for 30 days
  - Stating the 26th of January 2025

Analyze & understand the impact and difference in business performance using the **DDMRP methodology** to manage the flow of material



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#### Level 2 Results: Inventory and Utilization Dashboards





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#### Level 2 Results: Financial and Service Level Dashboards





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#### Level 2 Results



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#### Level 2 Results





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#### Level 2 Results



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### Game Level 3 (Tactical)

### The Level 3 challenge: Demand Driven S&OP

- Start with the Level 2 configuration
- Perform Preventative Maintenance (PM) on Filling line #3
  - 12 to 13 Feb 2025 for 48 hours
- Game Hint: Some SKUs can only be filled on Filler line #3
- Run the game for 30 days
  - Stating the 26th of January 2025

Analyze and improve the impact of **Preventative Maintenance** on the business







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A 32		Material Availability	100_mL_Bottle.FL	FL_DO174_3	Filing3	0.045
N 30 -		Material Availability	100_mL_Bottle.FL	FL_DO185_2	Filing3	0.047
g 25 -		Material Availability	250_mL_Bottle.FL	FL_DO168_2	Filing2	0.035
1 20		Material Availability	250_mL_Bottle.FL	FL_DO168_3	Filing2	0.046
S 15 -		Material Availability	250_mL_Bottle.FL	FL_D0172_2	Filing2	0.035
te 10 -		Material Availability	250_mL_Bottle.FL	FL_DO175_2	Filling1	0.047
5 5-		Material Availability	250_mL_Bottle.FL	FL_DO175_3	Filing1	0.035
0		Material Availability	250_mL_Bottle.FL	FL_DO179_2	Filing1	0.035
	***************	Material Availability	250_mL_Bottle.FL	FL_DO179_3	Filing1	0.035
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		Material Availability	400_mL_Bottle.FL	FL_DO165_3	Filling2	0.035
		Material Availability	400_mL_Bottle.FL	FL_DO169_2	Filing3	0.035
		Material Availability	400_mL_Bottle.FL	FL_DO176_2	Filling2	0.035
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#### Level 2 Base Case

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WIPTank5	D014 D D0145 D01 C D D D D D0164 D01 D0176 D017 D D0 D	D D D	DO19 D D
WIPTank6	D D0 D014 D D0146 D D D D D0176 D D D	D01 D	DO196 DO2
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	Level	2 Base Case			Maintena	nce Re	esults
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		Constraint Type	Constraint Item	Order	Facility Location	Duration (Hrs)
	Material Availability	Material Availability	100_mL_Bottle.FL	FL_DO171_2	Filing1	0.035
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₹ <sup>35</sup>		Material Availability	100_mL_Bottle.FL	FL_DO174_3	Filing3	0.045
ν <sup>30</sup>		Material Availability	100_mL_Bottle.FL	FL_DO185_2	Filing3	0.047
g <sup>25</sup>		Material Availability	250_mL_Bottle.FL	FL_DO168_2	Filing2	0.035
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#### Level 3 Results – Maintenance



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#### **Maintenance Results**



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#### Base Case Results

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#### Maintenance Results



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#### **Maintenance Results** Sales Revenue by Site d'a T 23 Daily Revenue ch 00 Site Id th KS Weekly Revenue th \*\* Monthly Revenue (All) | Warehouse2 | Warehouse3 600K Late Orders 1 55 Mor rh 55 = 25 **Gross Profit** Grand Total 4.47M 4.7M רָז בָּבֶי Ord Order Status = \$10.9M LateOrders: 0.83% th a Weekly Costs and Revenue th to Monthly 由 55 Daily Costs and Revenue In In iting Cost 🧱 Sales Revenue 📰 Gross Profit (USD) 4008 1/26/2025 1/28/2025 1/30/2025 2/1/2025 2/3/2025 2/5/2025 2/7/2025 2/13/2025 2/15/2025 2/17/2025 2/19/2025 2/21/2025 2/9/2025 2/11 CT XX Mo ekly Cost and Re 由 23 Grand Total Operating Cost Sales Revenue Gross Profit (USD) Inventory Cost 1.22M 4.47M 2.53M /26/2025 718K 4.7M 1.444 2.5M 756K 2/9/2025 1.42M 4.86M 2.63M 820K 2/16/2025 731K 1.48M 621K 4.53M 2.32M 2/23/2025 338K 1.88M Grand Total 3.36M 6.18M 20.44 10.9M

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### Impact of the 2-Day Maintenance Event

#### Primary impact on 2 SKUs

- Red\_100\_mL\_Bottle
- Green\_400\_mL\_Bottle
- Bulk mix stuck in WIP tanks #1, 2, 3, 4 and 6
- Resulting in 11 more late orders
- Loss of \$400k in Gross profit

# What can we do about it?



## Game Level 3 Adjustments

### Adjustment Strategy

- Produce and Ship ahead, only those items that cause most lateness (Constraint Pareto)
- DDMRP Planned Adjustment Factors
  - From 8 to 10 Feb for each warehouse for products Green\_400 and Red\_100
  - Increase Yellow Zone by 20% (increase heart of the coverage)

Demand	Planned Adjustment Factors Buffe	r Profiles Average D	aily Usage Decoupled I	ead Times Buffer Zone Size	es Qualified Spike Demand		
	Inventory Name	Start Date	End Date	Demand Adjustment Factor	Red Zone Adjustment Factor	Yellow Zone Adjustment Factor	Geen Zone Adjustment Factor
▶ 1	Green_400_mL_Bottle_Warehouse1	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
2	Red_100_mL_Bottle_Warehouse1	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
3	Green_400_mL_Bottle_Warehouse2	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
4	Red_100_mL_Bottle_Warehouse2	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
5	Green_400_mL_Bottle_Warehouse3	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
6	Red_100_mL_Bottle_Warehouse3	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
7	Green_400_mL_Bottle_Warehouse4	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1
8	Red_100_mL_Bottle_Warehouse4	2/8/2025 12:00:00 AM	2/10/2025 12:00:00 AM	1		1.2	1









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#### **Adjustments Results** Before Maintenance 山口 **Gross Profit** Late Orders = \$11.3M **Gross Profit** 4.47M 4.7M th to Ord = \$11.1M LateOrders: 0.53% L \*\* Weekly Costs and Revenu th to the Honti di 11 III II Cost 🧱 Sales Revenue 📰 Gross Profit (USD th 55 M d 55 Gross Profit (USD) Operating Cost Sales Revenue 4.47M 2.53N 4.7M 2.5M 4.89M 2.66M 4.65M 2.51N 1.92M 20.68 11.1M

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### Game Level 4 (Impending Strategical)

#### The Level 4 challenge: Adaptive S&OP

- Strategic planning starting with Level 2 configuration
- Ongoing 25% day-to-day variation in demand across the whole period
- Evaluate the business impact of the expected 2025 summer lift in demand
  - First 2 weeks in June = 5% increase
  - Second 2 weeks in June = 10% increase
  - First 2 weeks in July = 20% increase
  - Second 2 weeks in July = 10% increase
- Run the game for 220 days (7.3 month)
  - Stating the 26th of January 2025
  - Ending late September 2025



Analyze and improve the impact of the expected **2025** *summer lift* in demand on the overall business performance







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#### Level 4 Results: Gantt Charts and Inventory Dashboards







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#### Level 5 Results: Inventory, Constraint and Financial Dashboards







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# Impact of the Summer Lift

- Congested factory for 6 to 8-week period
- Almost deplete the stock in the HUB down to 7%
- Resulting in 390 late orders
- Gross profit of \$72M

# What can we do about it?



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## Game Level 4 Adjustments

### Adjustment Strategy

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- Demand Adjustment Factor to build ahead
  - All 4 warehouses = 10% adjustment to build ahead
  - Adjustment Factor set for May only
- Add Sunday shifts to increase capacity in the factory
  - Extra shifts for all of June and July

	Inventory Name	Start Date	End Date	Demand Adjustment Factor	ed Zone Adjustment Factor	Yellow Zone Adjustment Factor
▶ 1	Blue_100_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
2	Blue_250_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
3	Blue_400_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
4	Blue_500_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
5	Green_100_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
6	Green_250_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
7	Green_400_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
8	Green_500_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
9	Yellow_100_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
10	Yellow_250_mL_Bottle_Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 A	1.1	1	1
11	₽ Yellow 400 mL Bottle Warehouse1	5/1/2025 12:00:00 AM	6/1/2025 12:00:00 AN	1.1	1	1







Site Id

Hub

Warehouse:

Warehouse2 Warehouse3

Warehouse

Blue\_100\_mL\_Bottle

Blue\_250\_mL\_Bottle

) Blue\_400\_mL\_Bottle ) Blue\_500\_mL\_Bottle

Green 100 mL Bottle

Green\_250\_mL\_Bottle Green\_400\_mL\_Bottle

Green\_S00\_mL\_Bottle Red\_100\_mL\_Bottle

Red 250 mL Bottle

) Red\_400\_mL\_Bottle ) Red\_500\_mL\_Bottle

) Yellow\_100\_mL\_Bottle ) Yellow\_250\_mL\_Bottle

Yellow\_400\_mL\_Bottle

Yellow\_500\_mL\_Bottle

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#### **Summer Lift Results** Buffer Status for Planning 176/2025 Buffer Plot 📰 Green Zone 🧮 YellowZone 📰 Red Zone 📰 Net Flow Position 📃 Target On-Hand 📰 On-Hand 22 1.6K 1.56 1.4K 1.3K 1.2K 1.1K Tx 22 1K 0.9K 0.8K 0.7K 0.6K 0.5K 0.4K 0.3K 0.2K 0.1K 0K 2/1/2025 12:00 AM 3/1/2025 12:00 AM 4/1/2025 12:00 AM 5/1/2025 12:00 AM MAR 9/1/2025 12:00 AM

5/31/2025 Waiting time at Mixing **Constraint Types** = 50 hours Condition Express > 🗸 Destination Availability + 🗹 Material Availability Resource Arrival Resource Availability Transporter Pickup 년 🐩 👯 Constraint **Constraints** Paret instraint Type Constraint Item Order Eacility Locati Dest Destination Availability RoutingDestinations. . DO1233 Moting estination Availability RoutingDestinations. DO1234 Mixing Destination Availability RoutingDestinations. DO1235 Mixing Destination Availability RoutingDestinations. DO1236 Mixing

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Bottle Bottle Bottle

500\_mL 400\_mL 250\_mL 100\_mL

Bottl Bottl Bottl

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### Level 4 Results – Summer Adjustment







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## Game Level 5 (What-if Strategical)

## The Level 5 challenge: Adaptive S&OP

- Strategic planning starting with Level 4 configuration
  - Summer lift for 2025 and 2026 as per Level 4 challenge
  - New product introduction starting year 2 (January 2026) with 1-liter bottle for all products
- Run the game for 565 days (18+ month)
  - Stating the 26th of January 2025
  - Ending late August 2026
- Analyze the impact of the new product introduction on key KPIs to answer specific management questions

**Key Management Question:** How many markets can we serve to test the new product without having to do investment in new infrastructure and negatively impact current business? (Market is by Warehouses #1, #2, #3 and #4)

- Gross Profit
- Utilization (flexibility to respond)
- Customer service





### **Gantt Charts for Production**

#### 1 Warehouse

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	2025 Q1		2025 Q2			2026 Q3			2025 Q4			2026 Q 1			2026 Q2				
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#### 2 Warehouses



#### **3** Warehouses

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#### **4** Warehouses





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### **Inventory at the HUB**

#### **1** Warehouse Warehouse Capacity d) 8/13/2076 ch 55 Daily Warehouse Usage Q4 2025 Q2 2026 110.00% Site Id Hub Stock Warehouse1 Warehouse2 Warehouse3 100.00% 90.00% Warehouse 80.00% T. 22 Materials 70.00% (AI) Blue\_1\_L\_Bottle Blue\_100\_mL\_Bottle Blue\_250\_mL\_Bottle Values Blue\_400\_mL\_Bottle 50.00% Blue\_400\_mL\_Bottle Blue\_500\_mL\_Bottle Green\_1\_L\_Bottle Green\_100\_mL\_Bottle Green\_250\_mL\_Bottle 40.00% Green\_400\_mL\_Bottle 30.00% Green\_500\_mL\_Bottle Red\_1\_L\_Bottle Red\_100\_mL\_Bottle Red\_250\_mL\_Bottle 20.00% Red\_400\_mL\_Bottle 10.00% Red\_500\_mL\_Bottle Yellow\_100\_mL\_Bottle Yellow\_250\_mL\_Bottle 0.00% 3/1/2025 5/1/2026 1/1/2025 5/1/2025 7/1/2025 9/1/2025 11/1/2025 1/1/2026 3/1/2026 7/1/2026 9/1/2026

#### **3** Warehouses



#### 2 Warehouses



#### **4** Warehouses



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### Warehouse 1 Total Inventory





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#### 1 Warehouse Daily Resource Utilization Mixing c1-0.3 Daily Ut Green Yello 110 Resource Names 🕺 🐇 🖌 100 Hing1 Filing2 Filing3 Mxing1 Mxing1 Mxing2 WIPTank1 WIPTank3 WIPTank4 WIPTank5 WIPTank6 90 80 70 SQ 60 Valu 50 40 30 20 10 1/1/2025 3/1/2025 5/1/2025 7/1/2025 9/1/2025 11/1/2025 1/1/2026 3/1/2026 5/1/2026 7/1/2026 9/1/2026

### **Mixer 2 Utilization**

#### 2 Warehouses



### 4 Warehouses





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## Level 5 Results – Mixer 2 Utilization with 4 Warehouses



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Mixers running near full

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### Green 1 liter Bottle at the HUB

#### 1 Warehouse





**4** Warehouses

Inventory in the HUB cannot keep up with demand as the factory does not have sufficient capacity

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### Green 1 liter Bottle at the HUB

1 Warehouse



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## Green 1 liter Bottle at the HUB

Warehouses





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### Level 5 Results – Revenue and Service Level

## New part introduction and summer lift in 2026



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### Level 5 Results – Gross Profit

# The supply chain is struggling to keep up



Gross Profit



90

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**Statistical Analysis** 

*Run the Game multiple times with variation to evaluate the system responses* 



#### **Inventory Cost**

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Late Orders

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## Summary and Recommendation

- Introducing the new 1-liter bottle into 2 markets seems very possible within the capacity of the current factory and supporting network
- Introducing the third market seems to put the network on the edge
- The fourth market will push the network into instability and exceed all current capacity, negatively impacting all products

## **Recommendation to Management**

- To test the market response to the new product it will be best to introduce it to just 2 markets for the initial launch and then extend it to a third based on market response
- Introducing the 1-liter bottle to all 4 markets at once will put the whole network at risk including the current product supply



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## What did we learn from the *Game*, if this was real?

- Evaluate any business option or key decisions such as business rules, detail decision logic, changes in processes and resourcing.
- Fully understand the end-to-end supply chain impact from raw material supply through manufacturing and distribution
- The business can make informed decisions about all aspects of their operations and infrastructure to optimize performance and ROI

## But wait.....

# This can be done today!



## What is an Intelligent Adaptive Process Digital Twin?

An *Intelligent Adaptive Process Digital Twin* can be deployed <u>offline and/or online</u> for both <u>predictive and</u> <u>prescriptive</u> applications to facilitate comprehensive digital transformation and business re-engineering initiatives

Intelligent	Embedded AI for making intelligent, complex and optimized decisions fast by generating synthetic training data, training and testing NN agents as well as incorporating trained AI agents into Digital Twin simulation models
Adaptive	Automatically adapts to changes in enterprise data such as specific process related resources, materials, properties and attributes, product routings, network changes, BOM, labor requirements and schedules, maintenance schedules and product mix
Process	Any business process including detailed manufacturing operations inside the four walls or multi-factory processes, warehouse operations and material handling, supply chain and distribution processes including the end-to-end supply chain
Digital Twin	A detailed data generated and driven, object oriented, discrete event simulation model of the process that accurately replicates the physical behavior of the process to design, predict and prescribe current and future performance



## Intelligent Adaptive Process Digital Twin Key Deliverables

- Knowledge base capturing the detailed process flows, business rules and decision logic in a comprehensive simulation model of the process
- Performance benchmark to evaluate any business transformation changes or performance improvement initiatives to determine and validate ROI
- Control tower that provides global visibility for decision-making and end-toend process synchronization, scheduling and orchestration
- Digital reference model of the "current status" that accurately replicates the process behavior for ongoing and future analysis



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## Effective Digital Twins Enable the DDAE Model





## Want to learn more about Digital Twins?

Please join us tomorrow at 11:15 am in Auditorium 3 for an introduction to the Simio Platform (vendor track)

Or....

▶ Visit our booth in the exhibit area on the ground floor.



## **Questions?**



