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Transforming Manufacturing Process In Automobile Sector With Data Analytics And Automation In Tcua

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Abstract; The Automobile manufacturing industry is undergoing a paradigm shift driven by the convergence of automation & data analytics. This paper explores how these technologies particularly data analytics and smart automation are transforming traditional manufacturing process into intelligent & easy to access data as per business needs. These technologies such as - Predictive Maintenance & Process Optimization are not only enhancing productivity and operational efficiency but also enabling intelligent, adaptive systems that optimize manufacturing process in automobile sector.

Keywords: Transforming Manufacturing Process In Automobile Sector With Data Analytics And Automation.

1) **Predictive Maintenance**
   a. Using historical data to predict supply condition & procurement strategies.
   b. Predict current trend of organisation and suggest better procurement strategies.
2) **Process Optimization**
   a. Using data analytics to identify inaccuracies in Manufacturing BOM.
   b. Automation of functionalities which takes huge manual effort and time to achieve requirements of production.

Analytical & auto generated reports to give better understanding and planning for production.

1. Need of Data Analytics and Automation ER&D PLM

1.1. Purpose:

The automotive manufacturing industry is undergoing a digital transformation driven by advancements in data analytics, automation, and intelligent manufacturing technologies. As the competition intensifies and customer expectations evolve, automotive companies are increasingly leveraging data-driven insights and automated systems to improve efficiency, reduce costs, enhance quality, and accelerate innovation.

Manufacturing companies have vast volumes of data generated throughout the release lifecycle process of a vehicle from design to manufacturing and after-sales service. This historical data can be collected, processed and utilised to predict the procurement strategy thus automating the procurement process with data accuracy and reduced reworks.

1.2. The Challenge:

Companies are facing challenge to utilise resources but their engagement in procurement process restricts them.

1.3. The Solution:

Data analytics enables to process and interpret data with certain business logic integration. These processed output to be used to automate the procurement strategy during the release of vehicle bill of material (BOM).

2. Benefits

- ✓ Increased Productivity – based on Real-time monitoring and auto generated reports – without manual intervention – for predicting procurement & store location and subsequently eliminating user intervention for taking decision on procurement strategy.
- ✓ Workforce Augmentation - Re-skilling workers and automating repetitive tasks.
- ✓ Data Accuracy and ease of maintenance through automation in manufacturing process.

3. Demand for AI in Emerging Market

The demand for AI is driven by the need for resource utilisation, efficiency, accuracy, and decision-making in a rapidly changing market. These technologies are being used to automate tasks, predict current trends, and streamline the procurement process. Below are some key points:

1. Automation of Tasks
2. Predictive Analytics
3. Process optimization

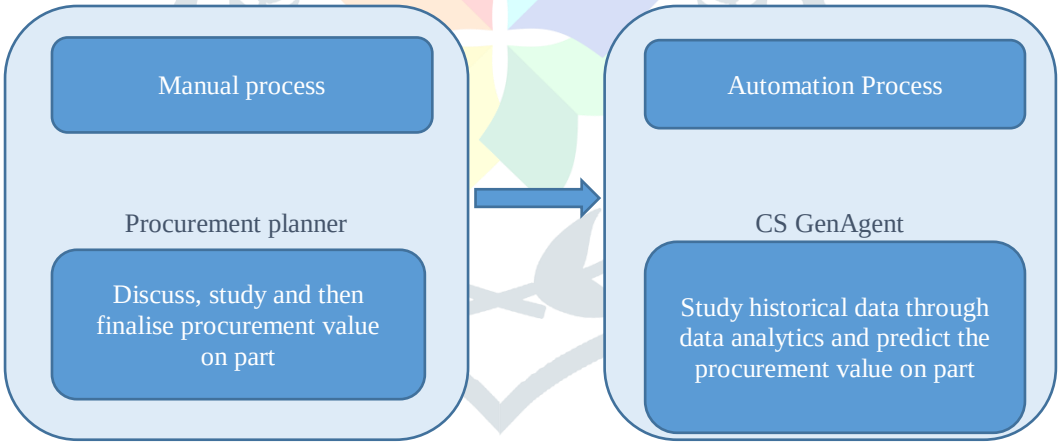

Figure 1: Overall System Architecture

4. How – Data analytics & Automation applied for Procurement strategy

Since inception automotive manufacturing industries have created vast data through the production lifecycle of a vehicle. These data contains multiple information which can be studied and utilized for strategizing, automating tasks and benefit organization with resource utilization and reduction in repetitive work.

In TCUA, a data model was created – to capture the manufacturing procurement data – through data analytics. The model was trained with procurement value information in-line with the business logic. CS GenAgent uses this trained data model - which helped organization to automate the procurement value mapping on a material during the release lifecycle process.

The procurement planners can also create new trends by updating procurement values while releasing parts based on current practice of organization procurement strategy being followed by a manufacturing plant location.

The CS GenAgent is be smart enough to predict the current trend of procurement over the historical data, this helps the manufacturing industry always lead ahead – in competitive market scenario.

4.1. Data Model Training:

The data model gets auto trained regularly – as & when required – based on business requirement. Benefits of trained data model:

- It allows models to learn from newly created data and help improve their accuracy and efficiency in predicting procurement value.
- It helps to adapt and be in line with current trend for procurement for a part.

5. Deliverable – Used case for Procurement & Storage Location prediction

5.1. Basic details:

In the automotive industry, the vehicle reaches to production via various workflows and multiple agencies which involves Design, Manufacturing planning, Quality, Finance, production, marketing and after sales services.

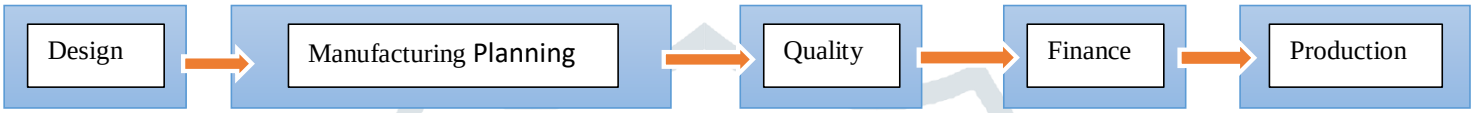

Figure 2: Generic Process stages of automotive industry

5.2. What is a vehicle?

A vehicle is the end product which is combination of parts which can be further classified as modules, assemblies, components and raw materials. These includes parts such as engines, transmissions, body components, and other assemblies. The vehicle Bill of Materials (BOM) serves as a blueprint, ensuring that all necessary parts are accounted for and available for the assembly process, which is crucial for the efficient production of vehicles.

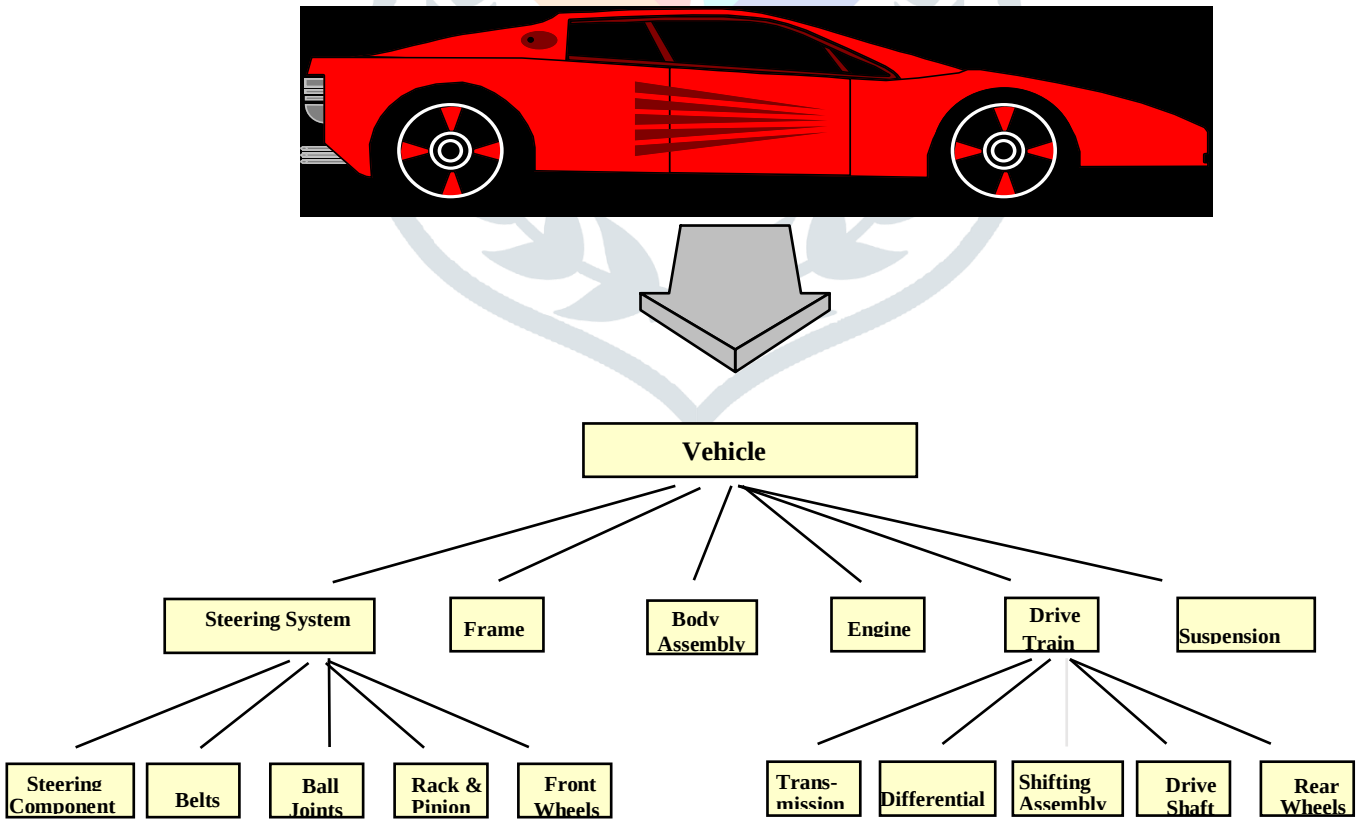

Figure 3: Vehicle Structure graphical representation

5.3. What is Bill of Materials (BOM)?

A BOM is a structured list of assemblies and components required for manufacturing a product where at top is the final product (vehicle) next are subassemblies and below those are the components and raw materials.

BOM includes part numbers, description, the quantity information of every structure level, procurement information, and storage location information and many more information required for vehicles production and differs from OEM to OEM.

Creating a bill of materials is a collaborative effort that typically involves input from multiple departments within a company. Each department brings specialized knowledge to ensure the BOM is accurate, comprehensive, and aligned with the product's requirements.

		BILL OF MATERIALS		09-09-2024								
SR NO.	MODEL NO	DESCRIPTION										
1	Vehicle-A-3	NextGen EV Vehicle										
BOM Level	**Part Number**	**Part Description**	**Rev**	**Drg. No.**	**Drg.Rev**	**Qty**	**Procurement**	**Plant Store**	**Maturity stage**	**PO NUM**	**PO DATE**	**Stock**
0	Vehicle	NextGen EV Vehicle	A	abc123	NR	0	IH		4			
1	P1	Steering system	A	abcP1	NR	1	IH		4			
2	A1	Belts	A			2	EX	12	4	abc12xx	11-10-2022	
2	A2	Ball Joints	B			2	EX	22	4	abc21xx	11-10-2022	75565
2	A3	Rear Wheels	A			2	IH		4			
3	C1	Rear wheel cover plate	A			2	EX	27	4	abc11xx	27-02-2024	4040
4	D2	Nyloc Nut	B			12	EX	90	4	abc33xx	27-02-2024	1000
2	A4	Front Wheels	A			2	IH		4			
3	C2	Front wheel cover plate	C			2	EX	28	4	NA		1220
4	D2	Nyloc Nut	B			12	EX	90	4	abc33xx	27-02-2024	
2	C3	PLATE	A			1	IH		4			
1	P2	Engine Assy With Batter	A	abcp2		1	EX	10	4	abc44xx	13-06-2023	
1	P3	Frame	B	abcp3		1	IH		4			141858

Figure 4: Tabular Representation of Bill of Materials

5.4. Current scenario:

The design team defines the finished product i.e. vehicle and create CAD drawings or Prototypes that reflects the vehicle's form and functionality. They assign part numbers and create assemblies and subassemblies. The finalized structure is then synched in TCUA via CAD-TCUA integration tools.

In TCUA, an Engineering change note (ECN) is created via which the Vehicle(s), assemblies and subassemblies are monitored and reaches to final stage of production through a business defined workflow – which requires approval of different agencies.

5.5. Stages of workflow:

Stage 1: Designer from design team creates ECN in TCUA and links the required parts with ECN task and initiates workflow for ECN in TCUA for release of part and its structure.

Stage 2: Reviewer from design team approves the ECN.

Stage 3: ECN reaches to Manufacturing planner of different plant locations (in case of multi plant scenario). The planner performs different activities i.e. estimates, line planning, procurement and storage update, restructuring of parts as per location specific line.

Stage 4: Manufacturing approver checks the details and approves the ECN.

Stage 5: ECN reaches to Quality planner where the final analysis is done. The quality planner approves the ECN.

Stage 6: ECN reaches to Quality approver. The approver checks all details of parts and approves the ECN.

Stage 7: The part and its structure is then transferred to SAP, from where the finance team takes it up further for its cost analysis till production.

Here this document focuses on the Manufacturing planning stage i.e. **stage 3** where manufacturing planner studies and defines the procurement and storage instructions of all assemblies and subassemblies.

Once the ECN reaches the Manufacturing planning via workflow process in TCUA, The planner studies the assembly for its manufacturing either in-house (IH) or procurement via supplier (EX).

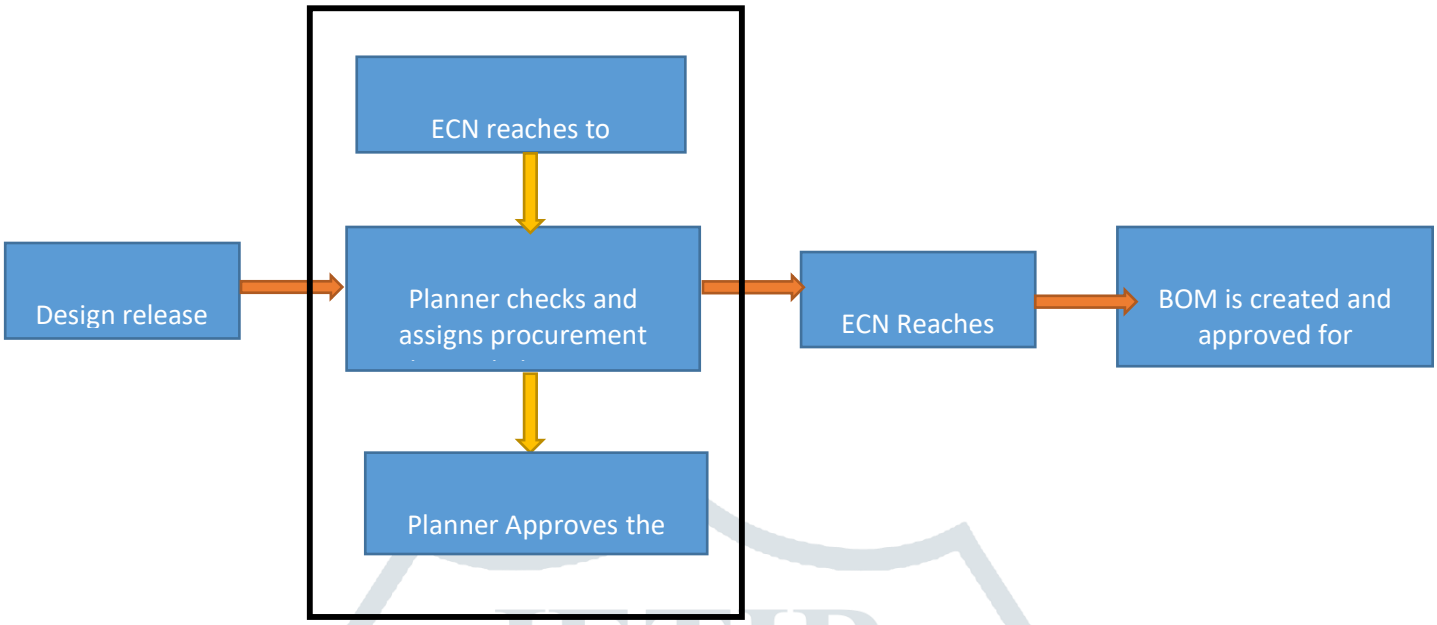

Figure 5: Existing Workflow process

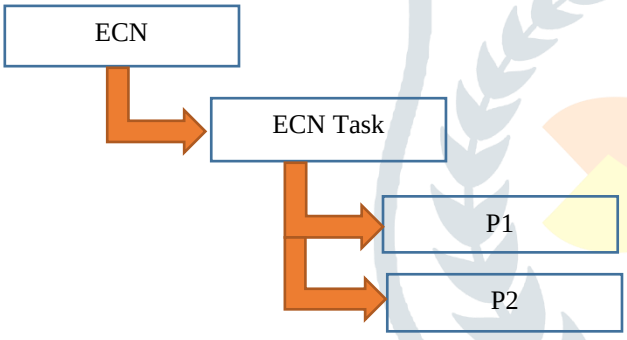

Figure 6: ECN hierarchy

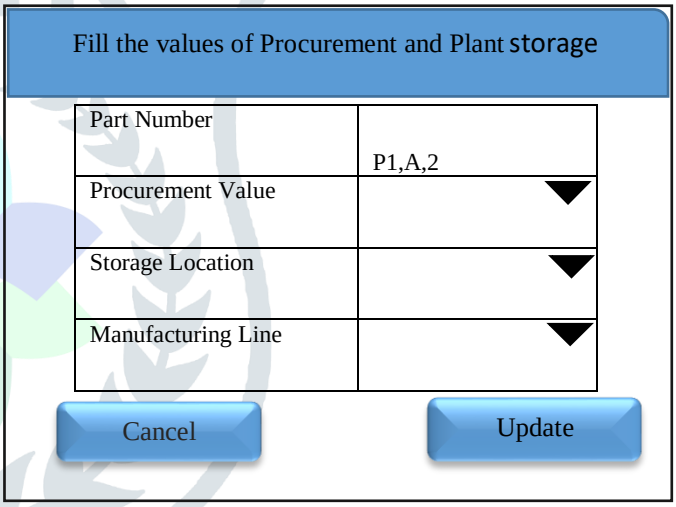

Figure 7: Option to update the attribute value

Here planner select the part and via some custom option provided, the assign the procurement and storage value to all parts before the approval of the ECN. This entire process requires discussions, historical study of category of parts and lots of rework to achieve the final outcome which consume lots of time thus leading to time to market loss ultimately loss to manufacturing organization.

5.6. Scenario after CS GenAgent integration for procurement strategy:

In the workflow in TCUA, the CS GenAgent was integrated at a node in workflow. This node lies between ECN Design approver and Manufacturing planner. The CS GenAgent comes into picture before the ECN reaches **Stage 3** i.e. the Manufacturing planner.

At this node CS GenAgent performs its activity – as per defined business logic.

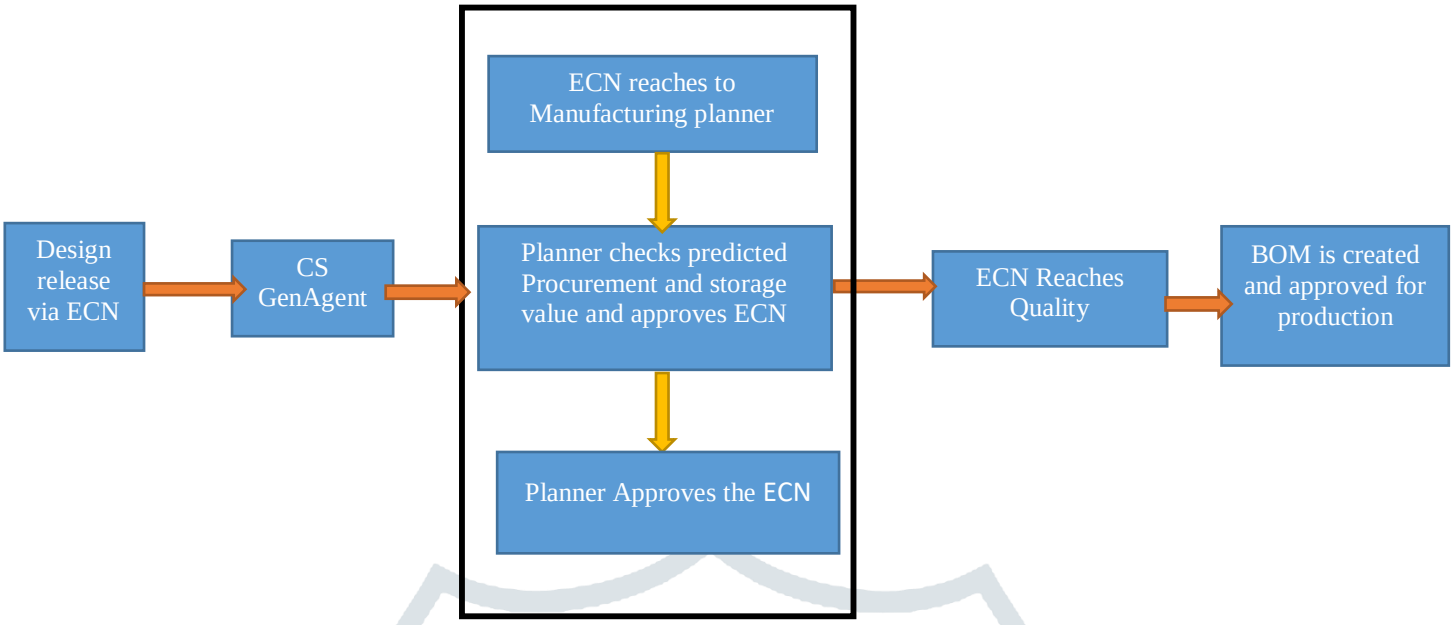

Figure 8: Enhanced workflow with CS GenAgent's integration

In the below figure it's illustrated with one of the information being used during the part's procurement & storage location value prediction.

Table 1: ProcV data for different plant locations of an organization. Multiple locations can have different procurement strategies.

Processed procurement values(ProcV)				
Properties	**Value1**	**Value2**	**Value3**	**Value4**
N Digits	339001	339001	359010	359010
Drawing Indicator	D	D	N	D
Part type	A	A	A	C
First Best %	85	92	87	76
First ProcV	IH	IH	IH	EX
Second Best %	10	5	12	20
Second ProcV	EX	EX	IH	IH
Plant Location	Loc1	Loc2	Loc3	Loc4

Table 2: Part XX359010XX released by design team. CS GenAgent predicted ProcV for Loc1 (IH) and Loc4 (EX). Parts pending for approval at manufacturing planners of Loc1 and Loc4.

XX359010XX	XX359010XX
D	D
A	A
Loc1	Loc4
IH	EX

Before reaching the procurement planner, CS GenAgent will fetch the details of procurement value from the data model for both Loc1 and Loc4 of the organization. These values are stamped based on location. The planner can either update the value (this will help in creation of current organizational trend) or check and approve the predicted procurement value – along with storage location.

Once the manufacturing agency of respective manufacturing location approve the value, these values are then transferred to the SAP system from where the further cost related activities are planned.

The data model gets auto trained as per data releases from manufacturing agency. This helps in predicting more accurate value and also in capturing the current procurement strategy for a category of part.

Before Go-Live – we did POC and published report to check accuracy of CS GenAgent procurement value.

A detailed comparative report was shared with the manufacturing department which captured the procurement value based on data analytics for historical procurement value and the procurement value which our CS GenAgent predicted for those assemblies from the data model.

The generated report consisted of procurement details of all the manufacturing locations of the organization to provide better picture how CS GenAgent can work with respect of manufacturing location's procurement strategy.

Below is snapshot of comparative report for procurement value with the CS GenAgent's predicted value.

Procurement value comparision report for already released parts

SrNo	Part ID	RevSeq	Part Type	Drawing Indicator	Spare Indicator	Part Category	Description	Project Code	Plant Applicability	Total Part Found	Part Having JSR CS	Loc1 1st Predicted CS	Loc1 Predicted CS -1st Best	Loc1 2nd Predicted CS	Loc1 Predicted CS -2nd Best	Loc1 Actual CS	Loc1 1st best storelocation	Loc1 storelocation	Loc1 Actual StoreLocation	Part Having Loc2 CS	Loc2 1st Predicted CS	Loc2 Predicted CS -1st Best	LOC2 2nd Predicted CS	Loc2 Predicted CS -2nd Best	Loc2 Actual CS	PUNE 1st best storelocation	Part Having LOC3 CS	Loc3 Predicted 1st CS
1	P1	NR;1	Assembly	D	FALSE	BTP	PRESSURE_H	111	P J	50	25	EX	100.00%		0.00%	EX	100.00%	11	11	0								
2	P2	NR;1	Assembly	D	FALSE	BTP_Bu	NYLON_PIPE	123	J	38	23	IH	47.80%	IH	47.80%	IH	39.10%	12	12									
3	P3	NR;1	Componer	N	TRUE		COVER_FUSE	123	J	0																		
4	P4	NR;1	Assembly	N	TRUE		BLOWER_MO	111	J	0																		
5	P5	NR;1	Assembly	D	FALSE	PHN_PI	NYLON_PIPE	123	J	128	54	EX	53.70%	IH	46.30%	EX	37.00%	13										
6	P6	NR;1	Assembly		FALSE	PHN_PI	PIPE_ASSY	111	L P	0																		
7	P7	NR;1	Componer	N	FALSE	PHN	AIR_VALVE	123	P J	1	0									0								
8	P8	NR;1	Componer	N	FALSE	BTW_B	TOP_BOX_SE	111	D P	22										21	EX	100.00%		0.00%	EX	0.00%	1	EX
9	p9	NR;2	Componer	D	FALSE	BTW_B	TOP_BOX_SE	123	D P	176										108	IH	100.00%		0.00%	IH	2.80%	14	IH

Figure 9: Published report to check accuracy of CS GenAgent procurement value

The CS GenAgent was able to predict values with more than 95% accuracy for the organization and it also predicted the organizations location wise storage details thus adding a strength in the CS GenAgent's portfolio.

6. Conclusion

- ✓ Data analytics with Automation fastens the part release to reach its production stage.
- ✓ Better accuracy from both historical data as well as current manufacturing trend of organisation.
- ✓ Time to Market – is reduced.
- ✓ Rework is reduced.
- ✓ Better resource utilization.
- ✓ Cost and complexity reduction.