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*Research Paper*

# APPLYING VALUE STREAM MAPPING FOR IMPROVEMENTS IN AUTOMOTIVE SEAT MANUFACTURING PROCESSES

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Toyota production system introduces the value stream mapping which is a method to evaluate and improve business functions. A value stream includes all elements both value added and non-value added which occur to a given product from its inception through delivery to the customer. Value Stream Mapping (VSM) mainly deals with three steps: current state map, future state map and action plan. Main steps to achieve a optimized value stream consists of selection of product family of high demand and low variety, forming a multidisciplinary team, understanding the customer demand, mapping the process, material and information flow, calculating the Takt time, lead time and change over time. Understanding and application of mapping symbols in designing material, process and information flow and data collection are vital parameter for the success of mapping. Work presented here is aimed at applying the VSM technique for leading seat manufacturing company. It uses foam (chemicals), frame (metal), trim (fabric or leather) and plastic parts as a raw material. There is a wide scope for process improvements through enhancing the supply chain from supplier end to the customer end which will results in tangible and intangible benefits such as time, cost and fatigue. Implementation of VSM tools has resulted in self examination of the present process performance against the customer demand. It also guides to the future state via scientific techniques like time and motion study, NVA reduction, Kaizen, 5S and focuses on root cause of the problem.

Keywords: Information flow, Inventory management, Pacemaker process, Value stream mapping

## INTRODUCTION

Value Stream Mapping (VSM) is an advanced form of process mapping. It is management system which gives a vivid picture of existing status of processes in an organization and highlights the path to

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achieve zero downtime, reduced number of defective parts, efficient working environment and ultimately the Total Productivity Maintenance (TPM). Basically VSM can be classified into three fields: (1) Information management, e.g., orders processing, purchasing, (2) Physical transformation, e.g., materials, logistics, (3) Intellectual property, e.g., improvement ideas, designs, project management.

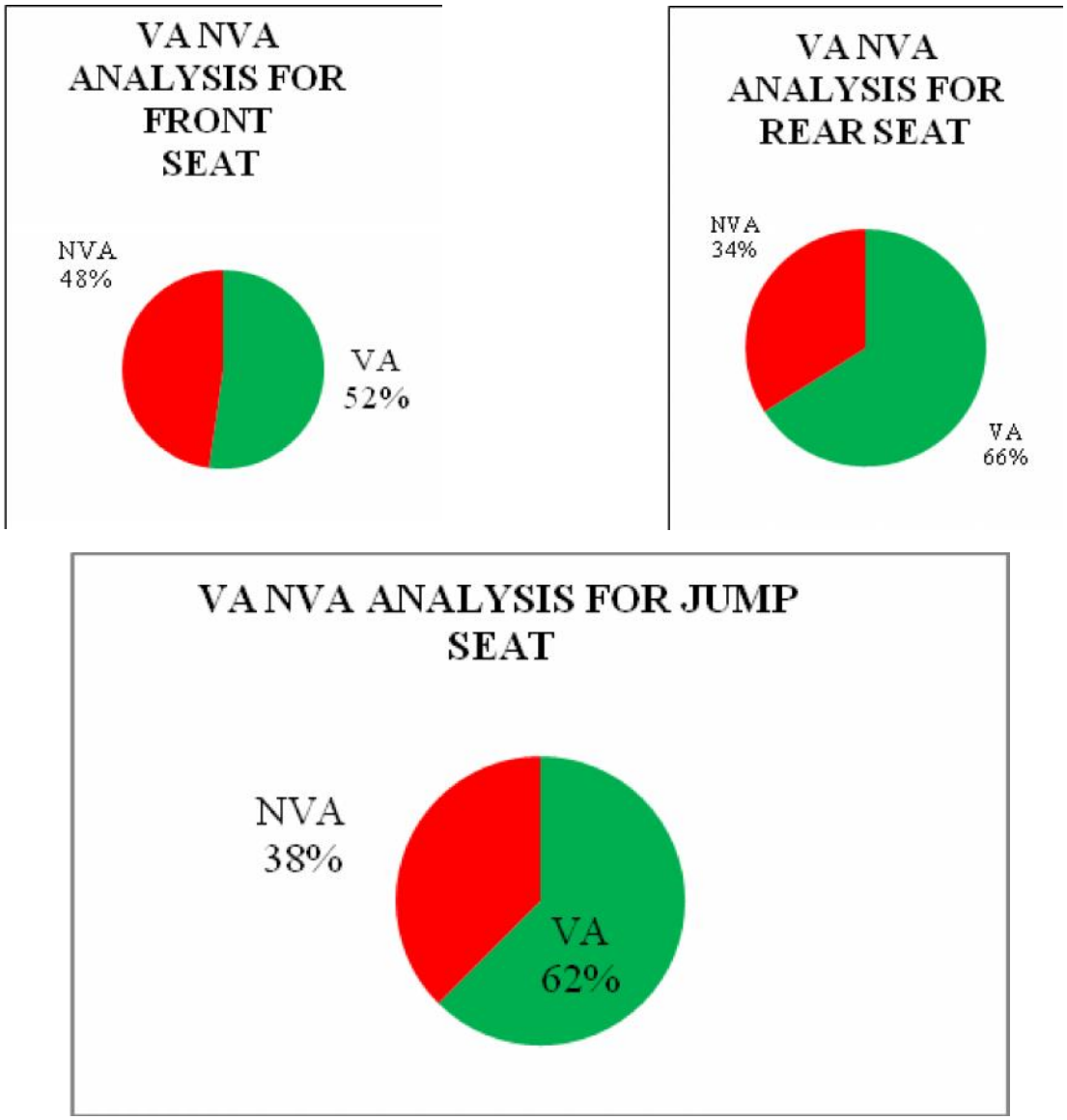
To achieve overall productivity improvement in any organization; value stream mapping along with other lean techniques like 5S, Kaizen, Pokayoke acts as an important tools to reduce 7 kinds of wastes. VSM is an excellent tool for any enterprise that wants to become lean. Rother and Shook (1999) defined VSM as a powerful tool that not only highlights process inefficiencies, transactional and communication mismatches but also guides about the improvement. According to Hines and Rich (1997), Value stream is a collection of all actions value added a well as non-value added that are required to bring a product or a group of products that use the same resources through the main flows, from raw material to the hands of customers. Jones and Womack (2000) explain VSM as the process of visually mapping the flow of information and material as they are and preparing a future state map with better methods and performance. A value stream consists of everything including the non-value added activities and provides a pictorial view of what elements of the process the customer is willing to pay for. Jones and Womack (2000) define VSM as 'the simple process of directly observing the flows of information and materials as they now occur, summarizing them visually and then envisioning a future state with much better performance'.

Main parts of any automotive seat assembly are back assembly, cushion assembly and head-rest assembly or nap-rest assembly. Raw materials like foam, frame and trim ["A" Class] are consumed along with numerous in-process materials like listing wires, plastic parts ["B" Class], etc., and nut bolts ["C" Class]. Cushion assembly is performed first at the start of the line by collection of frame and the putting on fixture. Further, foam is aligned on the frame, trim is put on the foam and hogering is done at predefined locations. As per design specifications, track and riser are assembled to cushion by marriage bolts. Finally, finishing is done and assembly is wrapped in a polythene bag and passed on to next station, mean while other operators perform back assembly by putting frame on the fixture, aligning foam on frame, picking and aligning trim on foam, hogering at prescribed locations, matching bezel holes of trim and foam, inserting and hammering active [on right side] and passive[on left side] bezels in foam and trim, finishing the assembly by steaming, wrapping the assembly in a polythene bag, passing the assembly to

Table 1: Total Cycle Time Required for Seat

| Seat | VA Time [Sec] | NVA Time [Sec] | Total Time [Sec] |
|---|---|---|---|
| Front Seat | 504 | 460 | 964 |
| Rear Seat | 549 | 283 | 832 |
| Jump Seat | 121 | 73 | 194 |
| **Total %** | **52.25,65.95, 62.42** | **47.75,34.05, 37.58** | **100** |

Figure 1: Value Added-Non Value Added Activities Analysis for Seat Assembly Line



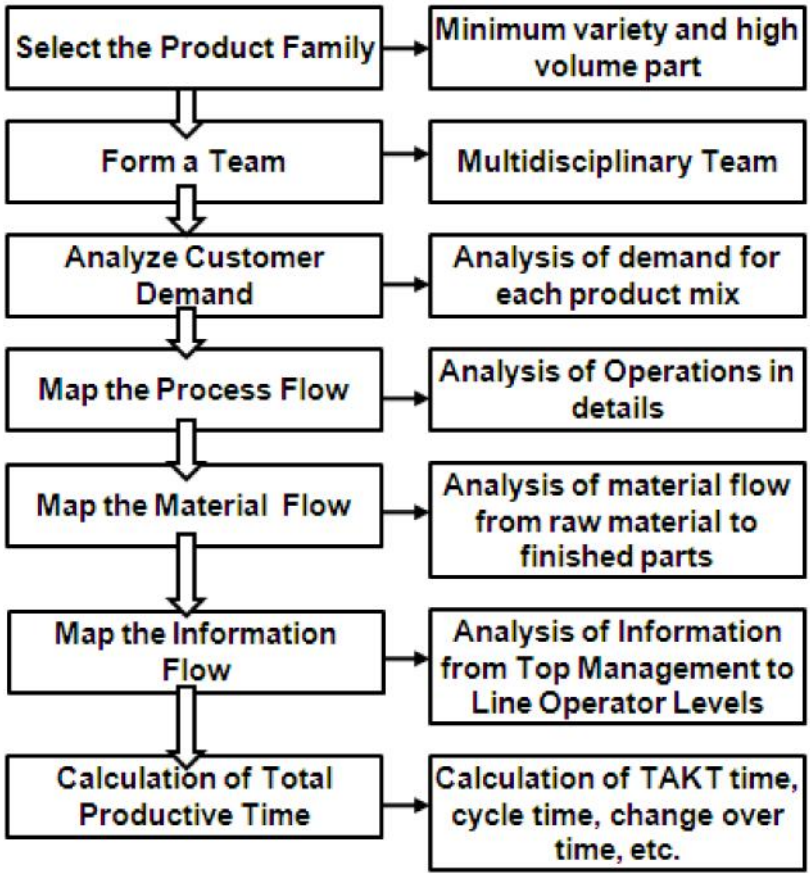

marriage. Analysis of the previous data (Figure 1) indicates that the existing seat manufacturing process has higher percentage of non value added activities Thus the objective of this paper is to map the present seat manufacturing process, compare it with a future state map and identify and eliminate non value added activities, thereby streamlining work processes, cutting lead times, reducing costs and increasing quality.

## CURRENT STATE MAP

For the initial Current state mapping activity, keep data at high level or 'overall level' for the process. The main purpose of the current state flow is to understand the current state process flow, material flow, information flow

in the Value Stream and analyze to find solution over the inhibitors to it. The steps involved in the mapping the current state of process are shown in Figure 2. Selected part should have minimum variety and high production volume. The obvious choice of the product for present study was seat family such as variants such as LX, EX and VXP and seats for front line Driver and Co driver; Rear seats 40%-60% each with head rest assembly and Jump seats LH, RH without headrest assembly. A multidisciplinary team was formed including production, stores and logistics, continuous improvement, line operators, etc. Analysis of the demand from customer was done for each product mix by obtaining information about the product from various departments including production control. Further, all the operations required for completion of part was analyzed by industrial engineering techniques. In coordination with Stores and Logistics team flow of material right from its inception to dispatch is analyzed. Stop watch time study was performed to calculate standard time of each operation Based on the observed time: Takt time, cycle time and change over time were calculated. Off line Non value adding activities such as material handling by operators and other futile activities which incur cost, time and fatigue to the operators are noted. Figure 3 of seat line gives vivid

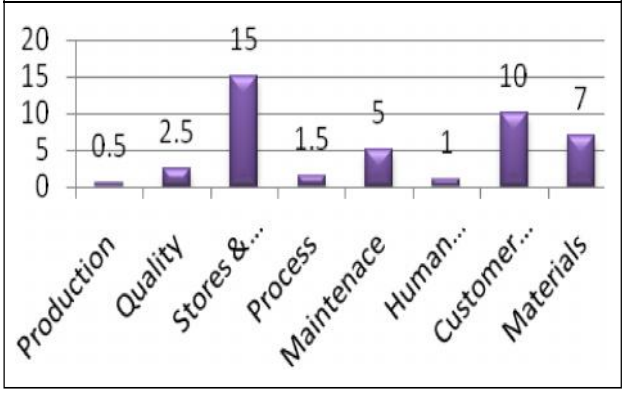
Figure 2: Steps for Mapping the Process



picture of process flow and material flow of seat assembly. Customer demand for seats is 65 units per day. Present manufacturing line has 16 workstations operated by 18 operators per shift.

The process flow of seat manufacturing process is shown in Figure 4. Operations involved are movement from, Driver seat cushion, Driver seat back, Track To slider and Driver seat marriage, End of line and inspection and similarly Co Driver Seat Cushion, back and marriage stations. Push arrow is shown in Figure 4 to indicate that each station gives its product to next using push system so line will be in balanced state. Driver & Co. Driver Seat Back assembly is done on fixture suitable for ease of process flow.

Figure 3: Monthly Down Time Loss Dept. Wise




## One Piece Flow

- Builds in quality: Every operator fixes the problem at the station only before passing it on; problems are delectated quickly and they can be immediately diagnosed and corrected.
- Creates flexibility: Shorter lead times, build to customer order, set-up time reduction.
- Creates higher productivity: Easiness to spot the idle station and calculate the value added work.
- Frees up floor space: Inventory reduction saves money and space.
- Improves safety: Smaller batches means simpler transportation system and simpler transportation system and fewer accidents.
- Improves morale and efficiency: People perform high percentage of value added work and can see faster results by striving for continuous improvements.

## Non Value Added (NVA) and Its Solution for Seat Assembly Line via Action Plan

### Top 3 Contributors to NVA Activities

- Material shortage by supplier (foam, frame, trim, and slider or): Non availability of the material on line results in stoppage of line-Dept. responsible Stores and Logistics.

Table 2: Strategies and Tools Used in Creating Connected Process Flow

| Strategies | Primary Lean Tools | Secondary Lean Tools |
|---|---|---|
| Continued elimination of wastes | Workplace/cell design | Kanban |
| Force problems to surface | Pull technique | Kanban boards |
| Make problems uncomfortable | Clearly defined supplier/customer relationship | Supermarkets |
| Establish connected processes to create interdependency | | FIFO lanes |
| Identify weak links in the flow and strengthen them by taking corrective actions | Visual controls | Problem solving |

- Tool down time: Stoppage time due to tool maintenance and no spare tool available Dept. responsible-Maintenance.
- Materials handling by operator (self or guiding material handler to pick right kind of material) Dept. responsible-Process.

### Station-Wise NVA Activities

Table 3: Monthly Down Time Assessment on Seat Line

| Dept. Name | Down Time hrs |
|---|---|
| Production | 0.5 |
| Quality | 2.5 |
| Stores and Logistic | 15 |
| Process | 1.5 |
| Maintenance | 5 |
| Human Resources | 1 |
| Customer Demand Fluctuation | 10 |
| Materials | 7 |
| **Total hrs** | **42.5** |

## FUTURE STATE MAP

Future state VSM as shown in Figure 7 lies in the continuous improvement processes like Kaizen on entire NVA's and NNVA's on line. Figure 7 indicates the clear picture of how future state VSM should be. It mainly focuses on pacemaker process which is the core Operation on the line as in this line, Driver Seat Back is the pacemaker process since all other operations depend on it and it takes higher cycle time than others on which the focus should be to reduce the cycle time.

Correct product mix to be given on as per production schedule for the maximum efficiency and proper utilization of resources. Kanban can be used as an effective tool mainly for operators and material handlers so that they will not have any confusion for picking right material from right place and operators will not be required to monitor them, ultimately saving their time and reducing the fatigue.

Table 4: NVA Activities on Seat Assembly Line

| Station | NVA | Solution |
|---|---|---|
| Front Seat Assembly Line | Excess material handling for 'A' class items involving 10 m distance travel each time and 5 min duration | Raw material storage shifted near to respective Front, Rear and Jump lines to reduce material handling distance to 2 m and time to 1 min |
| Front -Rear -Jump Seat Assembly | Poor visibility at the workstations and mainly at inspection stations leading to less detect ability of defects | Lux level increased to 2000 and on inspection stations to 2500 for 100% defect identification |
| Driver & Co. Driver Seat Back Assembly | Bending and segregation activity: Bezel bin position is below avg. MTM height and mixing of active and passive bezels occur | Materials pick up problem: clogging of back support lumber pads occur due to fitment with one another |
| Driver Seat Track to Cushion Assembly | Difficulty in picking up of sliders on right hand and left hand sided due to 180 degrees turning+ peeping action involved | Provision of in process bins on right and left hand sided for sliders to have mistake proofing |
| End of Line and Inspection | Belt conveyor damage due to stud of sliders as assembly is kept on conveyor for checking, the contact points rapture the conveyor completely | Provision of nylon board completely covering the station |

Table 5: Kaizen Implemented on Seat Assembly Line

| Problem/Waste | Changes | Results |
|---|---|---|
| **Rear Seat Line spring balancer rebounding issue [Refer Figure 8]**<br>1. Rebounding of nut runner and Pokayoke while return stroke on to MTM face.<br>2. Clogging of pneumatic and electric lines due to less space width.<br>3. High return force acting on MTM's torso. | 1. Spring balancers tension reduced.<br>2. Space width increased to 60 cm.<br>3. Electrical and pneumatic lines separated using hooks.<br>4. Sliding railing shifted as per the proper positioning of nut runner and Pokayoke. | 1. Safety issue of Pokayoke rebounding resolved.<br>2. Ease of processing the operation. |
| **Jump Seat assembly Process-Quality improvements [Refer Figure 9]**<br>1. Process modification was suggested to operators to carry out assembly without breaking the nip.<br>2. Trials shown the results that due to insufficient gap between frame and nip, nip slipped downside of frame and gap observed which is not as per specifications.<br>3. Seat got assembled, still plastic cover shown the wobbling effect due to non conformance of part assembly process with design. | 1. Process modification was suggested to operators to carry out assembly without breaking the nip.<br>2. Trials shown the results that due to insufficient gap between frame and nip, nip slipped downside of frame and gap observed which is not as per specifications.<br>3. Seat got assembled, still plastic cover shown the wobbling effect due to non conformance of part assembly process with design. | 1. No process performance difficulty while fitment of plastic cover to frame due to sufficient gap between frame and nip.<br>2. Ease of operation due to non braking of nip.<br>3. Process time reduction during assembly due to elimination of non value added activity.<br>4. No wobbling of plastic cover, no scratch marks appearance on plastic cover. |

## ACTION PLAN

For the initial efforts in creating connected Value Stream continuous improvements by rapid action implementations are required rather than long term project planning and evaluating the process. The aim should be to improve respective employee's workstation with complete involvement right form operator to manager. The actions were focused on layout changing for assembly and raw materials. Assembly layout changed as shown in Figure 7 to get the output of front and rear line in single finished seats trolley. Also firewall stations and seat review area are added for 100% inspection. Detailed action plan to create 'one piece flow' for a seat assembly line is as shown in Table 4.

### Kaizen Implemented

Figure 4: Spring Balancers Improvements

Figure 5: Jump Seat Process-Quality Improvements: A) Before, and B) After

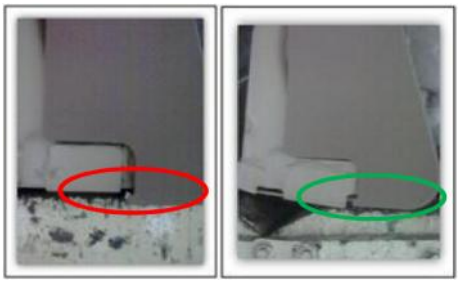


Table 6: 5S Improvements on Seat Assembly Line

| Problem/Waste | Changes | Result |
|---|---|---|
| **Jump Seat material mix up issue [Refer Figure 10]**<br>1. Mixed Storage in one Rack.<br>2. No visual identification.<br>3. Time loss for material handler to pick right material.<br>4. No any Proper location for leg tube. | 1. We prepare the separate small trolley for leg tube<br>2. Visual identification.<br>3. Defined specific locations for the trolley. | 1. No material mixing of leg tube.<br>2. Easiness for identification.<br>3. Dust Free Storage.<br>4. Material at its location with identification.<br>5. 5S Improvement in Storage.<br>6. Saves material handling and issuing Time. |

Figure 6: Jump Seat Material Storage Improvements; a) Before, b) After

Table 7: Improved Cycle Time for Seat Assembly

| Seat | VA Time [Sec] | NVA Time [Sec] | Total Time [Sec] |
|---|---|---|---|
| Front Seat | 504 | 380 | 964 |
| Rear Seat | 549 | 231 | 832 |
| Jump Seat | 121 | 35 | 194 |
| **Total %** | **56.97,70.32, 77.60** | **43.03,29.68, 22.40** | **100** |

Figure 7: Upgraded Value Added-Non Value Added Activities Chart

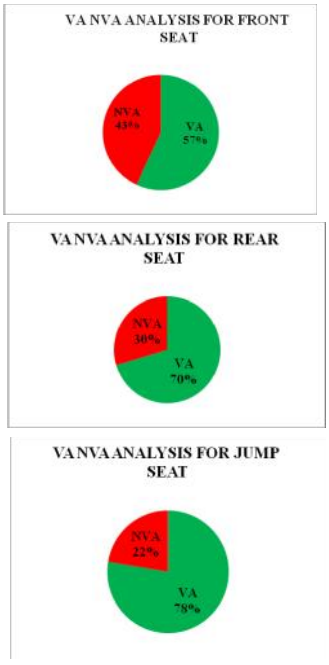


Figure 8: Process and Material Flow of Seat Assembly Line

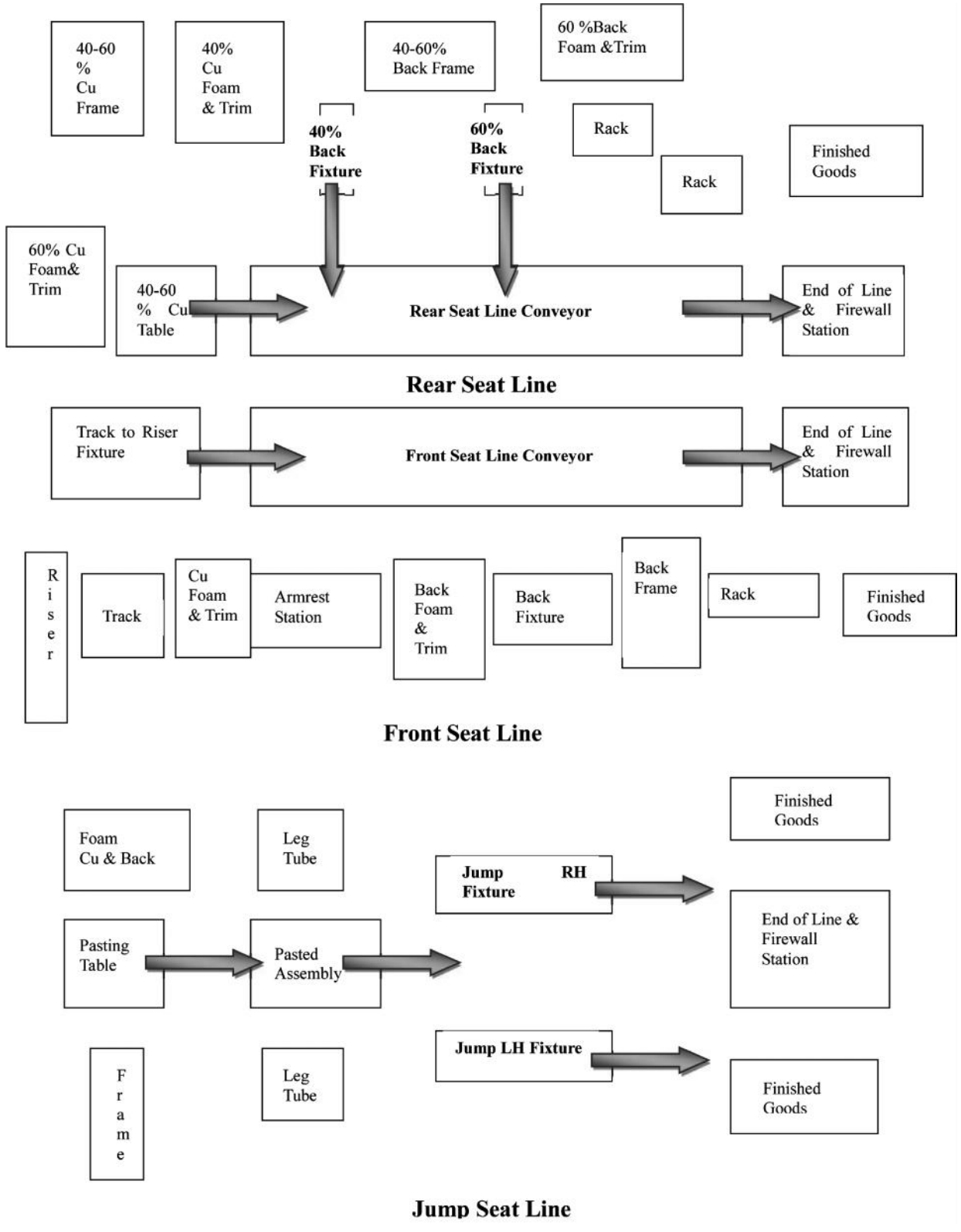


Figure 9: Seat Assembly Layout Change to Create "One Piece Flow"

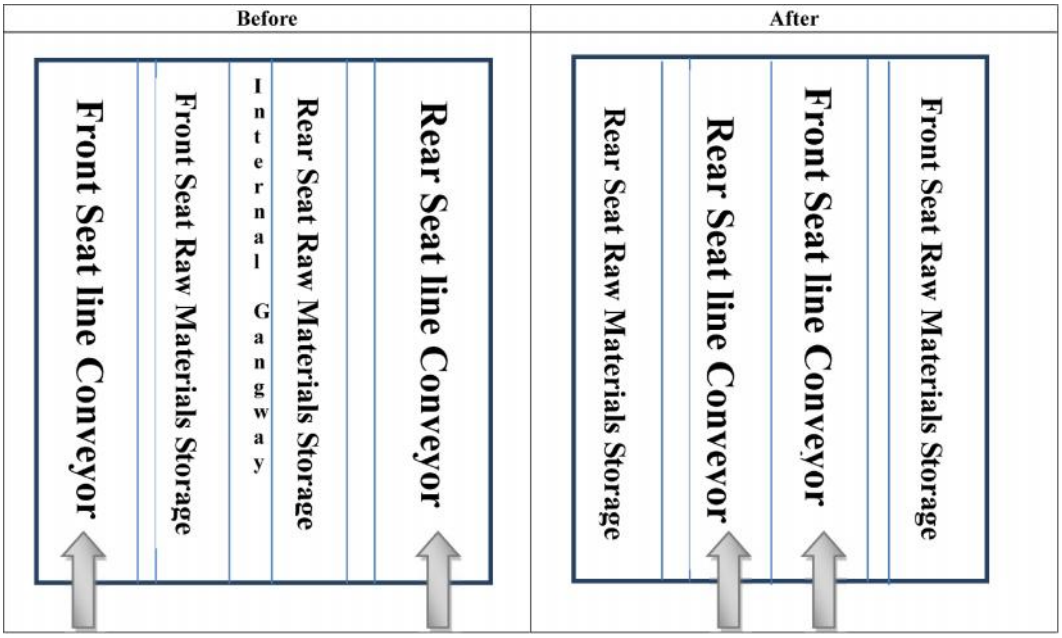



Table 8: Action Plan for Seat Assembly Layout Change to Create "One Piece Flow"

| Sr. No. | Action | Benefit |
|---|---|---|
| 1 | Assembly line layout to be change for one piece flow | Material flow improved with minimum handling |
| 2 | "A" class raw materials storage area to be shift near to assembly line with maintaining FIFO | All RM required on respective lines available with reduced transportation along with better visual management |
| 3 | Lux level improvement on all assembly stations | Better visuality to assembly process, quality issues |
| 4 | Firewall station to be introduce on all the three lines | Quality defects identified and resolved at designated places to avoid customer complaints |
| 5 | Seat review area to be introduce nearby to line | Seat quality for a particular schedule can be reviewed from time to time |
| 6 | Visual management improvement on raw material storage area. | Better identification of all types of raw materials with directions to maintain FIFO |
| 7 | All line side tools stands to be provide. | Good 5S |
| 8 | Place to be provide to keep raw material on line side rack | Good 5S |
| 9 | Both 40% and 60% back fixtures mounting blocks to be modify. | Ergonomics |
| 10 | Jump seat layout modification | "One piece flow" |
| 11 | Railings with spring balancers to be provide to keep jump line tools | Good 5S |
| 12 | FG trolleys for jump seat | Standardization achieved with designated trolleys given for both LH RH seats |
| 13 | New trolley to be developed for jump seat raw material storage. | Standardization achieved with designated trolleys given for both LH RH seats |
| 14 | Identification boards for RM storage, Finished Seats storage, "B" class components storage, Firewall stations, seat review area to be display. | Better visual management |

Figure 10: Current State Mapping of Seat Assembly Line

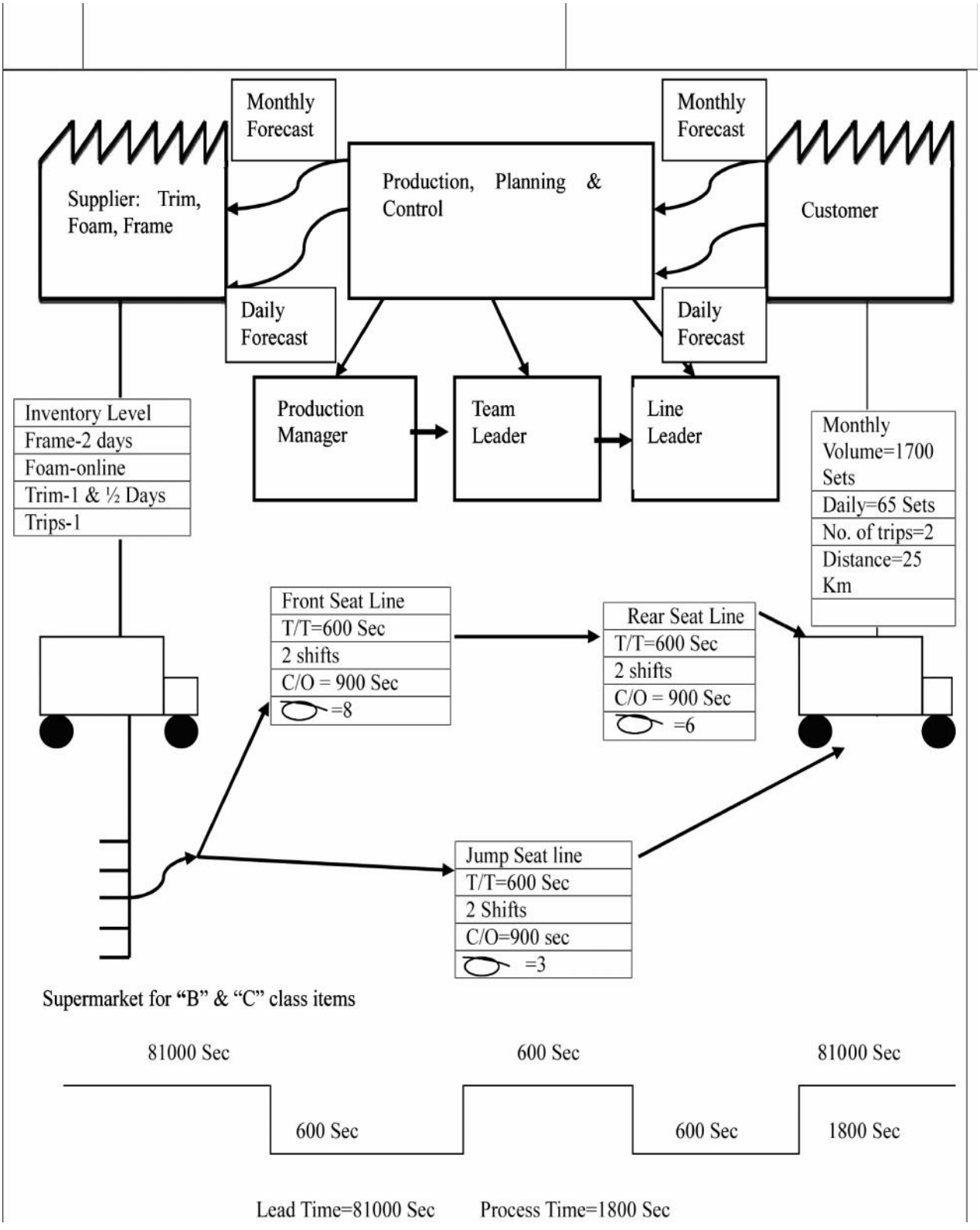
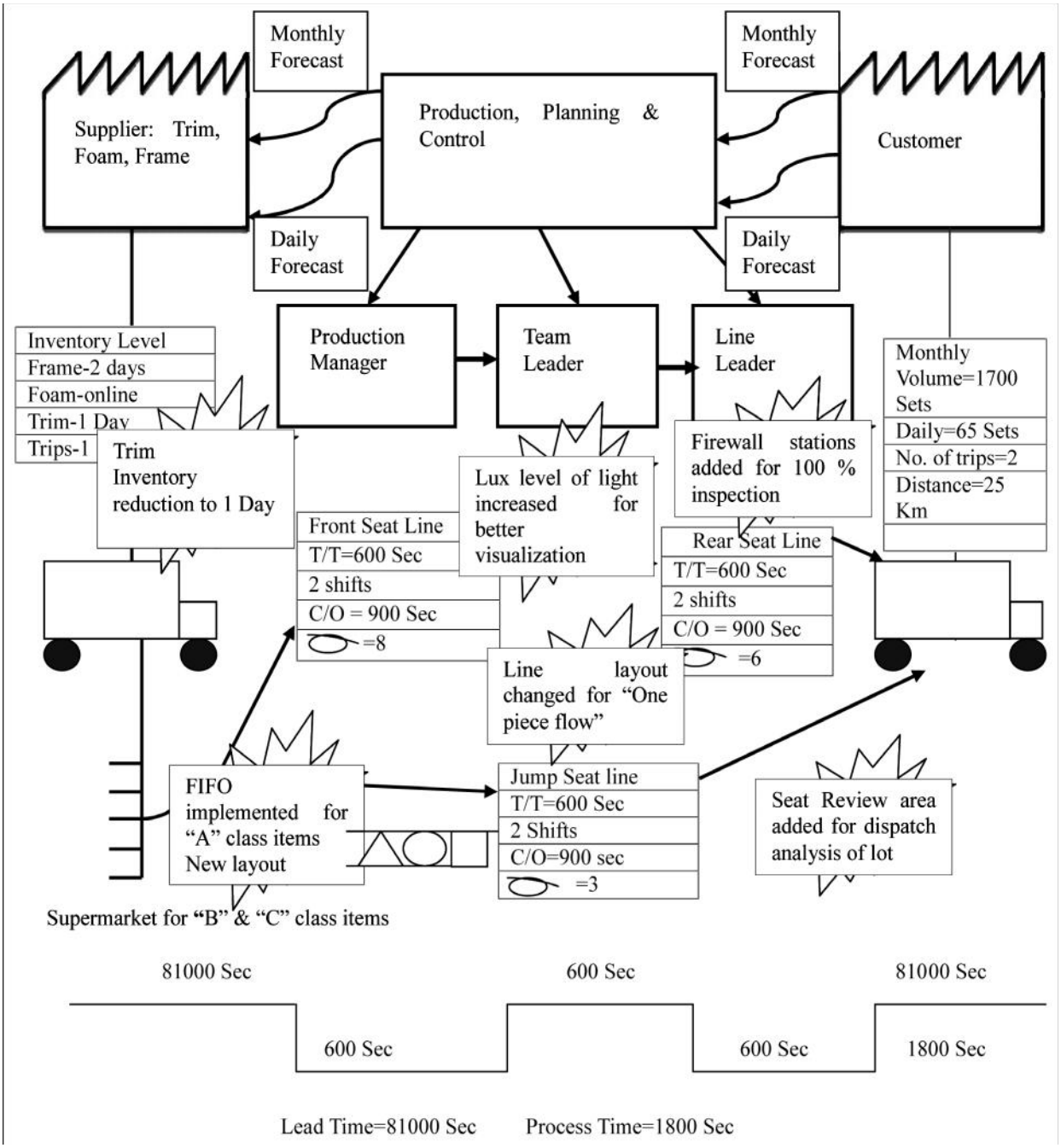


Figure 11: Future State Mapping of Seat Assembly Line




## NVA Reduction

NVA's are mainly created due to lack of material handlers, non standardized work, improper layout and equipment dysfunctionality, inappropriate line balancing, material shortage. To reduce these standard practices should be followed by operators with insurance that all the processes in the plant have the necessary material, qualified equipment and safety.

## CONCLUSION

Value stream mapping is a continuous process of self examining the process performance against the customer demand and satisfaction to the current state. It guides to the future state via scientific techniques like time and motion study, NVA reduction, Kaizen, 5S and focuses on root cause of the problem. After analyzing the most problematic NVA of waste-'Motion' during assembly operation at each station; through layout modification as per 'One Piece Flow' concept for overall Seat assembly setup reduction in NVA percentage was achieved as per the following data: (Refer Table 7, Figure 7).

Totally NVA reduction achieved by 25% all over the seat assembly line. Thus, it clearly indicates that the systematic application of value stream mapping process results in significant improvements in creating connected processes with continuous flow with reduction in non value added activities.

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