A

PROJECT REPORT

ON

"Productivity Improvement through Line Balancing Technique and Manpower Optimization using APS and STDS Software"

AT

GENERAL MOTORS INDIA PVT LTD
TALEGAON, PUNE

Submitted in partial fulfillment of the requirements of the award of the degree
of Bachelor Of Technology in **Mechanical Engineering**
By

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Under the Guidance of

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DEPARTMENT OF MECHANICAL ENGINEERING

SYMBIOSIS INSTITUTE OF TECHNOLOGY

(A CONSTITUENT OF SYMBIOSIS INTERNATIONAL UNIVERSITY)

PUNE-412115

(2015 - 2016)

Symbiosis Institute of Technology

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CERTIFICATE

The Project Report entitled **"Productivity Improvement through Line Balancing Technique and Manpower Optimization using APS and STDS Software"** is delivered and submitted by **Mr. Aishwary Jagetia (PRN NO: 13070121605)** of VI Semester for partial fulfillment of requirement for the degree of B.Tech. in Mechanical Engineering of Symbiosis International University during the academic year 2015-2016.

Prof. Nitin Solke	**Dr. Anand Kulkarni**
(Head Of Department)	**(Internal Guide)**
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2) **----------**
3) **----------**

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3rd June, 2016

To Whomsoever It May Concern

This is to certify that **Mr. Aishwary Jagetia** from Symbiosis Institute of Technology, Pune has worked as a project trainee in **Manufacturing** from 16th December, 2015 to 3rd June, 2016 on below mentioned topic.

"Productivity Improvement through Line Balancing Technique and Manpower Optimization using APS and STDS Software"

His performance during the project was good and we wish him good luck for all his future endeavors.

Poonam Yekad
Human Resources

CERTIFICATION OF EXCELLENCE

This is to certify that **Mr. Aishwary Jagetia** from **Symbiosis Institute of Technology, Pune** has successfully worked as a project trainee for 6 months in **Body Shop,** Manufacturing Department from **16th December, 2015** to **3rd June, 2016** on the following Projects:

1. Productivity Improvement through Line Balancing Technique and Manpower Optimization
2. Implementation of Assembly Processing System (APS) Software Process
3. Improvement through Time Study with the help of STDS Software
4. Study for the Implementation of New Models on Line
5. Reduced the Ergo rate of top rating station
6. Downtime Monitoring

Aishwary is a professional learner of the highest caliber, whose meticulous implementation of projects has earned him rich praise. He handled this project efficiently and was greatly appreciated in the company.

Mr. Sanjay Raina

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ACKNOWLEDGEMENT

I am using this opportunity to express my gratitude to everyone who supported me throughout the course of this Internship. I am thankful for their aspiring guidance, invaluably constructive criticism and friendly advice during the project work. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to the project.

I express my warm thanks to **Mrs. Poonam Yekad** for giving me this opportunity for completing my internship at **GENERAL MOTORS** and **Dr. Anand Kulkarni** for his guidance throughout this internship by giving me time to time valuable suggestions for completing monthly progress report , assignments and internship project.

I would also like to thank my project external guide **Mr. Sanjay Raina, Mr. Amit Kulkarni** and **Mr. Sachin Kulkarni** for giving me an opportunity to work under them and allowing me to work on project related to Productivity Improvement through Line balancing and Manpower Optimization.

I am thankful to **Prof. Nitin Solke** , Head of Department of Mechanical Engineering, for his motivating and valuable support throughout the course and all the people who provided me with the facilities being required and conductive conditions for my project.

I perceive this opportunity as a big milestone in my career development. I will strive to use gained skills and knowledge in the best possible way, and I will continue to work on their improvement, in order to attain desired career objectives. Hope to continue cooperation with all of you in the future.

Sincerely,

Aishwary Jagetia
(PRN : 13070121605)

ABSTRACT

- Productivity Improvement through Line Balancing Technique and Manpower Optimization
- Implementation of Assembly Processing System (APS) Software Process
    - Deploying APS on line by generating SOS and JES for each and every operator, as per the new balanced line.
    - Also Providing training to Team Leaders for APS deployment.
- Improvement through Time Study with the help of STDS Software
    - Providing time for each and every activities and based on Time study balancing the line and optimizing the manpower.
- Study for the Implementation of New Models on Line
    - Studying the change in Spots distribution and thus balancing the line as per the situation. Also to manage spots distribution for more than one model on the line along with it.
    - Solving Issues generated due to changes taking place and thus to provide solutions to it.
- Reduce the Ergo rate of top rating stations
    - Reducing the Ergo rate of the top rating stations, using Global Ergonomics Screening Tool (GEST) and thus improving the efficiency, safety and well being of employees.
- Downtime Monitoring
    - Monitoring the Downtime on Daily, Weekly and Monthly basis, Suggesting Action plans to reduce it and thus improving HPU.

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LIST OF ABBREVIATION

GM	General Motors
M300	Beat
SGM	Sail
MCM	Essentia
HB	Hatchback
NB.	Notchback
ENR	Engine Room
RRF	Rear Floor
FRF	Front Floor
UNB	Underbody
BSS	Body Side Sub Assembly
MFL	Main Frame Line
MRS	Main Respot Line
BIW	Closure Fitment Line
VS	Verification Station
HPU	Hours Per Unit
JPH	Job Per Hour
TT	Takt Time
ATT	Actual Takt Time
APS	Assembly Processing System
STDS	Standard Time Data System

MODE	Manufacturing Operations Data Environment
SOS	Standard Operation Sheet
JES	Job Element Sheet
LHD	Left Hand Drive
RHD	Right Hand Drive

Chapter-1

INTRODUCTION

1.1 Company Profile

1.1.1 History

General Motors is one such automobile manufacturer which has completed its century, set up way back in 1908 by William Crapo Durant to commercially produce cars & create the world's first automobile conglomerate. He did this by acquiring over 25 manufacturers/companies in a span of 2 years. This step also brought in some suppliers into the control of the company. His successor Alfred P. Sloan Jr., former President of the Hyatt Roller Bearings, one of the acquired companies, took over the reins in 1918 and with the blessings of the Du-Pont family; a turnaround was brought into the philosophies of the company by change in the leadership thereby the philosophy.

"Offer a car for every personal purpose"

Thus the concept of product length was explored for each class, different price, provided the lowest cost to generate highest volume of sales possible.

"Quickest way to profit is to serve the customer in ways the customer wants to be served"

Thus the concept of consumer satisfaction was started which saw to the meteoric rise of the company where it started exporting completely assembled cars to over 20 companies, since the operation overgrew the company after world war 1 started 19 new assembling plants by the year 1928 it had presence in 15 countries.

As part of the Standardization drive various companies were acquired of which namely Vauxhall in UK 1925, Adam Opel AG in Germany 1929, Holden in Australia 1931, etc. Over the decades it has seen the industrial ups and downs added to its

product range, operations and acquisitions, partnerships; presently acronym GMC, Corporate offices at Detroit, Michigan.

Organizational Structure

Presently its arms are divided as per the decentralization policy of GMC into various geographic regions:

GMC- General Motors HQ and Corporate Affairs **-** Detroit, Michigan, USA.

GMNA- North America Operations**. -** Vehicle Sales, Service, & Marketing Group - Warren Michigan, Midsize and Luxury Car Group - Los Angeles, California + Mexico & Canada sales offices.

GM LAAM- Latin America, Africa and Middle East Operations.

Brazil, Argentina, Egypt, South Africa, UAE.

GME- Europe Operations.

Poland, Germany, France, Italy, Belgium, Hungary, Czech Republic

GMAP- Asia Pacific Operations- HQ Shanghai (China).

Indonesia, Japan, China, Hong Kong, Philippines, India, Australia, Malaysia, South Korea, Thailand.

General Motors Corporation

GMC is one of the world's largest corporations and ranks highly amongst the first 4 of the Fortune 500 both in industrial manufacturing and assets terms in any given year of preview.

It has about 21% of the total world market share in the segment it operates. It employs over 8 lakh people and has sales practically all over the world. Plants for manufacturing are present in 43 countries and in over 50 countries various level of assembly plants and supplies procurement offices are located. With further plans on the anvil there is nothing to stop the lead of growth in the company in forthcoming years.

Value Management; PICOS; sourcing/Teamwork; Precise Communication; Common Process and Systems are some of the key strategies responsible for the company growth.

Headed by:

GMIO- General Motors International Operations for outside North American Operations

1.1.2 Vision:

"GM's vision is to be the world leader in transportation products and related services. We will earn our customers' enthusiasm through continuous improvement driven by the integrity, teamwork, and innovation of GM people."

1.1.3 Mission:

"G.M. is a multinational corporation engaged in socially responsible operations, worldwide. It is dedicated to provide products and services of such quality that our customers will receive superior value while our employees and business partners will share in our success and our stock-holders will receive a sustained superior return on their investment."

1.1.4 Brand Association :

General Motors fully owns the following automotive brands as of 2011:

Buick	Sold in North America, China
Cadillac	Sold by (except South America, India, South East Asia, Australia)
GMC	Sold in North America, Middle East
Chevrolet	Sold by (except Australia, New Zealand)
Vauxhall	Sold in United Kingdom
Opel	Sold in Europe (ex. United Kingdom), Middle East/Africa, Asia/Pacific, South America
Holden	Sold in Australia, New Zealand

Table 1 : Brand Association

1.1.5 GENERAL MOTORS INDIA PVT LIMITED

General Motors India is a wholly-owned subsidiary of General Motors Corporation, USA with over 12 years of operations in India. GM India started its Indian journey in 1996 and offers products under the Chevrolet brand in the country. Its flagship brand, Chevrolet, was introduced in India in 2003, under the banner "For a Special Journey Called Life". Chevrolet has emerged as one of the fastest growing automotive nameplates in India today. GM India presently makes the Chevrolet Tavera, Chevrolet Optra, Chevrolet Aveo, Chevrolet Aveo U-VA, Chevrolet SRV, Chevrolet Spark and

Chevrolet Captiva for the Indian market at its manufacturing facilities at Halol, Gujarat and Talegaon in Maharashtra.

With an array of product ranging from a mini car to a premium SUV, GM has brought international standards of product quality and customer care to the Indian consumers. The Chevrolet Tavera, Chevrolet Optra, Chevrolet Aveo U-VA and Chevrolet Spark have won numerous automotive excellence awards since their launch. In addition, Chevrolet Spark and Chevrolet Aveo U-VA have consecutively won the prestigious J.D. Power Quality awards in their respective segments in 2007 and 2008.
GM's state-of-the-art Halol plant in the western state of Gujarat now has a capacity to manufacture 85,000 units annually. The capacity was expanded to 85,000 units from the 60,000 units in April 2007. The Halol plant received the ISO 9002:1994 Quality Management System certification in 1999 and also was re-certified for ISO-9001:2000 in April-2005. GM India also received ISO 14001 certification for its Environment Management System in 2000 and was re-certified for ISO 14001:2004 in November 2005. GM India's plant also received the prestigious 3 Leaves Award from the Centre for Science and Environment (CSE) for overall environmental performance of GM India in 2001-02. It has also received the Energy Conservation Award for 2008 from Government of India in December 2008 and has also bagged Quality Circle awards instituted by various State Governments on many occasions.

General Motors India's second manufacturing plant at Talegaon has started production on 2nd of September 2008. This plant has a capacity to produce 140,000 units annually which has taken GM India's total manufacturing capacity to more than 225,000 units

On August 28, 2008, General Motors India and the Government of Maharashtra signed a Memorandum of Understanding for the establishment of a new Powertrain Production Facility with a capacity of 160,000 engines per annum in its Talegaon manufacturing plant premises. Representing an initial investment in excess of $200 million, the facility is soon coming up to service the requirements of GM's engine and gearbox requirements.

GM has also set up a Technical Centre at Bangalore under the umbrella of GM India. It is one of the four GM Technical Centers in Asia (GMDAT, GM China and Holden).

The Centre has three operational units: Research &Development (R&D), Engineering and a Design Centre. The Design Centre is India's first digital design studio. It supports a design strategy, and plays a key role for the GM Design network as a "listening post" in India to gather and understand local product design requirements. GM is also looking aggressively in developing environment friendly technology for future.

GM India is the pioneer in several industry-first programmes including a centralized, 24x7 call center to attend to customer complaints and provide information related to GM India's products and services. A local call to 3030-8080 from any landline or mobile phone across the country will access this service. GM also introduced the "Cost of Ownership" programme to further bolster the excellent ownership experience of Chevrolet vehicles.

Other industry first programmes introduced by the company earlier include chauffeur training programmes, mobile road show caravans, best-in-class warranty schemes, service holidays, mileage rallies etc. GM India has also introduced net-based initiatives aimed at increasing the sales volume through their website www.chevrolet.co.in. With a view to further expand its presence in the Indian market, GM India has tied up with BPCL for establishing Chevrolet Authorized Service Centres at select BPCL workshops called "V CARE". All such selected V-CARE centers will be equipped with GM India Diagnostic tools & tackles required for providing Periodic Maintenance Service to our valued customers

As of now, GM India has a total workforce of over 3500 personnel excluding contract workers. GM India has achieved significant localization for all its products and its local suppliers include domestic and multinational companies located in various parts of India covering areas from Chandigarh in the north to Cochin-Madras region in the south. The wide range of localized parts range from stampings to wiring harnesses. The stampings, radiators and other miscellaneous parts are sourced from and around Halol and Baroda.

As a responsible corporate citizen, GM India has been in the forefront of corporate social responsibility (CSR). It has provided relief to victims of natural disasters, helped renovate and repair homes of those in need, and carried out health-care and

health education programs. It is also supporting educational institutions as part of its CSR activities. GM India believes in working with the Govt. to spread awareness of issues that are in the public interest and have an overall impact on the state's development & economy. GM India has brought the latest manufacturing processes and human factor practices to its operations in India and set benchmarks for advanced technologies in the Indian automotive industry. Despite the ongoing recession, the company registered a growth of 9.5% in sales in the calendar year 2008 by clocking sales of 65,702 units which could be attributed to the growing popularity of the brand Chevrolet. India being one of the emerging and fastest growing marketing the region, GM is serious to this market and is exploring various business options in the automotive related fields.

1.1.6 Company catalogue

Car presently being produced at the General Motors India, Talegaon are :

1. Beat (M-300)
2. Sail (SGM NB/HB)

TURN ON STYLE
TURN ON THE BEAT LIFE.

CHEVROLET BEAT | FIND NEW ROADS

CHEVROLET

PRESENTING CHEVROLET BEAT, WITH STUNNING NEW DESIGN FEATURES.

1. New Jewel Effect Tail Lamp
2. Impressively Designed New Headlamps

Chevrolet Beat- the ultimate style statement!

The all new Chevrolet Beat is now even more stylish. The all new front styling with the signature Chevrolet dual port chrome lined grille, stunning new headlamps and fog lamps with new chrome lined contrasting black surround give it a distinctively stylish look. But that's not it. The all new stylish bumper, jewel effect tail lamps, dual tone wrap around rear bumper and the ergonomically located all new steering mounted audio controls add fresh new appeal and style to the uber stylish Beat.

Drive one and Turn on the Beat Style!

1. Stylish Dual Port Chrome Grille With Bold Front Fascia
2. Sporty Dual Tone Rear Bumpers
3. All New Steering Mounted Audio Controls

Figure 1 Beat Catalogue

CHEVROLET SAIL

15 EXCITING FEATURES

FIND NEW ROADS

CHEVROLET

NEVER SETTLE FOR ANYTHING LESS

15 EXCITING FEATURES IN THE CHEVROLET SAIL

The Chevrolet Sail embodies the bold pioneering spirit and ingenuity which has become the hallmark of Chevrolet. Stylish and classy, this car is artistically sculpted with muscular contours. Packed with advanced safety features, superior boot space, luxuriously spacious interiors and powertrain options, the all-new 2014 Chevrolet Sail is perfect for urban heroes aiming to conquer life.

STAND OUT The Sail is a perfect match for those who prefer to stand out. Aggressive and macho, with a front styling based on Chevrolet's Dynamic Sculpture Design philosophy, its wide stance lends it unbeatable grace. Elegant wide-angled, jewel-effect tail-lamps and wrap-around head-lamps adorn this dazzling beauty.

WOW FOR YOUR DRIVE Knowing that a good music system enhances the driving pleasure, the Chevrolet Sail comes with 2 DIN Audio System. Enjoy the Bluetooth® enabled Music Streaming and Mobile Hands-free function that makes your journey even more convenient. Fitted with the Aux-in, USB, Radio, CD player, MP3/WMA support, get ready for an ultimate musical journey.

A SAFE BET While crafting the perfect all-round performer for you, we also made sure that you'd be seated in one of the safest cars on the road. The Sail's safety design is a holistic and thorough package of features which protects all the passengers in case of a collision. A 'Safe Cage' structure protects passengers by dispersing the force of a collision through the body of the car. Features like ABS with EBD, Speed Sensitive Door Autolock and several other features come together to ensure one thing – that you always enjoy your drive with the complete peace of mind as you & your loved ones are in safe hands at all times.

Figure 2 Sail Catalogue

Chapter-2

INTRODUCTION TO DEPARTMENT

Picture 1 : GENERAL MOTORS TALEGAON

POWER TRAIN	VEHICLE PLANT
Site Area: 25 Acres	Site area : 300 Acres
Start of production : Nov 2010	Start of production : Qtr-3 of 2008
Capacity : 1,60,000 units p.a	Capacity : 1,40,000 units p.a
Management systems: GM-GMS	Management systems: GM-GMS
Automation level : Low-Medium	Automation level : Low-Medium
	Automation level : Medium

Table 2 : Plant Information

2.1 Basic Plant Operations

Major Areas In GMI

The Manufacturing Engineering Department performs the function of converting the raw materials into the final product-the car. The Plant works in two shifts-the Blue Shift and Yellow shift.

The Department consists of four divisions-Press shop, Body Shop, the Paint Shop & General Assembly. The General Assembly may be essentially divided into two parts-The Assembly of the car and Quality Verification Stations.

There is a single production line for both the models i.e. Spark & Beat. Sequence of production is decided by customer requirements and tact time considerations. The assembly line uses a floor conveyor in the trim and final finish lines. As per GMS requirements and the company policies in tune with the SPQRC philosophy, Business Deployment Boards (BPD) boards are set up for each shop, the purpose of the boards being to inform the shop-floor employees about the production status in the plant. The BPD boards are divided into five sections-SPQRC (Safety, People, Quality, Responsiveness, Cost) with the PDCA (Plan, Do, Check, Action) status of each item being displayed. BPDs keep the shop-floor informed about the current PDCA status in the plant through visuals. Green signifies no incidents on the shop-floor whereas red marks are used to indicate the occurrence of an incident leading to injury.

The line has two different Andon buttons which are used to call for help. In the plant, there are three Andon buttons-one for materials, one to call for maintenance personnel and the third to call for the team leader/supervisor. Apart from the Andon System which is a pull system, there is also a Kanban system, where the operator has to place his material requirements through the placement of a Kanban card in the Kanban bin. This card is then collected by the materials team and the operator is supplied with the materials in required amount.

2.2 Plant Structure

- Plant Structure is created starting at the highest level to the lowest level

– Plant
– Plant Configuration
– Shop
– Department
  - Teams can be created in each department
– Group
– Operation
– Job

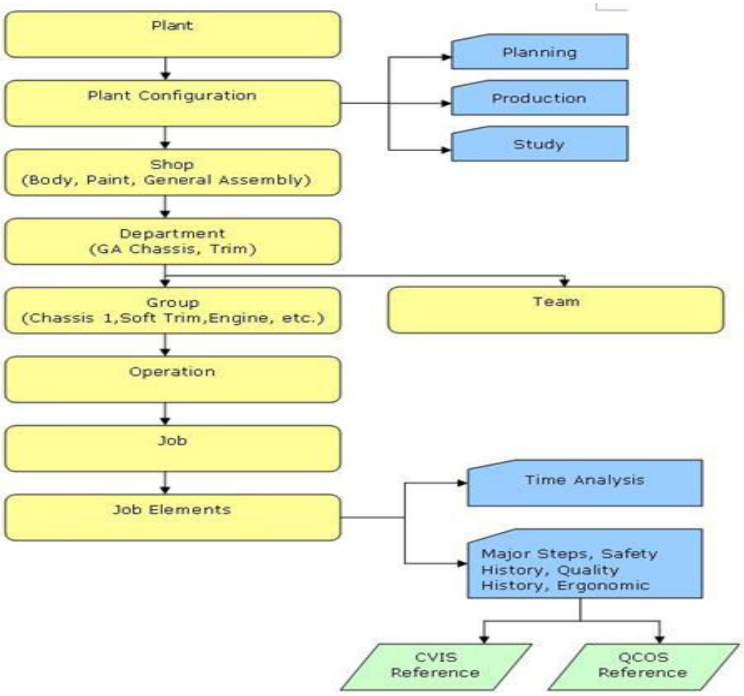


Figure 3 : Plant Structure Flow Diagram

The manufacturing department of General Motors India, Talegaon plant is divided into four major departments:

Press shop

Body Shop

Paint Shop

General Assembly

2.2.1 Press Shop

In press shop the thin material sheets are given required shape which later are assembled in body shop. The process involved to convert raw sheets into car body are as follows.

CLEANING OF SHEETS: By Oil using cleaning M/C with Nozzle

SEPARATION OF SHEETS: By Using Magnetic Technology

CENTERING

TANDEM PRESS LINE

1. Press 1800 ton: Drawing Operation
2. Press 800 ton: Trimming Operation
3. Press 800 ton: Piercing Operation
4. Press 800 ton: Restrict Operation

INSPECTION

The major equipment involved in this shop are Sheet lifting robots, Heavy duty presses & Die lifting cranes.

2.2.2 Paint Shop

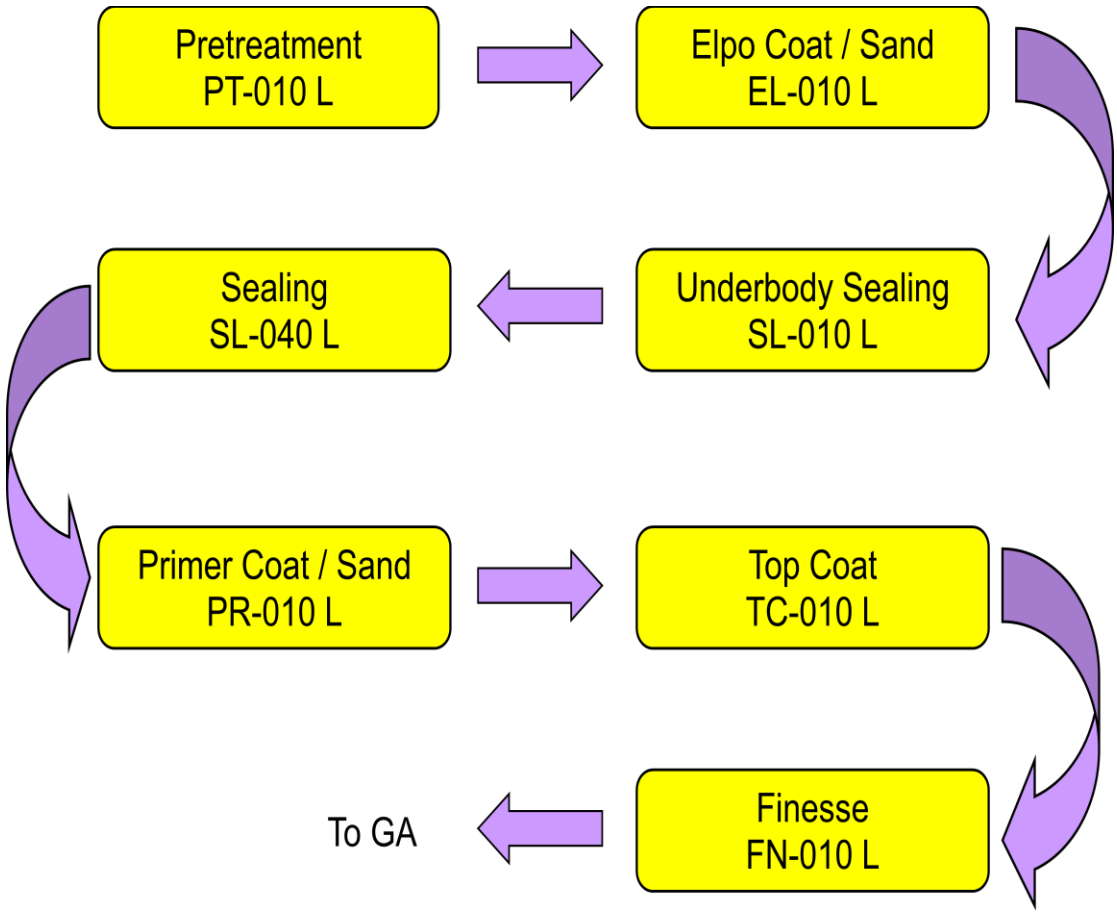


Figure 4 : Paint Shop Layout

The paint shop is further divided into Body Paint shop and Plastic paint shop. The output from the Body shop comes to the Body paint shop and after the paint job is completed the painted car body is transferred to the Assembly shop for final assembly. Major areas or booths in Body Paint Shop are Pre Treatment plant, electro dip plant, electro coat oven, spray booths, prima and topcoat oven, paint shop ventilators, body-carrying trucks, PT-Elpo conveyors and spray-booth/oven conveyors. The Plastic parts like Bumpers are painted in the Plastic Paint shop and once the paint job is completed it is send to the Assembly line for final assembly. The Major equipment's in the plastic paint shop are Flaming Zone, Spray Booth, and Humidifier; Sludge handling system, Oven and plant ventilation. Maintenance Team 4 is responsible for this area.

GMI has a modern paint shop with the painting of the cars being divided into five stages-

1. Pre-cleaning-done in 8 stages
    - Manual wiping
    - Degreasing
    - Spray rinse soft water
    - Activation
    - Phosphating
    - Passivation using Zr
    - Manual spraying.

2. ELPO line containing the following stations
    - ELPO enclosure for electro deposition
    - Cleaning chamber
    - Unloading station for manual rinsing
    - ELPO oven for baking

3. Sealing line having the following stations
    - ELPO sanding
    - Sealer application
    - Deadener and plug fitment
    - PVC and Underbody application

4. Spray booth having the following stations-
    - 1ST Manual –for interior base coat painting
    - 1st Bell having 4 robots for exterior base coat painting
    - 2nd Manual—for interior clear coat painting
    - 2nd Bell- having 4 robots for exterior clear coat painting

5. Top coat oven and finesse it having the following stations-
    - Primer and top coat oven for baking
    - Finesse it for sanding, buffing and polishing
    - Spot repair for paint touch-up
    - Primer sanding

2.2.3 General Assembly Shop

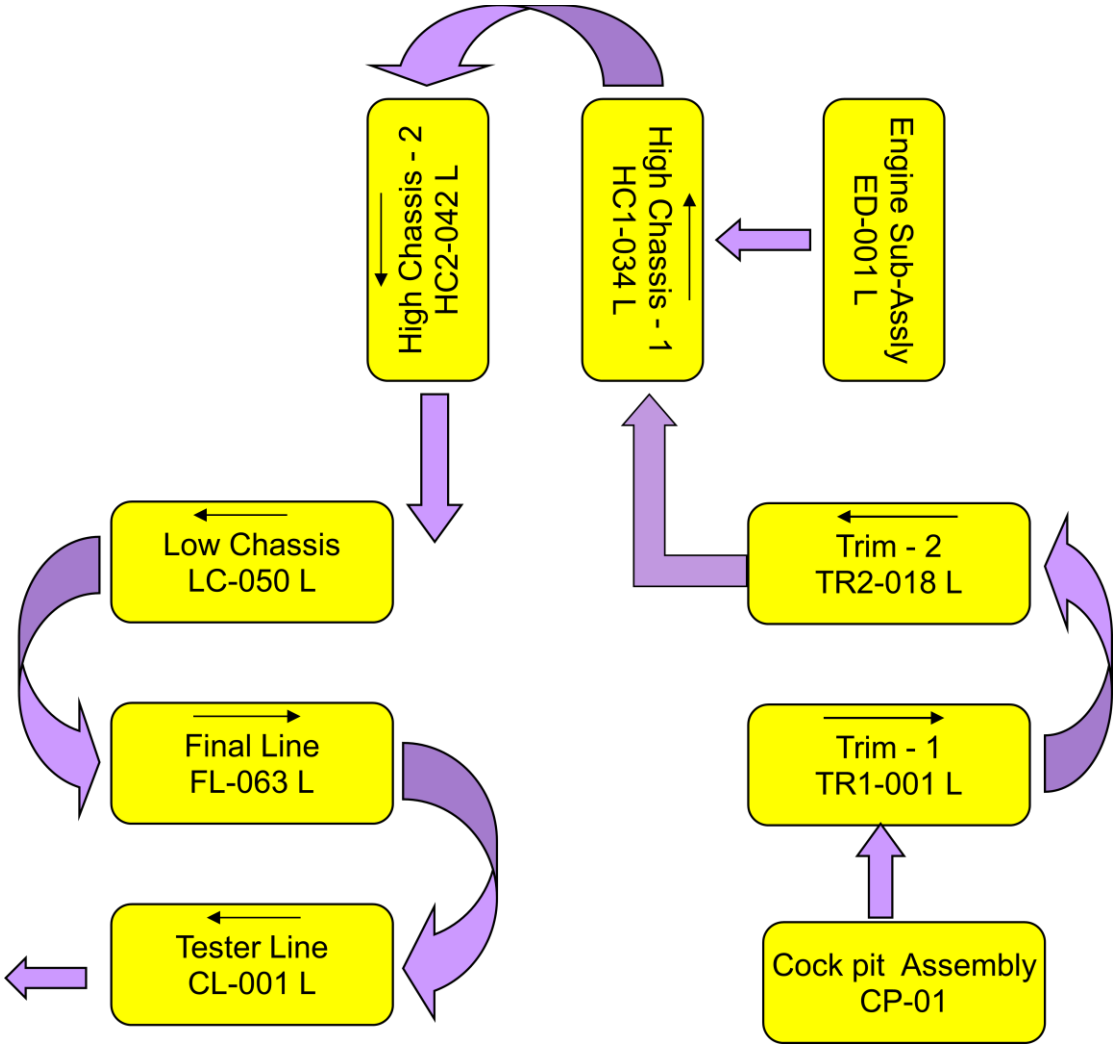


Figure 5 : GA Shop Layout

The General Assembly of GMI is divided into two parts –the actual car assembly and the quality stations. The actual car assembly itself consists of two parts-the trim line and the final car finish. The trim line of one particular conveyor line collects the car from the paint shop and fits trim accessories before handing the car to the chassis area. Trim accessories include headliner fitment, brake line fittings, weather strip fitment, and waxing cockpit assembly. The interior fittings are then made, including the cockpit and the floor carpets. The parts like Fuel tank, Engine, Exhaust muffler, Radiator etc. are fitted on Chassis line. While Final line activities includes Coolant Filling, Brake fluid filling, Tire fitting etc. Once the vehicle is ready on final line, it is tested as explained above while describing functions of quality department. Following figure shows Various Areas of the GA shop.

2.2.4 Body Shop

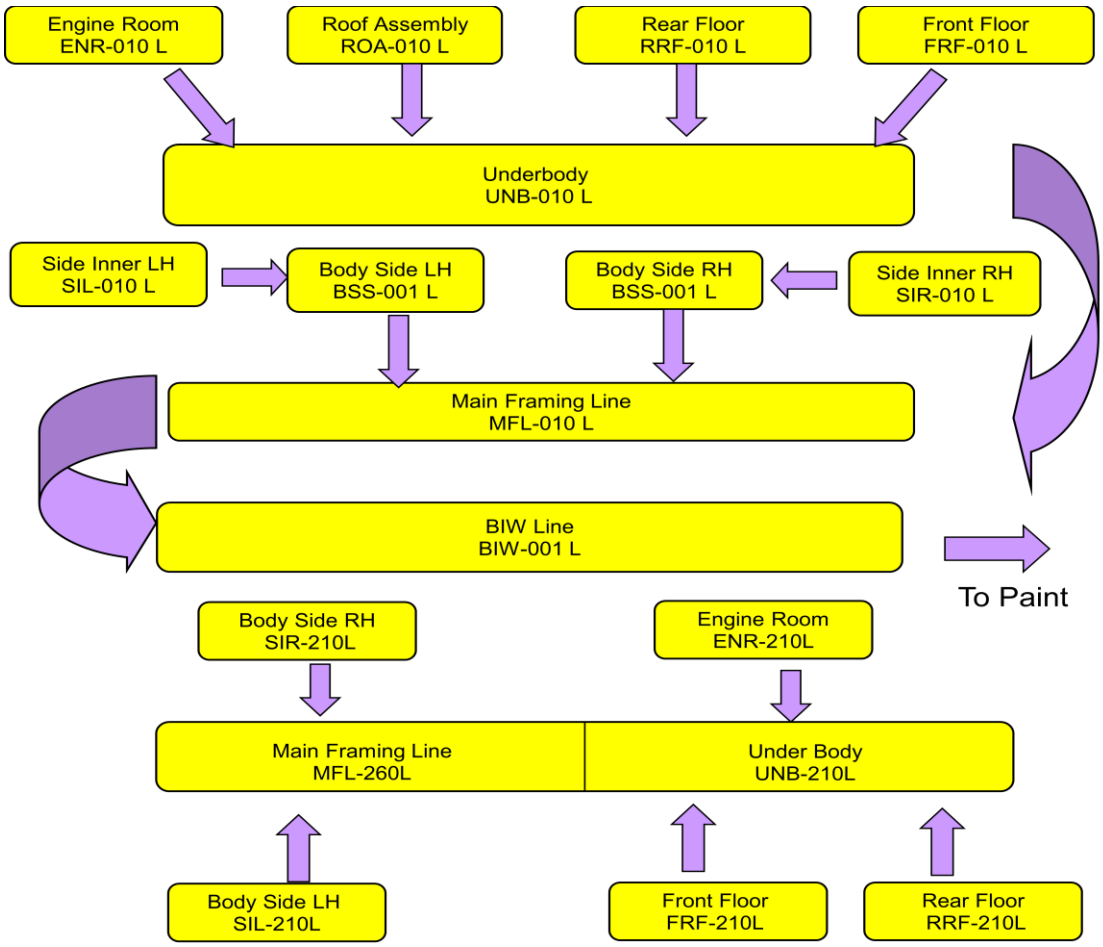


Figure 6 : Body Shop Layout

Body shop is the part of an automotive plant where the main frame of the car body is manufactured. The different sheet metal parts and the outer panels are assembled and joined together by various techniques such as spot welding; stud welding, CO2 welding, nuts and bolts and hemming. The final product going out of the body shop is known as the white body since the structure formed has a white appearance due to the luster of the sheet metal. The structural parts of a vehicle are usually made from a special sheet metal known as the **cold roll**.

Picture 2 : Vehicle in Body Shop

2.2.4.1 Layout Of The Body Shop

The body shop consists of the following divisions:

1. Engine
2. Rear Floor (RRF)
3. Front Floor (FRF)
4. Underbody (UNB)
5. Dash Assembly
6. Side Body (Inner and Outer)
7. Body Side Sub Assembly (BSS)
8. Roof Assembly (ROA)
9. Underbody Line (UNB)
10. Main Frame Line (MFL)
11. Main Respot Line (MRS)
12. Closures (Front and Rear doors, hood, tail gate/deck lid)
13. Closure Fitment line (BIW)
14. Verification Station (VS)
15. Heavy Repair Line

The body shop is also divided into six groups with each group encompassing a definite subset of the above mentioned divisions.

The body shop has been divided into these groups for greater efficiency, improved participation and better organization of the otherwise cumbersome process into a well-

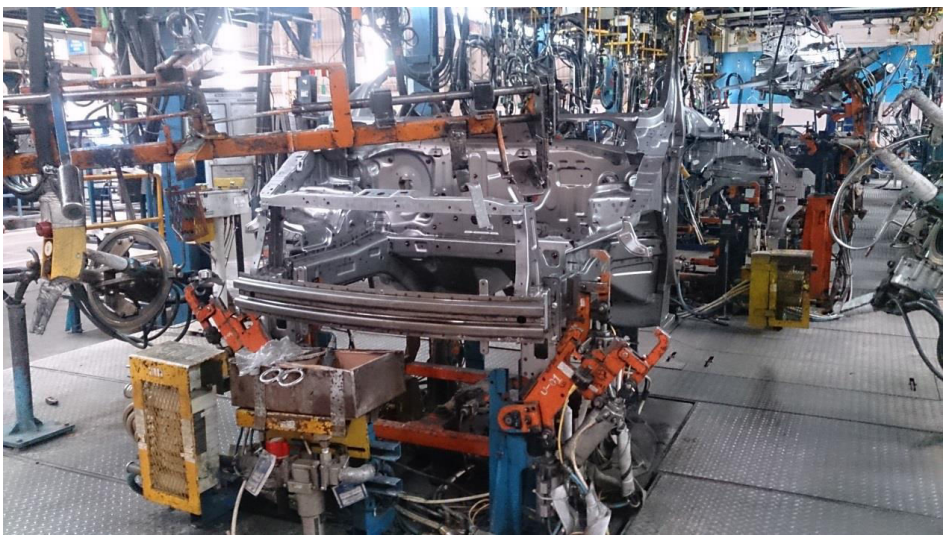
defined chain of processes. This helps the manufacturing process to go on without any hindrance.

Group 1: ENR, RRF, FRF, UNB
Group 2: SIL, SOL, SIR, SOR, ROA, MFL, BSS
Group 3: MRS, BIW (consists of closure fitment line and the verification station).
Group 4: Closures (doors, hood, and tailgate/deck lid)
Group 5: ENR, RRF, FRF, UNB
Group 6: SIL, SOL, SIR, SOR, MFL

Group 1 and Group 2 are dedicated for the manufacturing of M300 and M200 while Group 5 and Group 6 are dedicated for the production of SG308 HB/NB.
In group 3, the stations are common for all the models. In Group 4, four hemming machines are used for different closures.

Engine Room :

The engine room is the section of the car which is occupied by the car engine. The engine room consists of six stations from **ENR010RH/LH** to **ENR060RH/LH**. This division is responsible for the manufacturing of engine rooms for **M300**. **ENR10/ENR20**: Left and right hand longis, dash assembly, cross member and front panels are assembled and welded with minimum number of spots required to hold the assembly to form the basic structure of the M300.



Picture 3 : Engine Room - Body Shop

ENR30: This station is employed for spot welding of both the engine rooms. These spots serve the purpose of providing strength to the structure increasing the rigidity of the assembly.

ENR40/ ENR50: The side panels are welded to the M300 assembly. These side panels are used as the mountings for the fenders.

ENR60: This station is used as a buffer for the Under Body Line.

Front Floor :

Front floor consists of two stations **FRF010** and **FRF020**. FRF010 station is dedicated for the manufacturing of **M300** front floor. For **M300** front floor, the following parts are assembled and welded:

Reinforcement bars, tunnel, front floor panels and cross members.

Respoting sealer (grey color) is applied to the reinforcement bars and the tunnel before placing front floor panels over them. After taking minimum number of spot welds, the cross bars are properly located and welded using the position of the locating pins and clamps.

Rear Floor :

Rear floor consists of five stations from **RRF010** to **RRF050**.

RRF010, RRF020: The rear floor is manufactured by the assembly of primarily two panels known as **rear floor panel** and **rear floor rear**. Respoting sealer is applied to the joint between the two panels. Four **seat belt clamps** are attached to the rear floor panel. **Wheel mount** is welded in the center of the cavity in the rear floor rear. The cavity is used for keeping the stepney. The RRF010 station is used for **M300.**

RRF030: At this station, the rear floor assembly is fitted to the load assembly.

RRF040: At this station, the rear floor assembly so formed is joined with two longis. The longis form the support framework of the structure thus carrying the maximum load.

RRF050: The station is a respoting station. No new parts are added to the assembly.

Picture 4 : Rear Floor- Body Shop

Under Body :

The underbody line for **M300** has five stations from **UNB010** to **UNB050**. In the underbody division of the Body Shop, the three sections namely; engine room, front floor and rear floor are assembled and welded to form the base to which the side body is fixed.

The three sections are bought together using the trussle system and assembled in the proper sequence at **UNB010.** These segments are joined together by **spot welding** at **UNB020**.

At **UNB030** the side pillar reinforcement panels are attached to the underbody. Structural sealer (blue colored) is applied to all the three pillars A, B and C. The sealer helps in proper adhering of the side body to the underbody at the three pillars. The under body is completely manufactured and buffered at **UNB050**.

Side Inner Body :

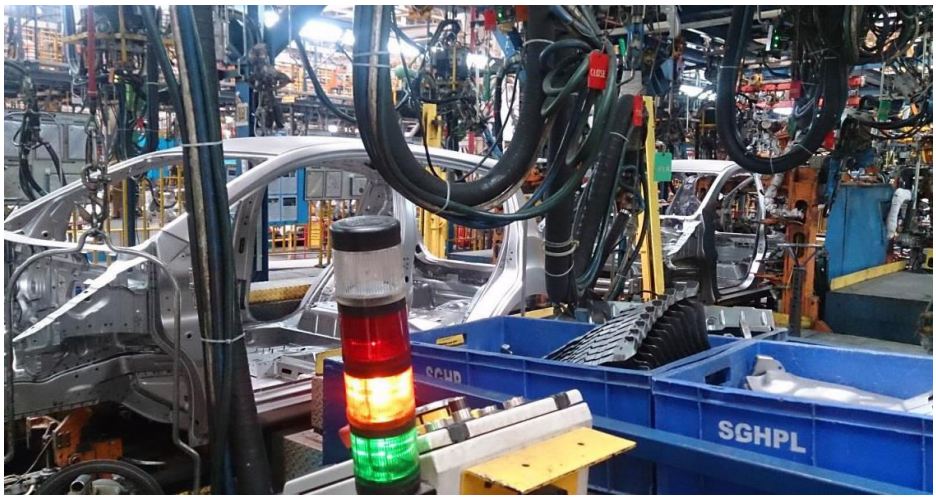
The **SIL/SIR** consists of two stations each, from **SIL010/SIR010.**

At these stations, various parts such as the hinge pillar, centre pillar, rocker arm, roof reinforcement panel and inner quarter panel are assembled and welded. The so welded assembly forms the inner side body which provides the strength and rigidity to the flimsy outer panel.

Picture 5 : Side Body - Body Shop

Main Frame Line :

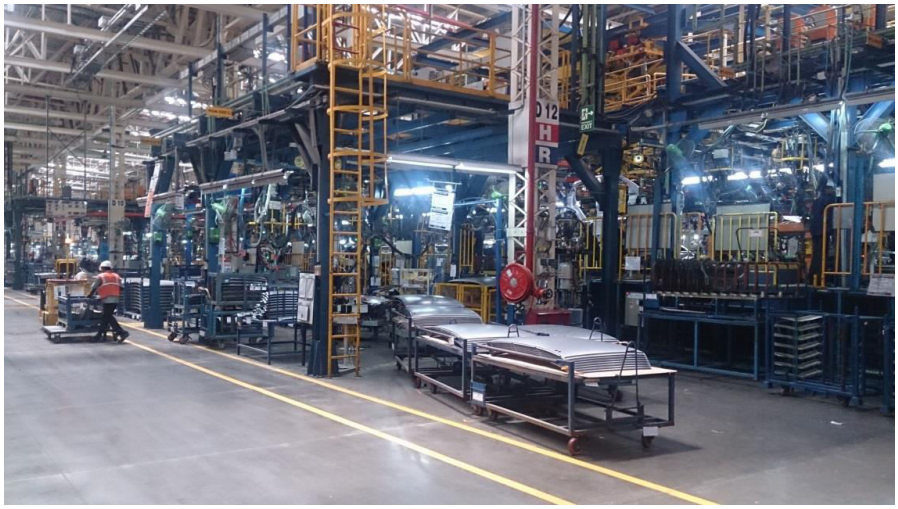
The main frame line for **M300** has six stations from **MFL060 to MFL110**. The main frame line starts with the loading of the side bodies onto the underbody at **MFL060** followed by spot welding at the next station i.e. **MFL070**. At **MFL080** station. Station **MFL100** is a respoting station. **MFL110** station used as a buffer before moving the structure to the MRS line with the trussle and tackle system.



Picture 6 : Main Frame Line - Body Shop

Roof Assembly :

The roof, in case of M300 **ROA010** and **ROA020** stations. The outer roof panel is fitted with the inner reinforcements to manufacture the roof assembly. **Anti-flutter sealer** is applied to the reinforcements to make them adhere to the roof panel without making any fluttering noise at the time of motion of the car.



Picture 7 : Roof Assembly - Body Shop

Main Respot Line :

The main respot line is **common for all the models** i.e. M300, SGM308 HB and SGM308 NB. This line consists of 8 stations from **MRS010** to **MRS080**. In this line, all the parts are properly spot welded, i.e. complete number of spots are taken to give the assembly sufficient strength and rigidity. This is the final stage for reinforcement of the main structure.

At **MRS070**, the vehicle undergoes CO2 welding. It is the only station in the entire body shop where CO2 welding is done.

At **MRS080**, the vehicle undergoes quality check for the removal of any defects due to welding such as weld spatter, excess weld etc.

Picture 8 : Main Respot Line - Body Shop

Closure Fitment Line :

Closure fitment line (**BIW**) is **common for all the models**. The line consists of seven stations from **BIW020** to **BIW070**. Primarily, the closures, i.e. the four doors, hood, tailgate/deck lid are attached to the body so as to complete the body of the car.

Rear doors are connected first at stations from **BIW020** to **BIW040** followed by the front doors, fender loading and hood hinges at **BIW050**, tail gate at **BIW060** and hood at **BIW070**.

Picture 9 : BIW Line - Body Shop

Metal Finish Line :

Metal finish line is **common for all the models** being manufactured in the Body Shop. The line consists of five stations from **BIW080** to **BIW120**. The car body is checked for any defects, primarily dents and dings, and removed by grinding, buffing and dent pulling.

BIW120 station is buffer station.

Verification Station :

The verification station consists of stations from **BIW130** to **BIW160**. These stations are responsible for the quality check of the vehicles coming from the metal finish line. The vehicles are checked for any defects such as dents, dings, burrs, scratches and damages are repaired. These defects are booked in the **GSIP** under **DRL** to check the overall performance of the shop.

In case of heavy damage, the vehicle is taken offline and then repaired in the heavy repair area.

Picture 10 : Verification Line - Body Shop

SGM308 HB/NB

Engine Room :

In case of **SGM308 HB/NB**, the engine room has stations from **ENR210** to **ENR230**. At these stations, various parts are spot welded to the dash assembly such as longis are welded to the dash assembly at **ENR220**. The front impact panel and cross beam are attached to the assembly at **ENR230**.

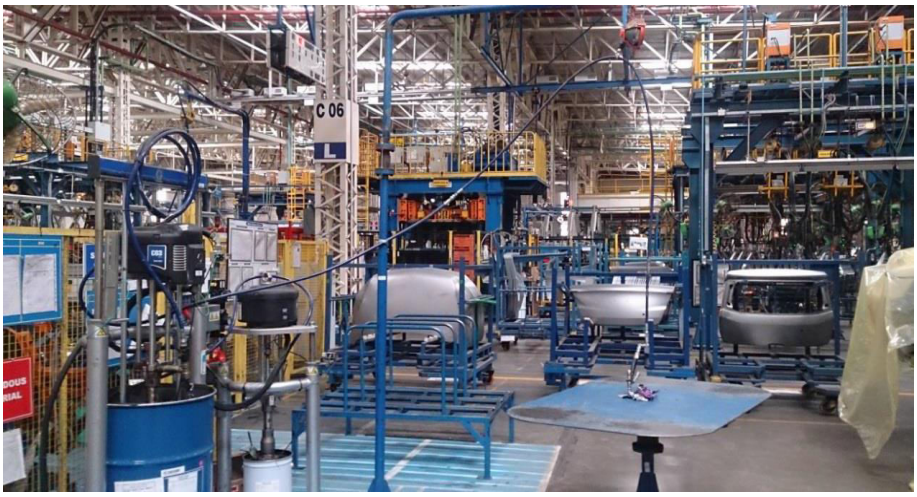
The **front floor, rear floor** and **underbody** assemblies are similar to those in M300 except for the difference in welding guns, the sealer application and the fact that stud welding is done in rear and front floor. In SGM308, the structural sealer is applied in the underbody at the three pillars mountings.

In the **side body,** structural sealer is applied for the proper pasting of the inner and outer panels.

Main Frame Line :

Essentially, the process of the main assembling of the side bodies on the underbody is similar to that of M300 except the fact that **global fixtures** are used in the SGM line eliminating the need for dedicated stations for every model. Also, **the roof is assembled at the main frame line itself** rather than having a separate set of stations for the assembly.

Closures :



Picture 11 : Closures - Body Shop

The closures consist of the four doors, hood and deck lid. **HEMMING** is the main process in the closure manufacturing. The closures manufacturing is divided into **four** parts.

In case of **M300, chemical flange sealer** is applied on the reinforcement bars and the inner door panels along with the application of hemming sealer on the edges of both the inner and the outer door panels. In case of **SGM308, anti-flutter sealer** is applied instead of chemical flange sealer.

The manufacturing of M300 closures involves respoting the inner and outer panels after the hemming procedure to ensure proper joining around the door frame.

2.2.4.2 Manufacturing Processes In The Body Shop

Several processes are carried out in the body shop at different stages in order to manufacture the **body in white**. Some of the important processes are:

1. **Spot Welding**
2. **Hemming**
3. **Stud Welding**
4. **Buffing**
5. **Projection Welding**
6. **Grinding**
7. **CO2 Welding**
8. **Dent pulling**
9. **Torqueing**
10. **Reaming**
11. **Sealer application**
12. **Brazing**

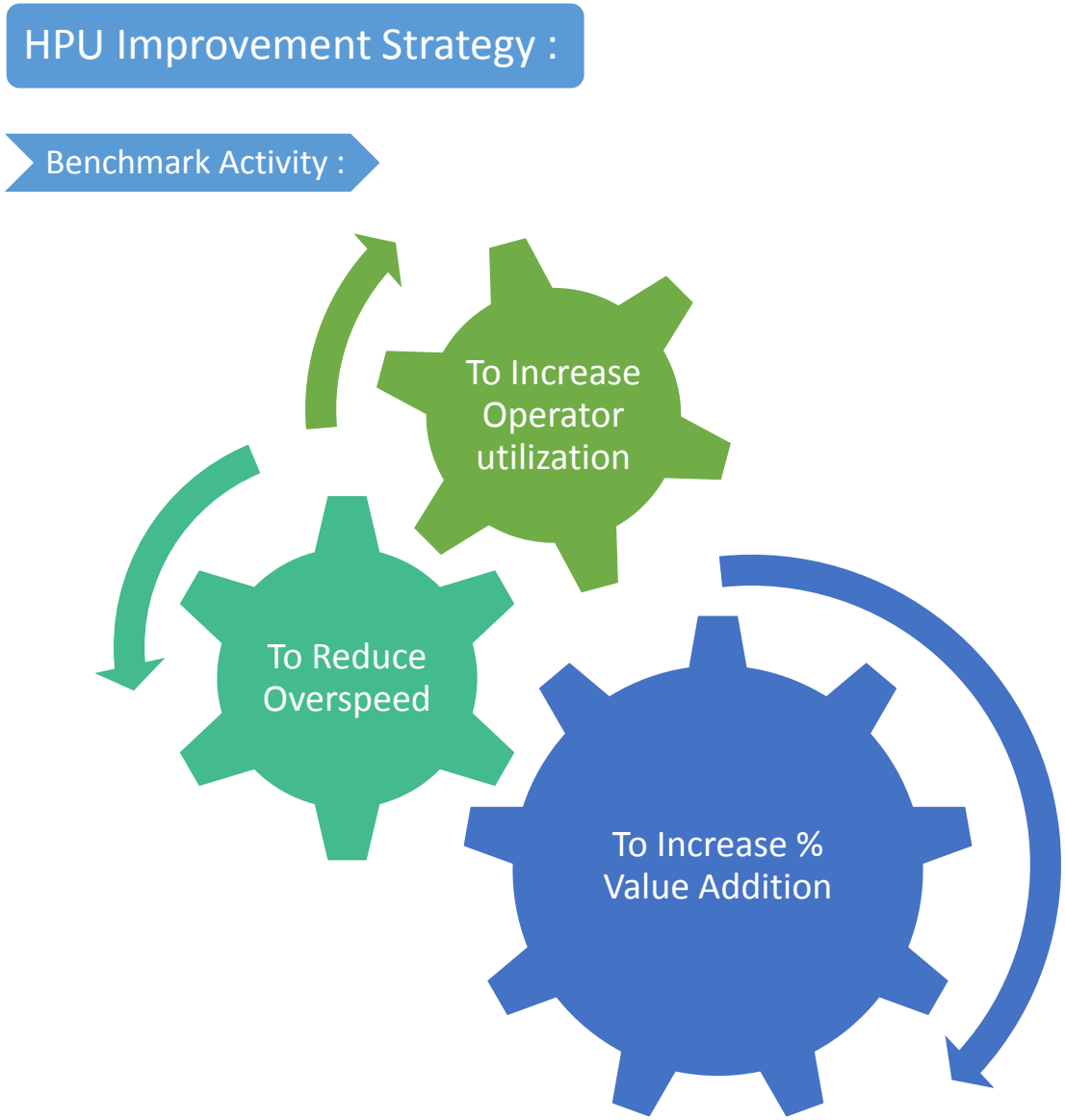
Chapter-3

INTRODUCTION TO PROJECT AND PROJECT PROGRESS

3.1 Project Objective:

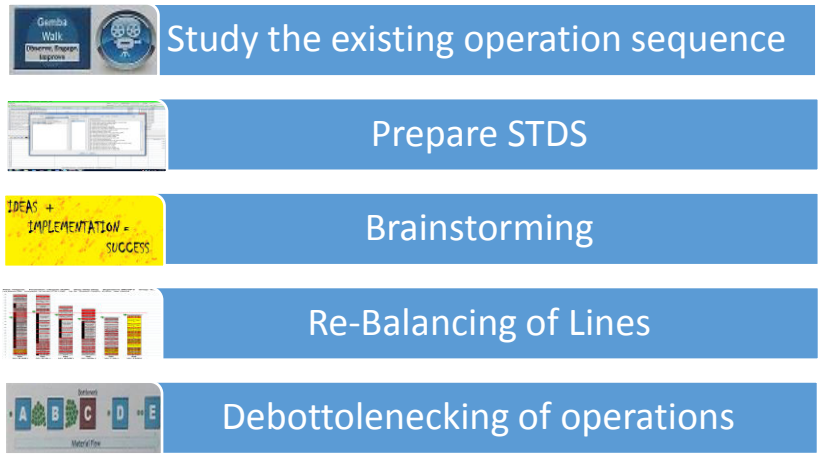
The main objective of the project is to Achieve Plant Internal Benchmark in Labor Productivity using the strategy of improving the HPU.

3.2 How to Execute the Project:



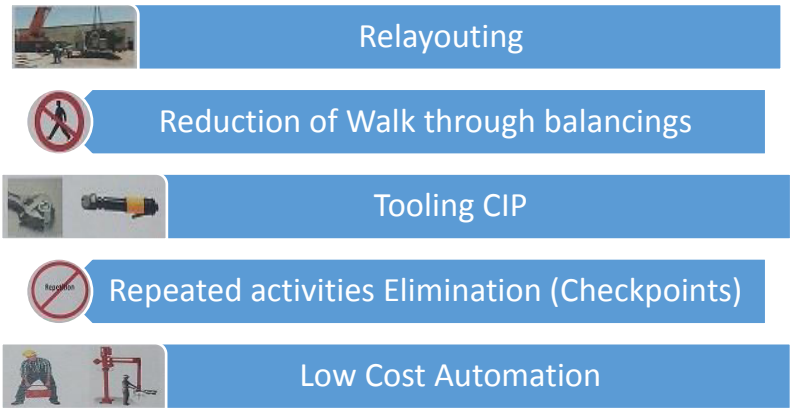
1. To Increase Operator utilization :

   (Target Waste to eliminate Waiting & Motion)



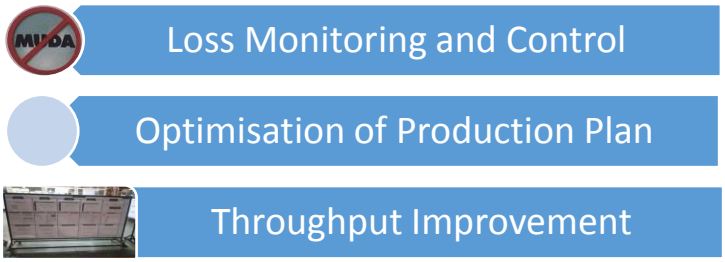
2. To Increase % Value Addition :

   (Target Waste to eliminate - Motion, Extra Processing & Transport)



3. To Reduce Overspeed :

   (Target Waste to eliminate - Overproduction & Inventory)



Efficiency Improvement :

To Resuce containments	Others	7 Types of Wastes
• Improvement in Quality (DRR/FTQ) • Permanent countermeasures • Reduction in Manufacturing support	• Overtime Management • Absenteeism Control	• Inventory • Defects • Overproduction • Transport • Motion • Waiting • Extra Processing

Table 3 : Efficiency Improvement ways

As mentioned above we are trying to improve the HPU by balancing the line. We have planned to reduce the HPU and thus improve the productivity. And thus increase the utilization from 79% to 90%. Also the Value added work content will be increased from 59% to 62%. The value added work content can be improved by reducing the non-value added work, because the value added work is constant and thus can be changed.

If we are able to successfully implement it we can reduce the over speeding from 25% to 11%. Over speeding can be considered as the losses caused for example:

If we are required to manufacture 200 cars and the over speeding is 10% then we will have to actually plan for 220 cars from which 20 cars are considered as loss. Whereas if we reduce the over speeding from 10% to 5% then the plan will be for only 210 cars.

3.3 Project Background :

"Manual assembly lines technology has made a significant contribution to the development of American industry in twentieth century" [Grover, 2001]. This phrase emphasizes the importance of assembly line especially in several sectors such as automobiles, consumer appliances and those sectors that produced large quantities product. This indicates the success factors are depending on the efficiency of assembly line. Along assembly lines various operations can be done either manually, automatically or integrated. For manual operations, the workers will perform jobs like brazing, assemblers, welding and so on. Normally for manual process the station will equipped with aided stationary depends on type of tasks. Automation operations are done for high volume quantities with additional features on the workstation. However, assembly line suffered one major problem, bottleneck. This phenomenon is defined as stage where causes the entire process to slow down or stop [Taj,2006]. This can be due to improper scheduling, improper line balancing and machine breakdown or equipment repairing.

3.4 Projects :

1. Productivity Improvement through Line Balancing Technique and Manpower Optimization
2. Implementation of Assembly Processing System (APS) Software Process
3. Improvement through Time Study with the help of STDS Software
4. Study for the Implementation of New Models on Line
5. Reduce the Ergo rate of top rating stations
6. Downtime Monitoring

3.5 Definition of Important Terms:

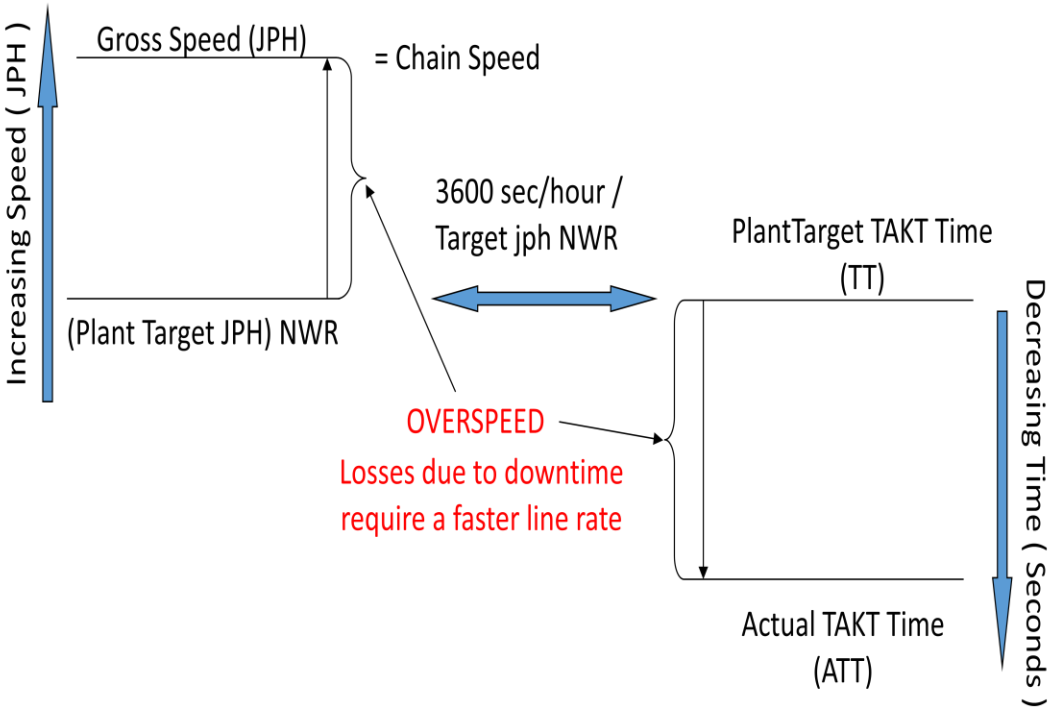


Figure 7 : Concept of Overspeed

- **Mean Cycles Between Failures (MCBF):**

  Is the average number of job cycles a station/cell/line produces between failures.

- **Mean Time to Repair (MTTR):**

  Is the average time it takes to repair equipment failures or a line stoppage.

- **Stand Alone Availability (SAA):**

  Percentage of time a station would be able to produce if never blocked nor starved, but including internal downtimes. *SAA [%] = SAT / Speed*

- **Stand Alone Throughput (SAT):**

  The number of jobs per hour a station would be able to produce if it was never blocked or starved. It includes internal downtime. *SAT [JPH] = SAA * Speed*

- **Gross Speed :**

  Output, expressed in JPH not inclusive of any downtime, breaks or other stoppages.

  Speed = 3600 / Cycle Time

- **Net While Running (NWR):**

  Net Capacity based on production hours available and annual volume required.

  NWR = Volume / working days / shifts / running hours

- **Takt Time (TT):**

  Average time a station needs to produce 1 part based on customer demand. TT inherently includes all Blocked/Starved line conditions and Breakdowns.

  TT [s] = 3600 / NWR

3.6 Project Progress :

3.6.1 After First Quarter :

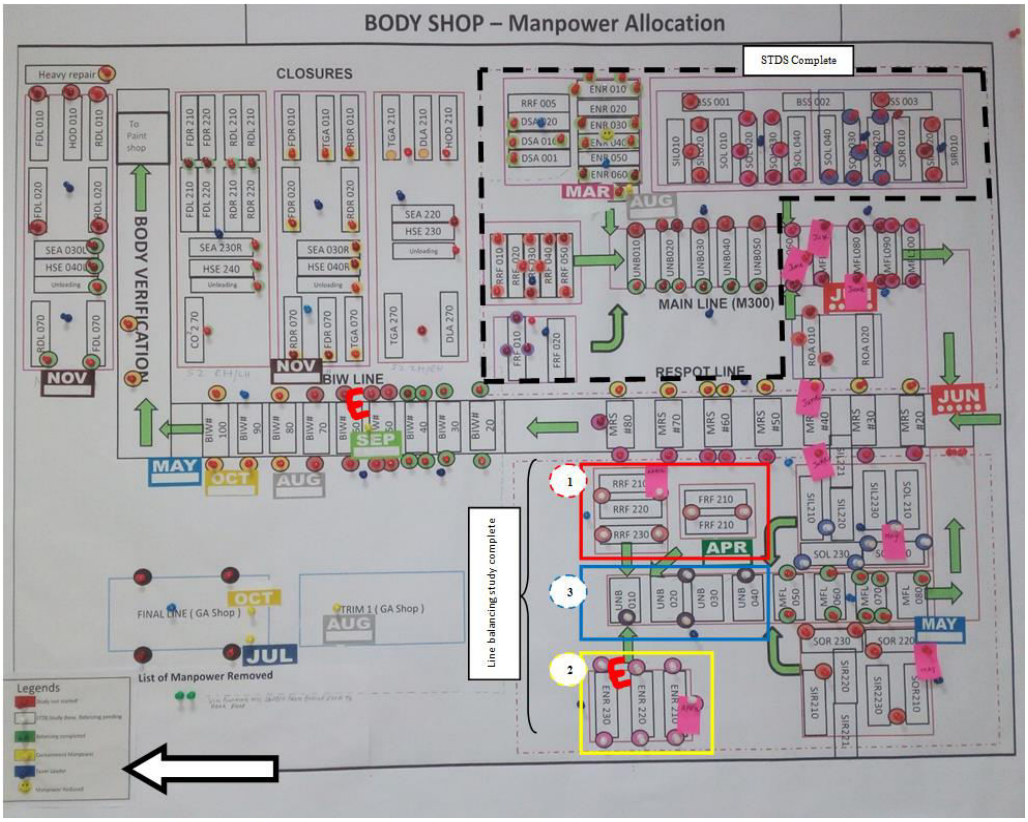


Figure 8 : Manpower Allocation Chart - After First Quarter

The above pictures illustrates the layout of the body shop as well as it shows the status of the projects I was working on. The area marked by the black dash lines are the stations of which the STDs I have completed i.e. Group 1 and 2 which are to be balanced in the near future. The positions where E are marked are the stations where High Ergo rate are being observed . Furthermore there have been a few cases of line balancing marked in colored boxes of which the studies are completed and will be implemented very soon.

It has been planned to opt for low cost atomization using Robots in the Body shop. The Automation is going to start implementing from the month of May and will start functioning from the month of June. The atomization will be taking place in the Mainframe line which may lead to high manpower optimization and efficient productivity.

3.6.2 After Second Quarter :

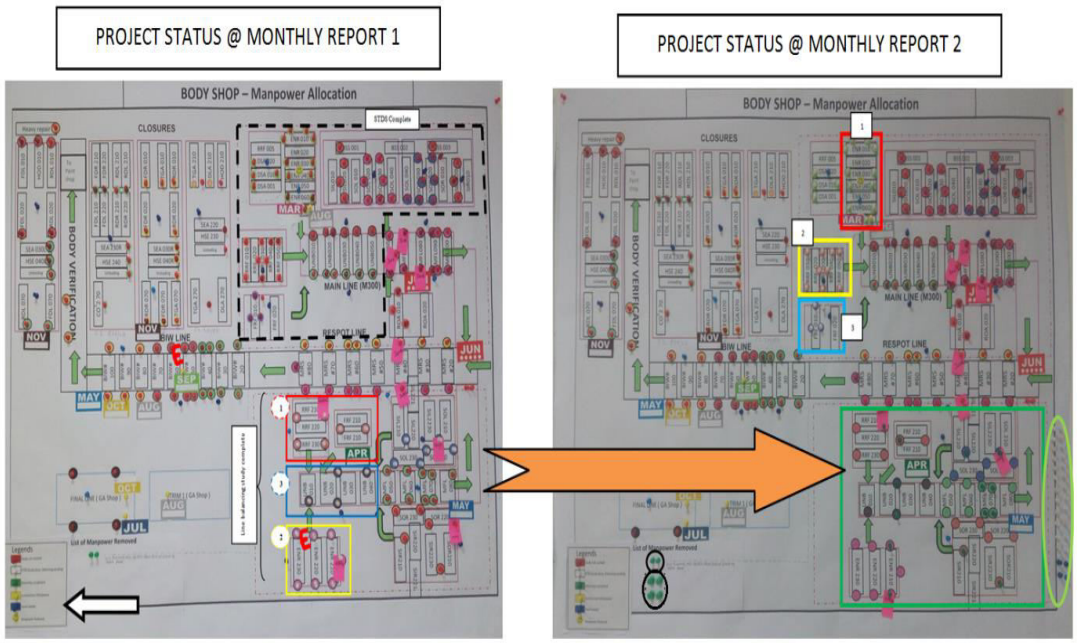


Figure 9 : Manpower Allocation Chart - After Second Quarter

The above picture illustrates the implementation of the line balancing done in the SGM area. It also shows the manpower optimized in the respective stations or lines. Picture on left side shows the project status as stated in my first monthly report. The picture on right is the current project status. As per the process of line balancing is done after the completion of the STDS as was done for SGM balancing. Similarly the M300 balancing has been completed.

3.6.3 After Third Quarter :

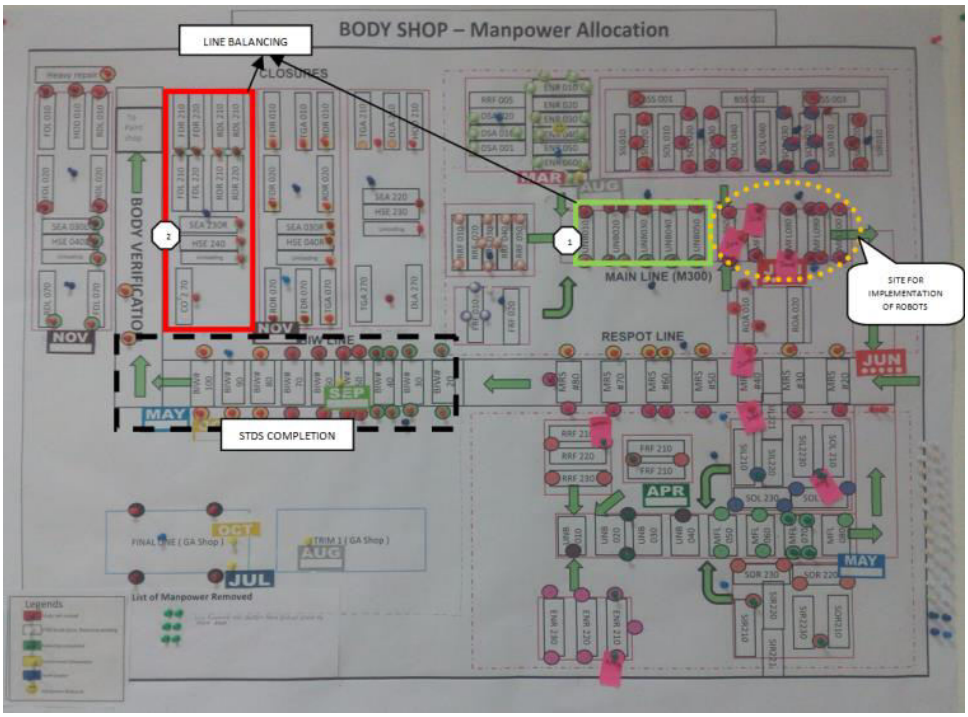


Figure 10 : Manpower Allocation Chart - After Third Quarter

The above pictures illustrates the layout of the body shop as well as it shows the status of the projects I was working on during my third quarter. The area marked by the black dash lines are the stations of which the STDs. There have been a few cases of line balancing marked in colored boxes of which the studies are completed and will be implemented very soon.

3.6.4 Project Implementation :

The Fourth Quarter involves the implementation of APS and STDs software's of the Line balanced in these three quarters. Following are the Proposals made for the execution of the project.

AREA	PROPOSAL MADE
SGM M300	JPH Change from 6JPH/2Shifts to 2JPH/2Shifts JPH Change from 18JPH/2S to 22JPH/2S
CLOSURES	Closures M300 JPH change from 15JPH/3S to 18JPH/3S AND Closures SGM JPH change from 6JPH/2S to 6JPH/1S
ROBOTS	Proposal of transferring Robots from Australia

Table 4: Proposals

3.7 Project Summary :

MANPOWER OPTIMIZATION STATUS

TOTAL MANPOWER OPTIMIZATION PER SHIFT

		LINE	Befor @ 6 JPH	LOADING & UNLOADING	After @ 2 JPH	LOADING & UNLOADING	DIFFERENCE WITHOUT LOADING (PER SHIFT)
MAPOWER REMOVED	SGM NB	FRONT FLOOR	2		2		-4
		REAR FLOOR	4				
		ENGINE ROOM	6	1	2	0	-4
		UNDERBODY	4		2		-2
		SIDE LH	6		2		-4
		SIDE RH	6		2		-4
		MFL	9		4		-5
		Total	37		14		-23
		LINE	Before M300 @15 JPH & SGM @6 JPH	LOADING & UNLOADING	After M300 @22 JPH & SGM @6JPH	LOADING & UNLOADING	DIFFERENCE WITHOUT LOADING (PER SHIFT)
	CLOSURES	M300	21	2	28	2	7
		SGM (ONLY 1 SHIFT)	8	1	6	1	-2
		Total	29		34		5
MAPOWER ADDED		LINE	Before @ 18 JPH	LOADING & UNLOADING	After @22 JPH	LOADING & UNLOADING	DIFFERENCE WITHOUT LOADING (PER SHIFT)
	M300	ENGINE ROOM	9	1	12	1	3
		FRONT FLOOR	2	1	3	1	1
		REAR FLOOR	9		11		2
		UNDERBODY	10	2	12	2	2
		DASH	4		5		1
		SIDE LH	6	2	7	1	1
		SIDE RH	6	2	7	1	1
		INNER & BSSA	8		10		2
		ROOF	2		3		1
		MFL (USING ROBOT)	10		4		-6
		Total	66		74		8
NO CHANGE		LINE	Before	LOADING & UNLOADING	After	LOADING & UNLOADING	DIFFERENCE WITHOUT LOADING (PER SHIFT)
	COMMON LINE	MRS	16	2	16	2	0
		BIW	23		23		0
		GA	5		5		0
		CONTAINMENT	15		15		0
		Total	59		59		0
	LOADING	ALL		14		11	-3
	BODY SHOP MANPOWER (PER SHIFT)		205		192		13

SUMMARY	INITIALLY	AFTER BALANCING		Manpower removed (PER SHIFT)
SGM NB	37	14		-23
CLOSURES	29	34		5
M300	66	74		8
COMMON LINE	59	59		0
LOADING	14	11		-3
TOTAL MANPOWER OPTIMIZATION PER SHIFT				**-13**
TOTAL MANPOWER OPTIMIZATION FOR 2 SHIFTS				**-26**
CLOSURE SGM TO BE OPERATED ONLY FOR 1 SHIFT , 2ND SHIFT MANPOWER REMOVED =			18 + 7	**-25**
TOTAL MANPOWER OPTIMIZATION				**-51**

Table 5 : Manpower Optimization Status

Complete summary of the project based on the above proposal made can be explained as above in Manpower Optimization Status. It shows Before and After situation and the difference between them.

TOTAL BODY SHOP MANPOWER WITHOUT TL & ABSENTEEISM	428	377	51

ABSENTEEISM				DIFFERENCE
BEFORE		AFTER		
%	12	%	12	
	51		45	-6

TL (PER SHIFT)			
BEFORE		AFTER	
6	SGM	2	SGM
2	MFL + ROOF	1	MFL + ROOF
3	SIDE	3	SIDE
2	ENR	2	ENR
2	FR,RR	2	FR,RR
2	UNDERBODY	2	UNDERBODY
2	RESPOT	2	RESPOT
2	BIW	2	BIW
1	METAL FINISH	1	METAL FINISH
1	GA	1	GA
1	SGM CLO	1	SGM CLO
4	M300 CLO	6	M300 CLO
2	3RD SHIFT	0	3RD SHIFT
30		25	

TOTAL TL				DIFFERENCE
60		50		-10

TOTAL BODY SHOP MANPOWER WITH TL & ABSENTEEISM	539	472	67

ME	8
UNION	2

TOTAL BODY SHOP MANPOWER	549	482	67

Table 6 : Total Manpower Optimization Status

Total Overall Manpower Optimized was 67 Manpower. Among 67, 51 manpower were removed by the help of line balancing were as the additional 16 manpower was from 12% absenteeism and Team Leader to Workmen ratio (There is One TL for every group of 7 Workmen).

The Manpower Optimized from the M300 / SGM workshop were transferred to New Body shop prepared for Spin Vehicle i.e. into the Launch department.

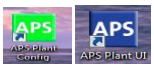
Chapter – 4

INTRODUCTION OF ASSEMBLY PROCESSING SYSTEM (APS) SOFTWARE AND ITS IMPLEMENTATION

APS is an electronic system created to support the GMS process in the plants.APS is used by Industrial Engineers to do line balancing.APS Data is Entered By:

- Future Program IEs to generate initial APS data as part of pre-production
- Plant IEs (and sometimes core team members) to perform line balances and update the data and validate the data during steady-state production.

4.1 Installation and Login

- GMIT will install APS on your computers
- IT Service Request is required for APS Software to be pushed through GM Online for instructions go to https://gmweb.gm.com/sites/me_IntStts/aps/Pages/apsHome.aspx
- NO separate login for APS – just log into Windows
- Double click on the APS Plant Config icon (green) to select your plant and open APS Plant UI 

4.2 Navigation - Landing Page

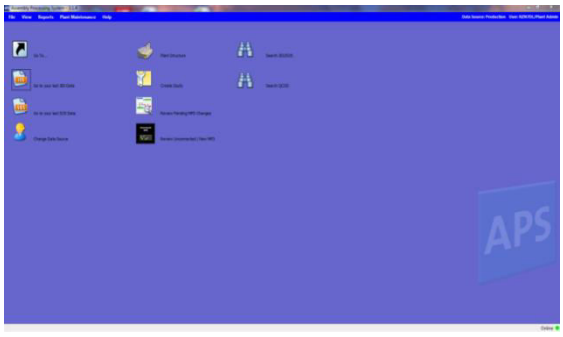


Figure 11 : APS Navigation Page

Action		Result
Go To …		Allows user to move to different operations and job elements.
Go to your last JES Data		Displays the last JES user accessed in APS.
Go to your last SOS Data		Displays the last SOS user accessed in APS.
Change Data Source		Moves user from Production to Planning
Plant Configuration		This opens the plant structure screen with the higher plant level information like Plant Configuration, Shop, Department, and Group.
Create New Study		Displays the **Create/Edit Study** window, where user can select the operations you want to use to build a study.
Review Pending MPD Changes		Allows user to review Master Process Documents (MPD's) that have changed
Review Unconnected / New MPD		Allows user to preview MPDs that have not been connected to a JES

Search SOS/JES		Search for job elements.
Search QCOS		Allows user search for QCOS related items.
Pending QCOS Approvals		Displays QCOS items with pending approvals.
QCOS Coordination		Displays work items for the QCOS coordinator.

Table 7 : APS Tools

Navigation – Go To

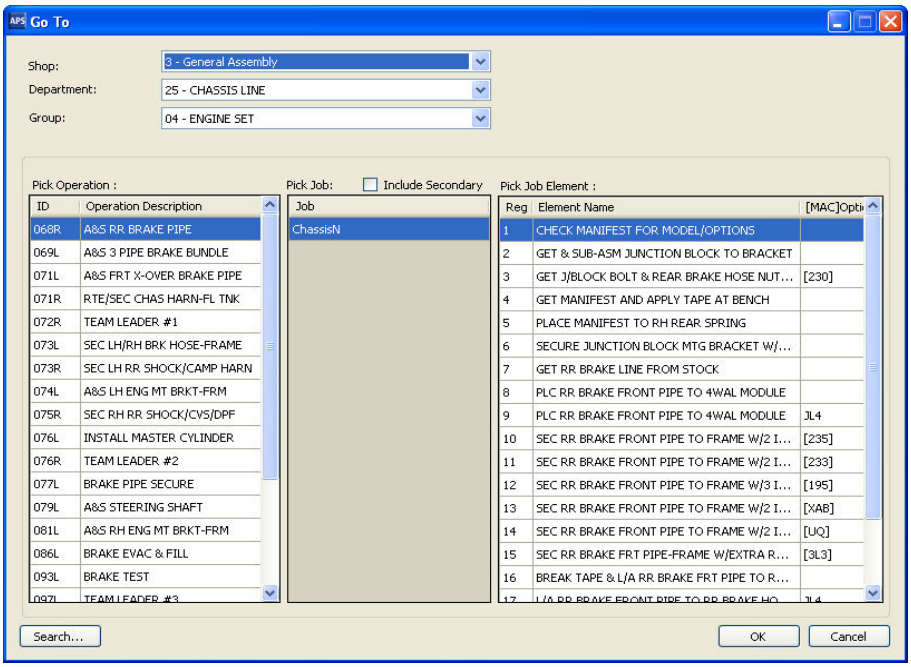


Figure 12 : APS Go To Screen

- Go To screen lets you move to different operations
    - Choose Shop, Dept, Group, and Operation
    - Double click on Job to go to Standard Operation Sheet (SOS)
    - Double click on Job Element to go to Job Element Sheet (JES)

- Allows for more efficient movement between Operations / Jobs / Job Elements
- Other Navigation
  - Toolbar Icons
    - Back and Next 
    - Search – Find a job element by name 
    - JES – Go to the JES from the SOS 
    - SOS – Go to the SOS from the JES 
    - Wall - Go to the Line Balance Wall 

4.3 Data Entry - Job Element Sheet

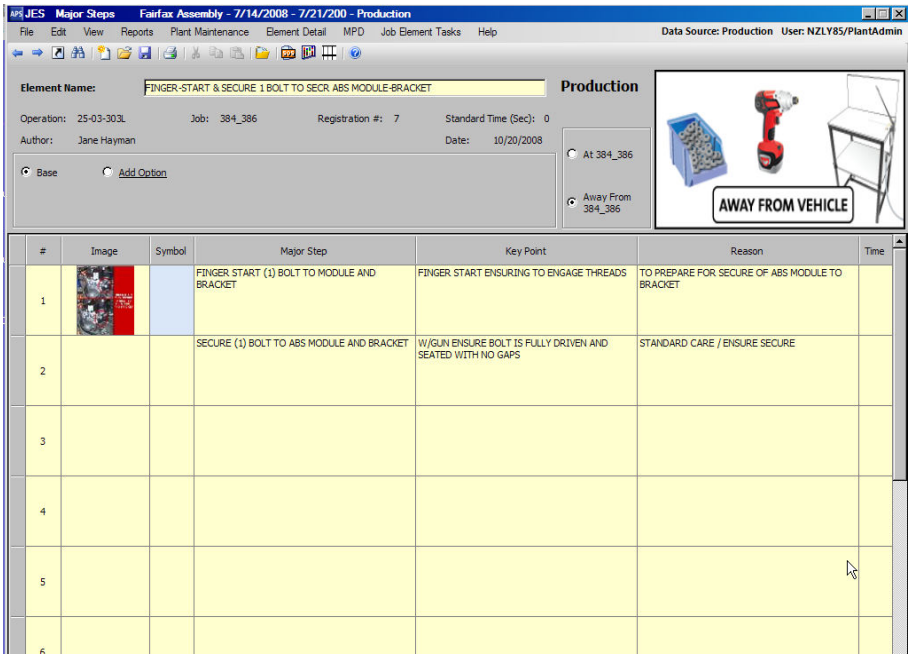


Figure 13 : APS Job Element Sheet Screen

Job Element Sheet Screen – Major Steps

- Element Name

- At/Away from Vehicle
    - Choose Work Location
    - “Away” location is defined on the scroll
- Base/Option content (Team Leaders view only)
- Job Element Total Time (if applicable)

- Changing the Job Element Option
    - On the Job Element screen, click Add Option
        - The Option/MAC window will open
    - Select the option on the Option tab
    - Select the MAC on the MAC tab
        - MAC means Model Assembly Code (Category Code for SWAT users)
    - Reset un-selects the option and the MAC
    - Click OK

- Data Entry - Job Element Sheet Body
    - One line per major step
    - Right click in the major step image area to add previously saved image as required.
    - Use symbol if needed
        - Right click in symbol box to add
    - Every “How” must have a “Why”
    - Save your work after each job element sheet
    - No two people should be writing the same job at the same time

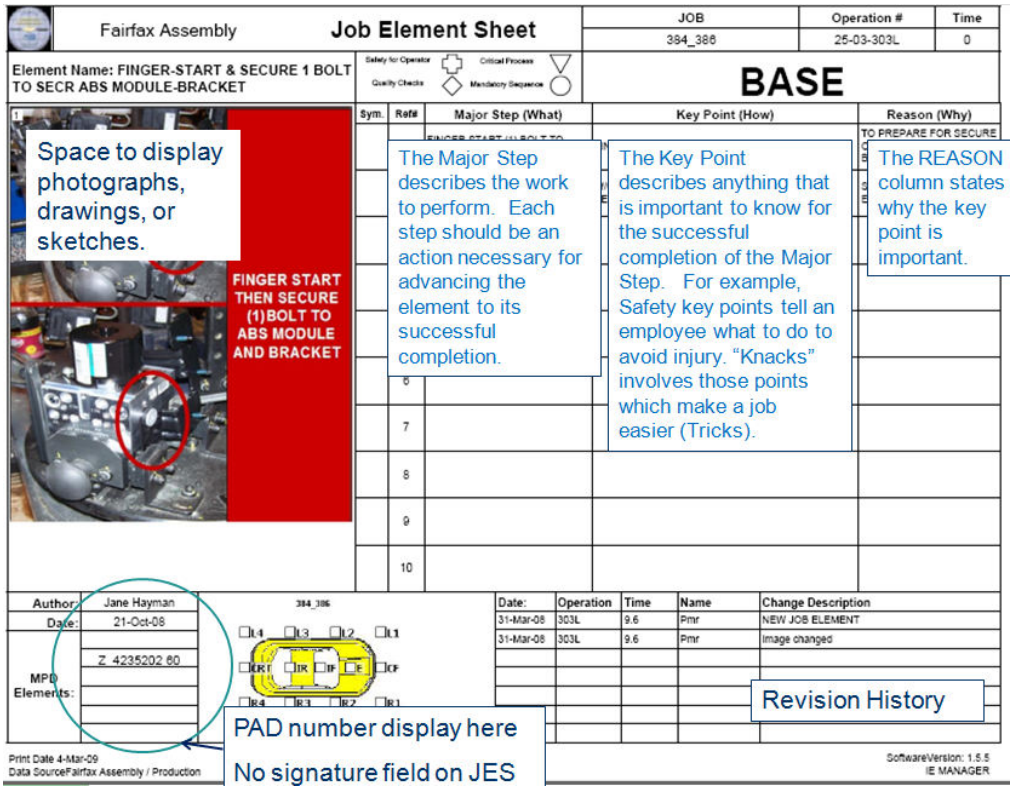


Figure 14 : Job Element Sheet (Example)

- Major Steps (WHAT)

  A major step within an element is:

  - An action necessary for advancing the element to its successful completion

- Key Points (HOW)

  Key Points describe how to perform a Step (not all Steps require Key Points)

  Examples of things to consider when writing Key Points:

  - Could the team member get injured if they failed to follow a certain method or technique? If so, describe that method or technique
  - Does the success or failure depend on performing the work a certain way? If so, describe how to perform that task successfully

        - Have you learned an easier way to perform the Step? If so, describe that easier method

- Reasons (WHY?)
    - What happens if the key point is ignored?
    - Why is it done this way? What is the reason?
    - Every Key Point must have a reason.
- Major Step Symbols
    - Right click in the symbol area to add a symbol
    - Four possible symbols
        - Safety 
        - Critical Process 
        - Mandatory Sequence 
        - Quality 
    - Symbols are not required for every major step
- New/Insert Job Element
    - Click on Job Element Tasks
    - Select New Job Element or Insert Job Element
        - New job element will be added to the end of the current job
        - Inserted job element will be added before the current job element
        - Add your major steps, key points, and reason
    - Save your job element

4.4 Standard Operation Sheet (SOS)

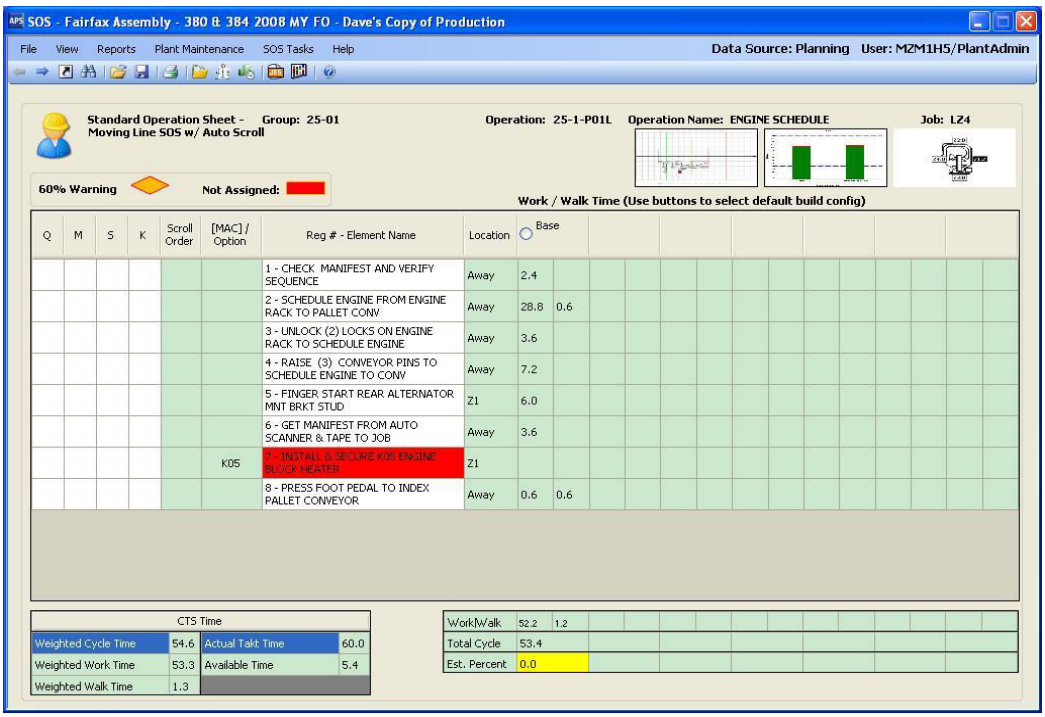


Figure 15 : APS Standard Operation Sheet

- Standard Operation Sheets are populated by the job element sheets in the operation.
- There can be a single SOS per operation or multiple SOS's per operation, depending how the plant decides to set up their operations.

- SOS Tasks
  - Personal Protection
  - View Scroll
  - View Work Combination Table
  - All Jobs Time Summary
  - Add to Build Configuration
  - Remove From Build Configuration
  - Delete Build Configuration
  - Delete Job Elements
  - Copy/Move Job Elements
  - Re-sequence Job Elements
  - Revision History

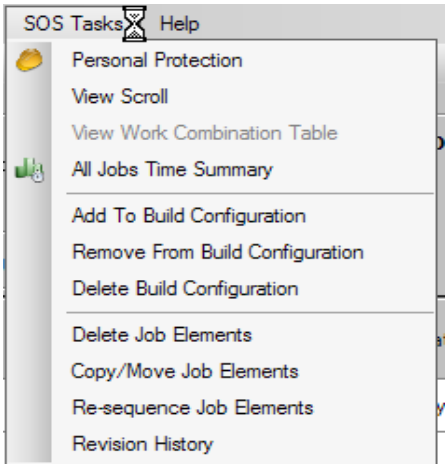


Figure 16 : APS - SOS Task Screen

- Standard Operation Sheet (SOS) Right Click Menu

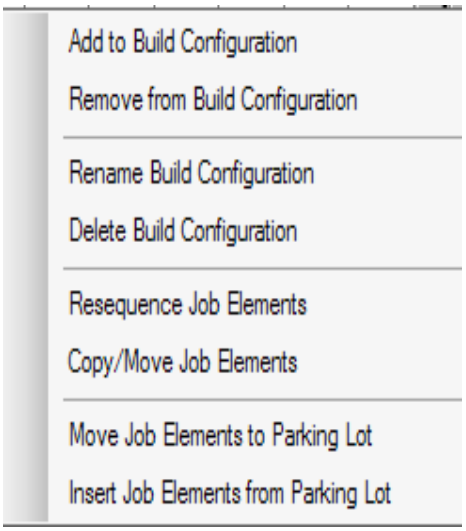


Figure 17 : APS - SOS Menu

  - Build Configuration
    - Add, Remove, Rename and Delete build configurations
  - Re-sequence Job Elements
  - Copy/Move Elements (No Team Leader Access)
  - Move Elements to and from Parking Lot (No Team Leader Access/Planning Areas only.)

- SOS Icons

Figure 18 : APS - SOS Icons

  - Back/Next
  - Job Element Search
  - Go To
  - Change Data Source

- Save
- Revision History
- All Jobs Time Summary
- Go to Line Balance Wall
- Help
- Print one document
- Personal Protection
- Go to current JES
- Go To Ergo Summary Page

- Personal Protection

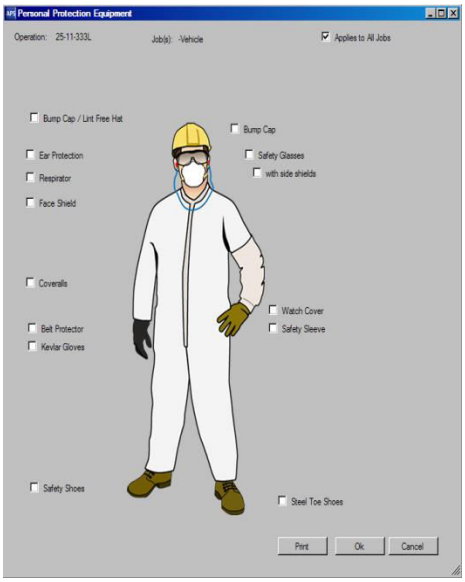


Figure 19 : APS - Personal Protection Screen

- Click SOS Tasks and select "Personal Protection."
- Check the boxes for the required operator protection.
- Click OK

- All Jobs Time Summary

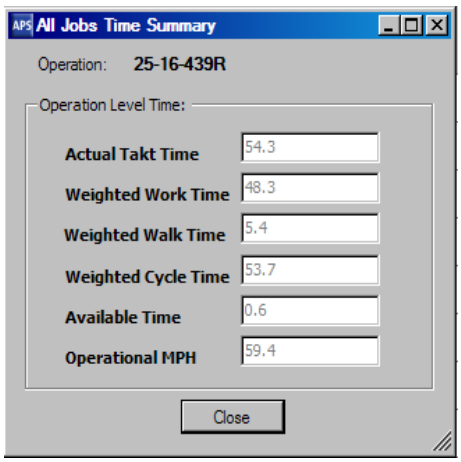


Figure 20 : APS - All Jobs Time Summary Screen

- Click SOS Tasks, All Jobs Time Summary.
- Quick look at operation loading

4.5 Build Configurations – Columns on the SOS

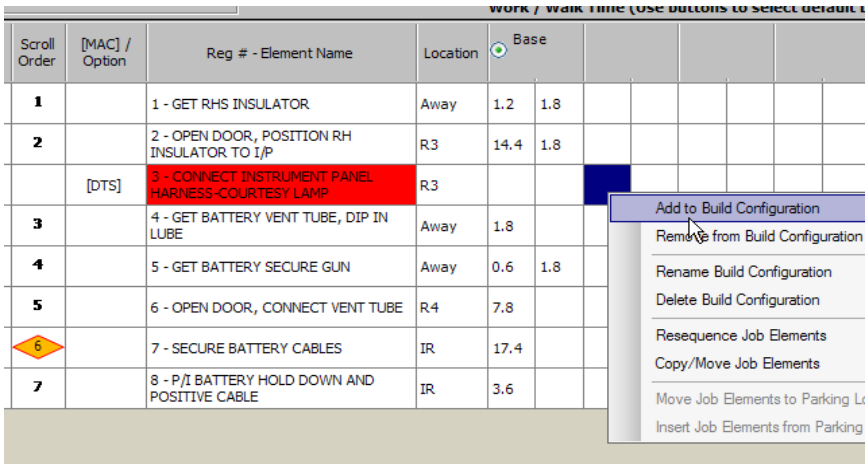


Figure 21 : APS - Build Configuration Menu

- Non-base job elements are red until added to a build configuration (column)
- Right click in a build configuration column and select "Add to Build Configuration"
- All of the job elements with that option will be added to the build configuration
- You can add multiple options to a build configuration
- Click Save

- Build Configurations – Removing Elements

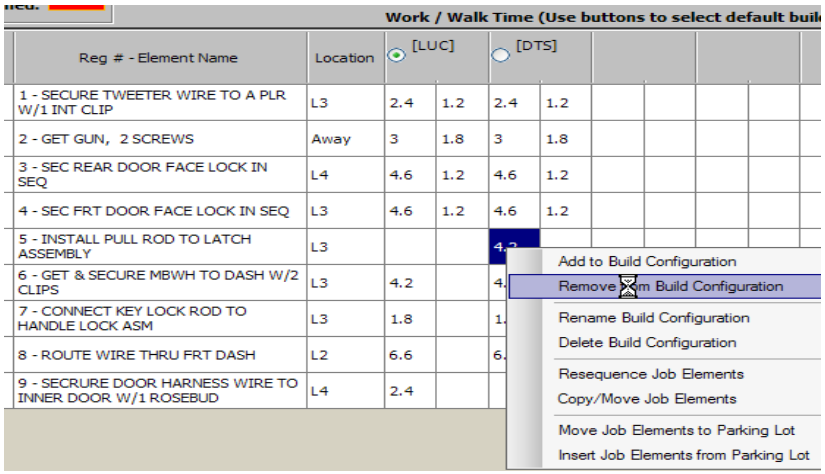


Figure 22 : APS - Build Configuration Menu (Removing Elements)

- Right click on a job element in the build configuration
- Select “Remove from Build Configuration”
- All of the job elements with that option will be removed from the build configuration
- Click Save

- Build Configurations – Renaming the Build Configuration

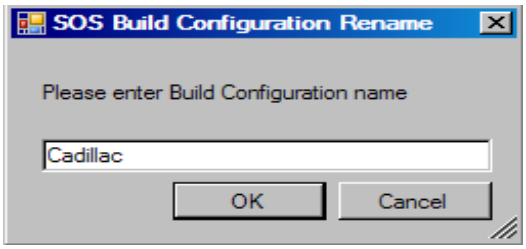


Figure 23 : APS - Build Configuration (Renaming)

- Right click in a build configuration and select “Rename Build Configuration”
- Enter the new name you want the build configuration to have
- Click OK. The new build configuration name will appear at the top of the column. This name will also display on the cycle time chart
- Click Save

- Build Configurations – Deleting the Build Configuration

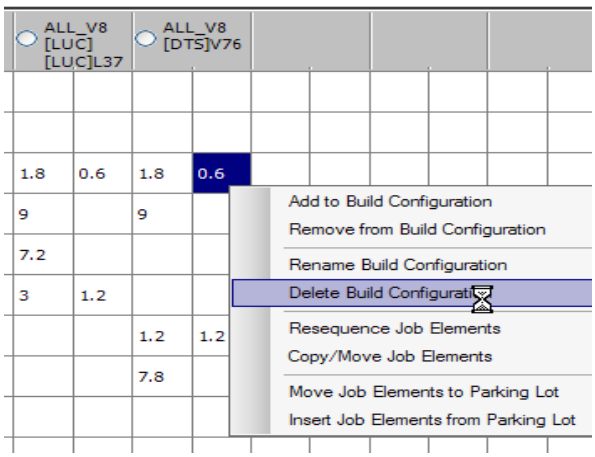


Figure 24 : APS - Build Configuration (Deleting)

- Right click in a build configuration and select “Delete Build Configuration”
- APS will ask “Are you sure you want to delete?” Click OK
- The build configuration column will be deleted
- Click Save

4.6 Scrolling

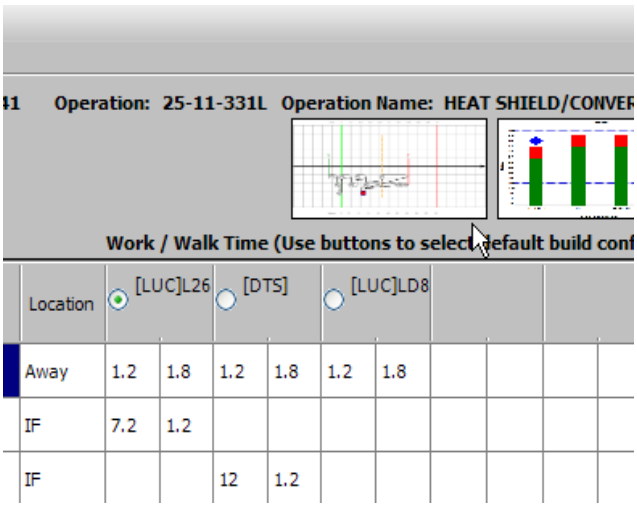


Figure 25 : APS - Scrolling

- Double Click on the scroll picture at the top of the SOS to open the Scroll screen
- Select build configuration to scroll
- Create scroll items (tools, bins, benches)
- Connect “AWAY” job elements to the scroll items to create walk path
- Go to Plant Maintenance, Operation to change scroll settings as required
    - Only your IE can change scroll settings

- Scrolling–Pick Build Configuration
    - After opening the scroll, select Build Configuration from the dropdown list. The elements from that Build Configuration will display below

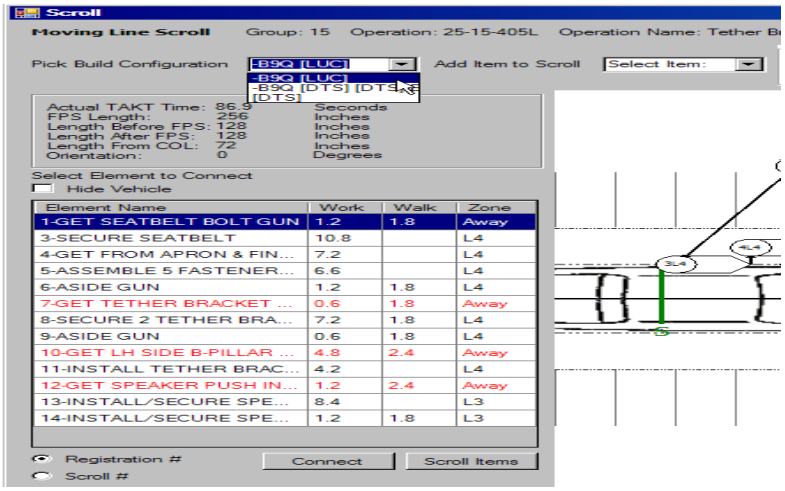


Figure 26 : APS - Scrolling Menu

- Scrolling – Add Bins and Benches

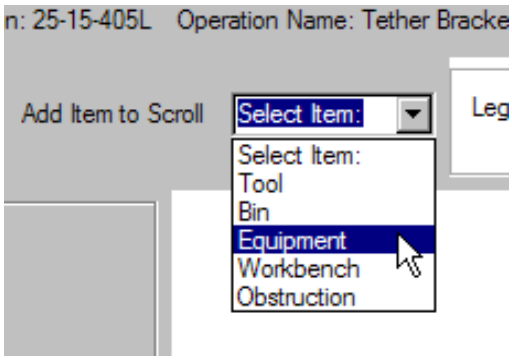


Figure 27 : APS - Scrolling (Add Items)

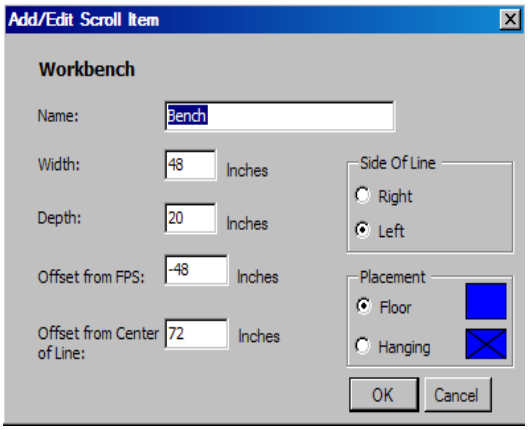


Figure 28 : APS - Scrolling (Edit Scroll Items)

Add items like Tools, Bins, and Benches that the operator walks to when not working at the vehicle.

1. Select the Type of Scroll Item
2. Enter its location, dimensions and side of line

Add Name of Item

Add Width

Add Depth

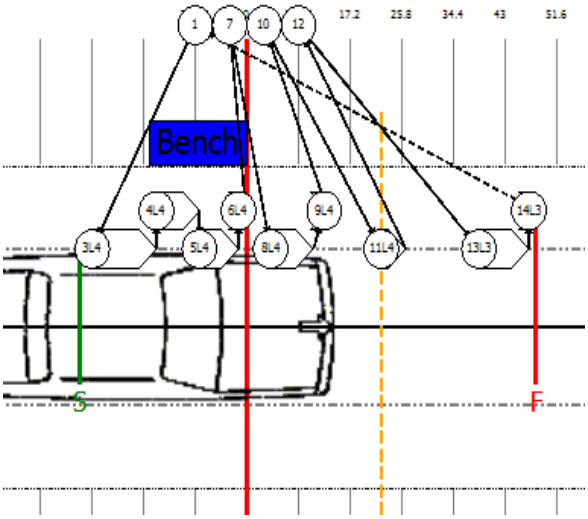
Add Offset from FPS (can be a negative Number

Add Offset from Center of Line

Select Side of Line

Select Placement

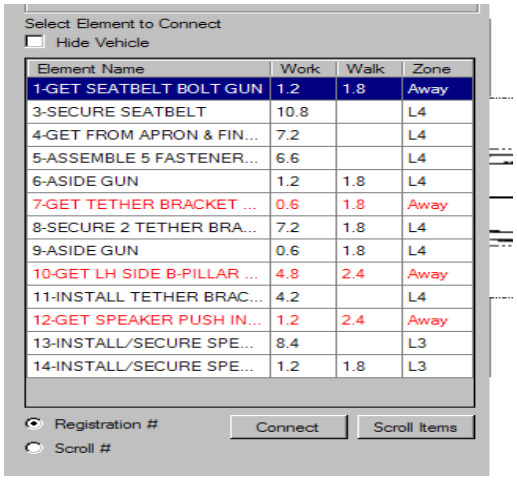
Click OK



Double Click on Scroll Item to change the scroll item name or dimensions.

Figure 29 : APS - Scrolling Diagram

- Scrolling – Connect job element to scroll items

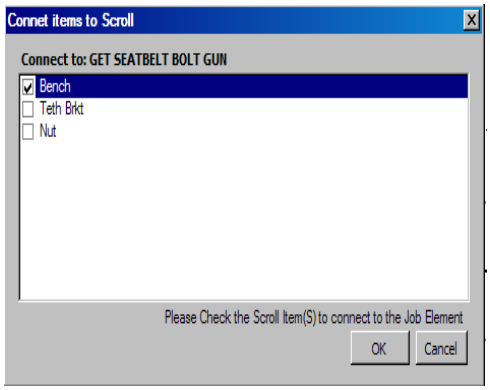


You can only connect job elements with the zone "AWAY" (red for easy reference)

Select an "AWAY" element

Click Connect

Figure 30 : APS - Scrolling (Job Connection)



Check the box next to the scroll item where the job element takes place

Click OK

Figure 31 : APS - Scrolling Connect Screen

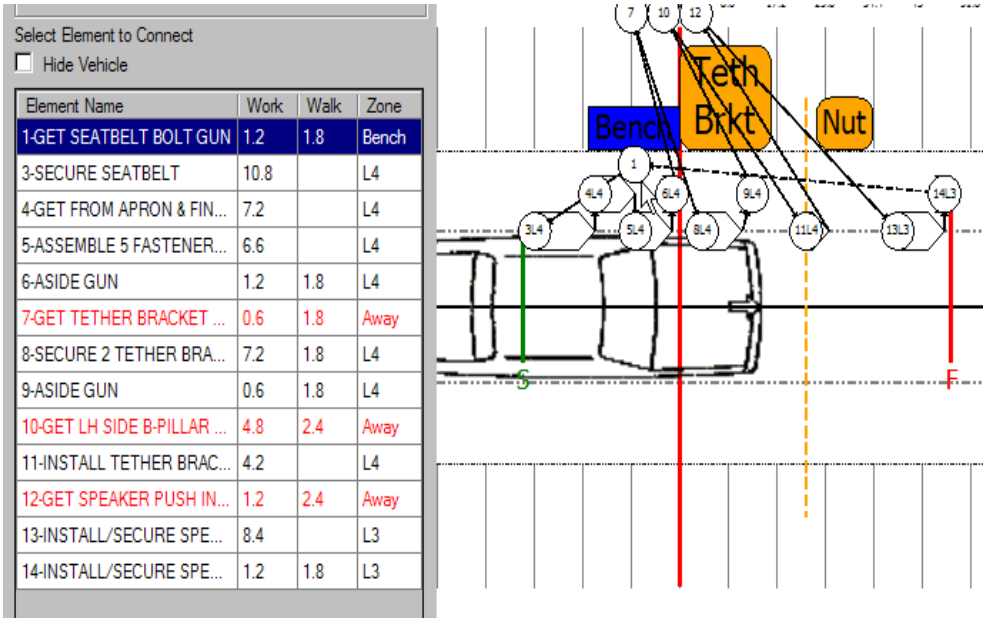
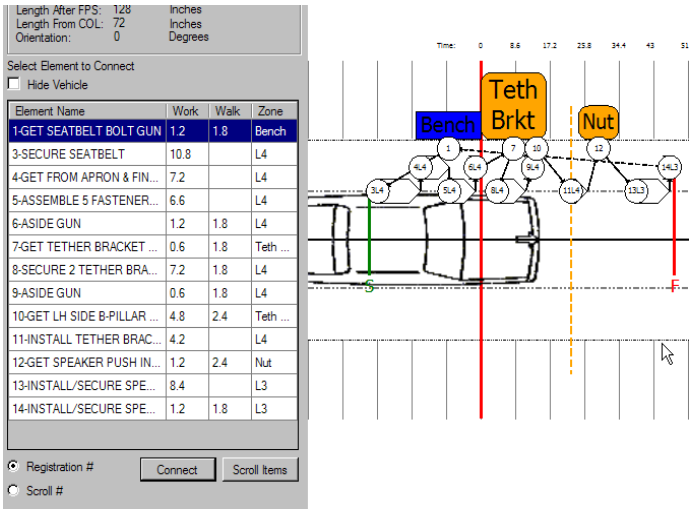


Figure 32 : APS - Scrolling Job Connection

- Scrolling – Complete Walk Path



This is a complete scroll

Close the scroll and click Save on the SOS

Figure 33 : APS - Scrolling Complete Walk Path

- Notes on Scrolling
  - Double click on scroll item (bins, benches, etc.) to modify the scroll item name or dimensions.
    - The user may also open the scroll items window, select the item, and click Edit.
  - Scroll can be numbered by Registration Number or by Scroll Element Number

- If there is a problem with the scroll dimensions (for example, the Fixed Position Stop is incorrect), the user must ask the Manufacturing or Process Engineer to change the data.
- Be Careful not to Double Click on Job Element when selecting it will take you to the JES Screen

- SOS Images
  - Operation must be “Static” (not moving line)
    - This selection is made in the Plant Maintenance, Operation Screen.
  - To add SOS image, double click on SOS area where the scroll usually is

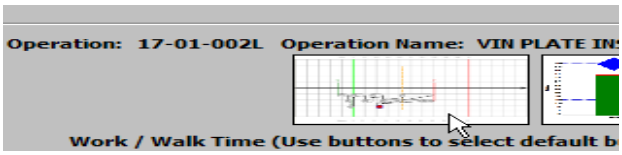


Figure 34 : APS - Flow Diagram Icon

  - Browse for an image and save it to the SOS
  - Image will display in the scroll area in the SOS

- Operation Screen with Static SOS

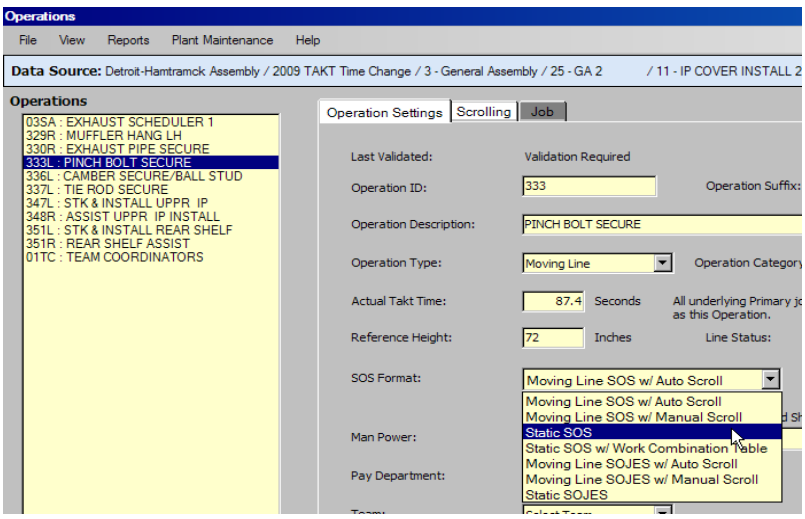


Figure 35 : APS - Operation Screen

- Delete Job Elements
  - The Delete Job Elements command allows the user to delete one or more job elements on the current SOS.
    - Click SOS Tasks and Select Delete Job Elements
    - A window will open with a list of job elements from the current SOS.
    - Select one or more elements using the Ctrl key, and click Delete, or Cancel to close without deleting.
    - Job elements will be deleted from the current SOS.

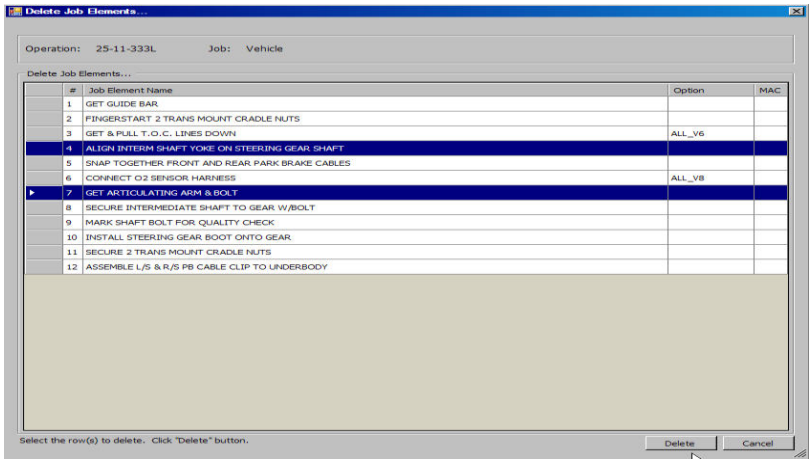


Figure 36 : APS - Delete Job Element Screen

- Re-sequence Job Elements

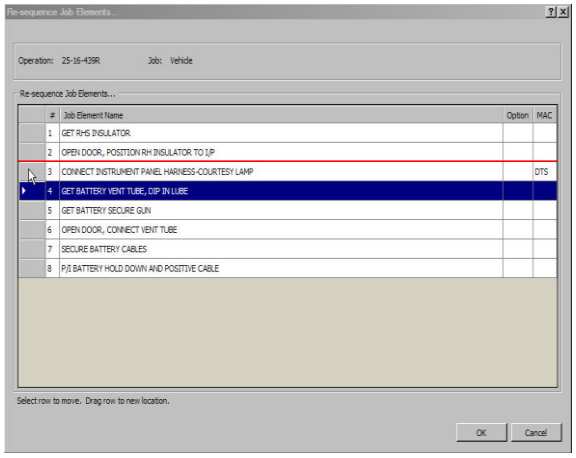


Figure 37 : APS - Re-sequence Job Element Screen

Right click on job elements in SOS to open re-sequence screen

Click and drag elements into a new order

You can click and drag multiple elements at one time

Click OK

- Copy/Move Job Elements
  - Open SOS Tasks menu or right mouse click on the body of the SOS
  - Select Copy/Move Job Elements
    - Copy/Move window will open
    - Copy is selected
    - Current job element is selected
  - Select Move if you wish to move instead of copy
  - Select the element(s) to copy/move
  - Select the destination operation
  - Drag the job element(s) to the destination operation and click OK.

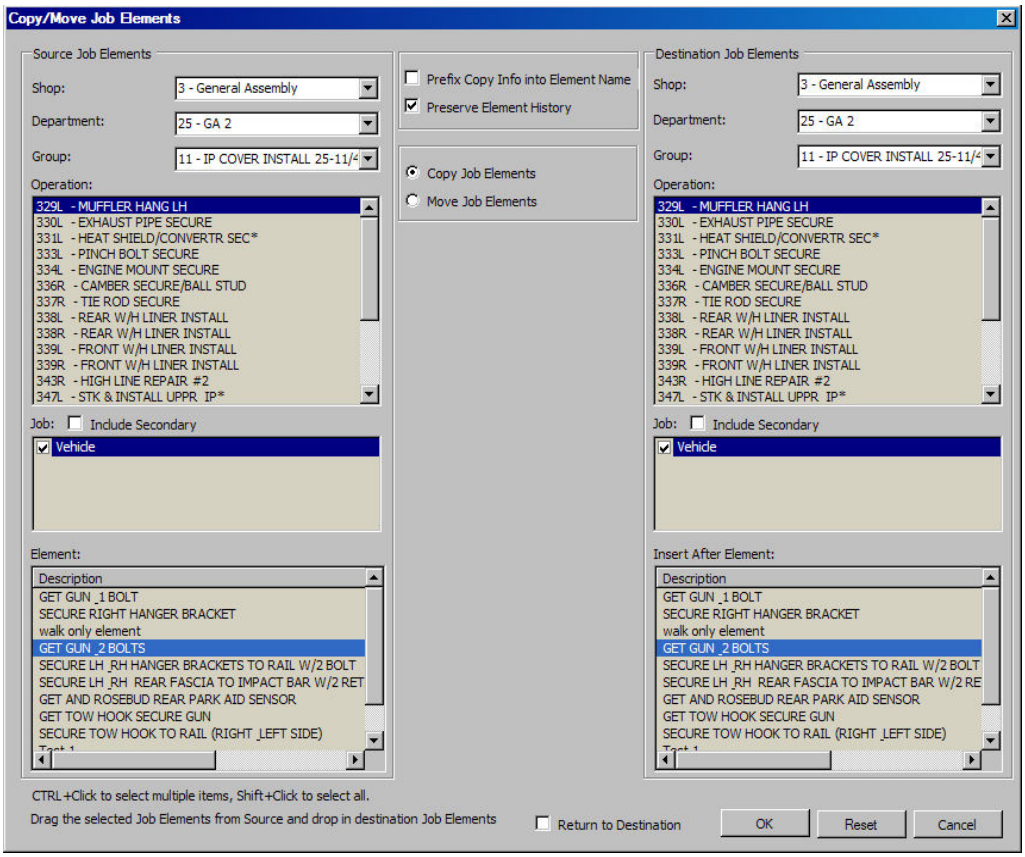


Figure 38 : APS - Copy/Move Job Element Screen

- Revision History
  - Click SOS Tasks, Revision History

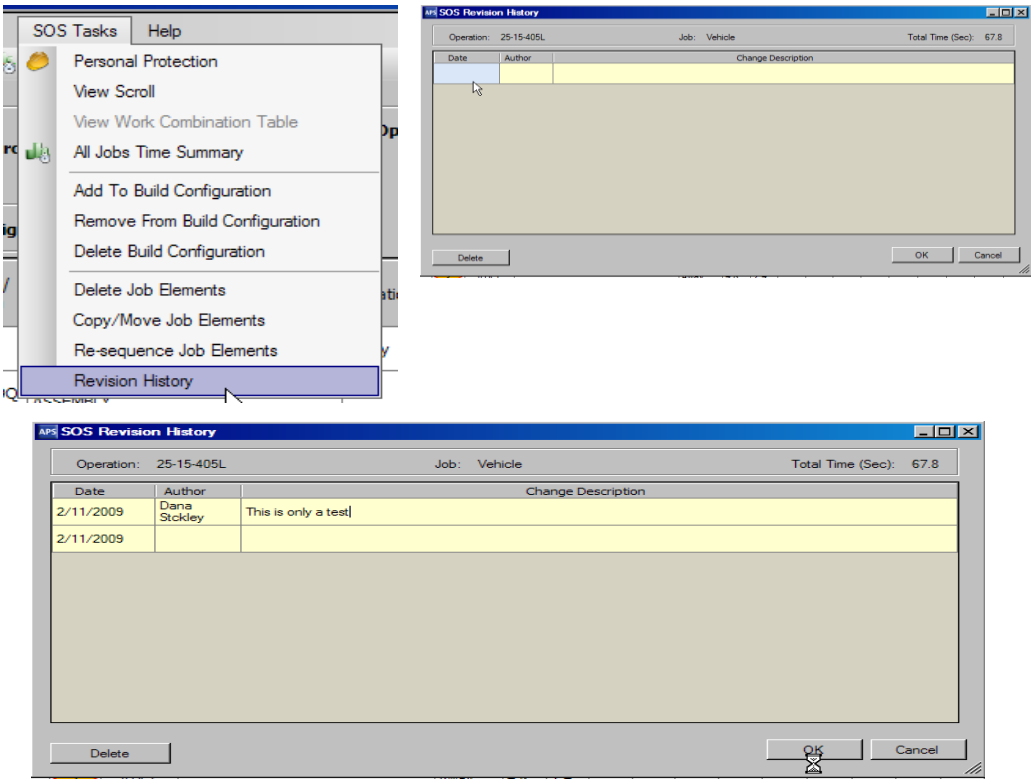


Figure 39 : APS - Revision History Screens

4.7 Line Balance Wall

- Each operation is a pillar of job elements
  - Visual representation of work
  - Elements sequenced from top to bottom
  - Optional elements have a black bar on the left border
- User can line balance by dragging job elements from one operation to another
- Weighted average cycle time of a job is displayed with a “floating arrow”

– Weighted average cycle time of operation is displayed by Grey horizontal line

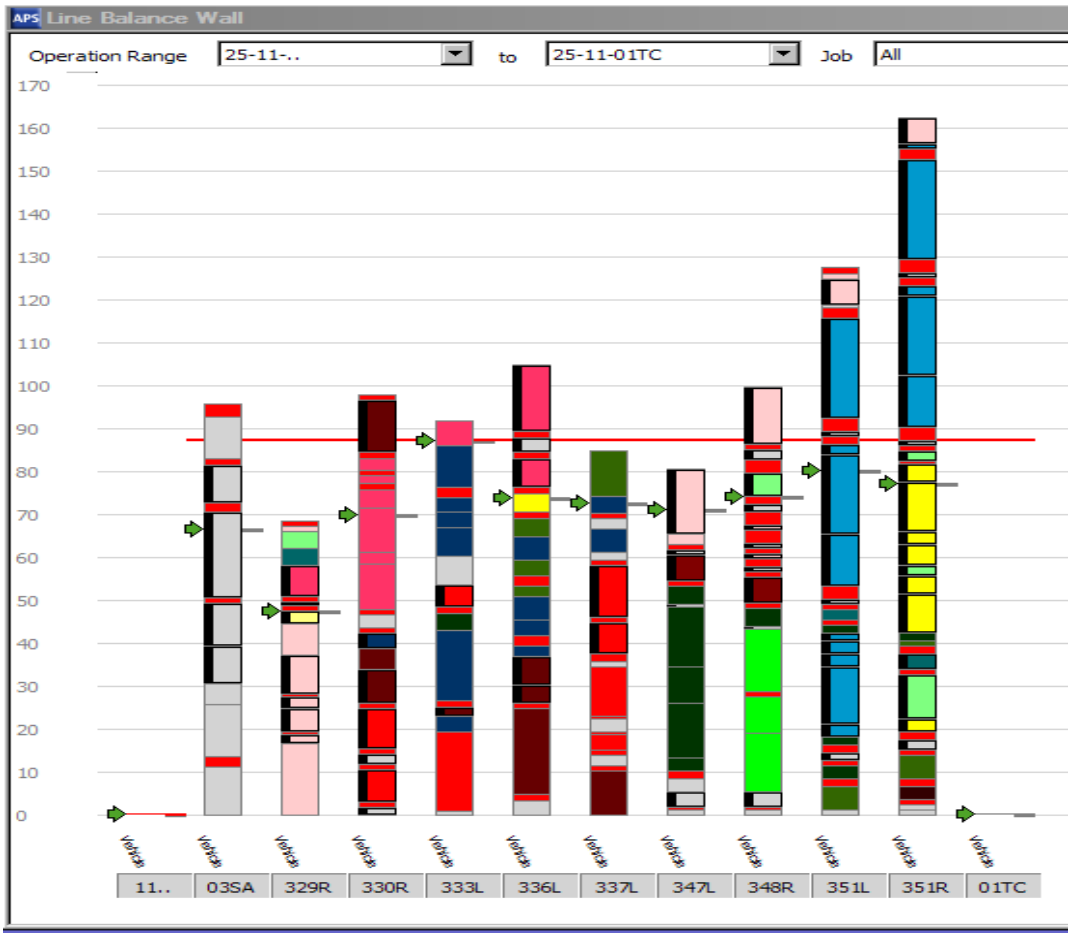


Figure 40 : APS - Wall Chart

Line Balance Wall

Each rectangle is a job element.

The red elements represent walk times.

Each column represents a Standard Operation Sheet

The operation address displays at the bottom of the screen.

4.8 Implementation Of Assembly Processing System (APS)

For complete implementation of the process is it necessary to complete JES and SOS as per the new balancing. During the Deployment of APS we had monitored all the important elements for example : SOS Sequence, Picture addition, Symbols addition, Scroll Diagram Completion, Revision History and Safety Quality History Updation, Time Updation through STDS Software and Print Out completion.

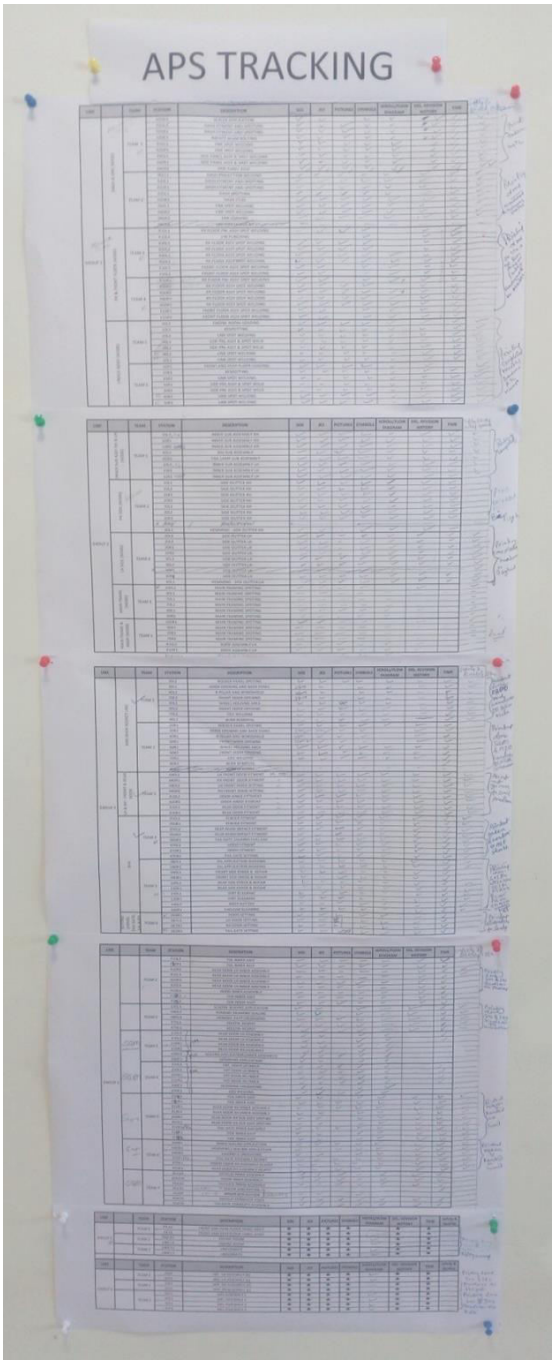
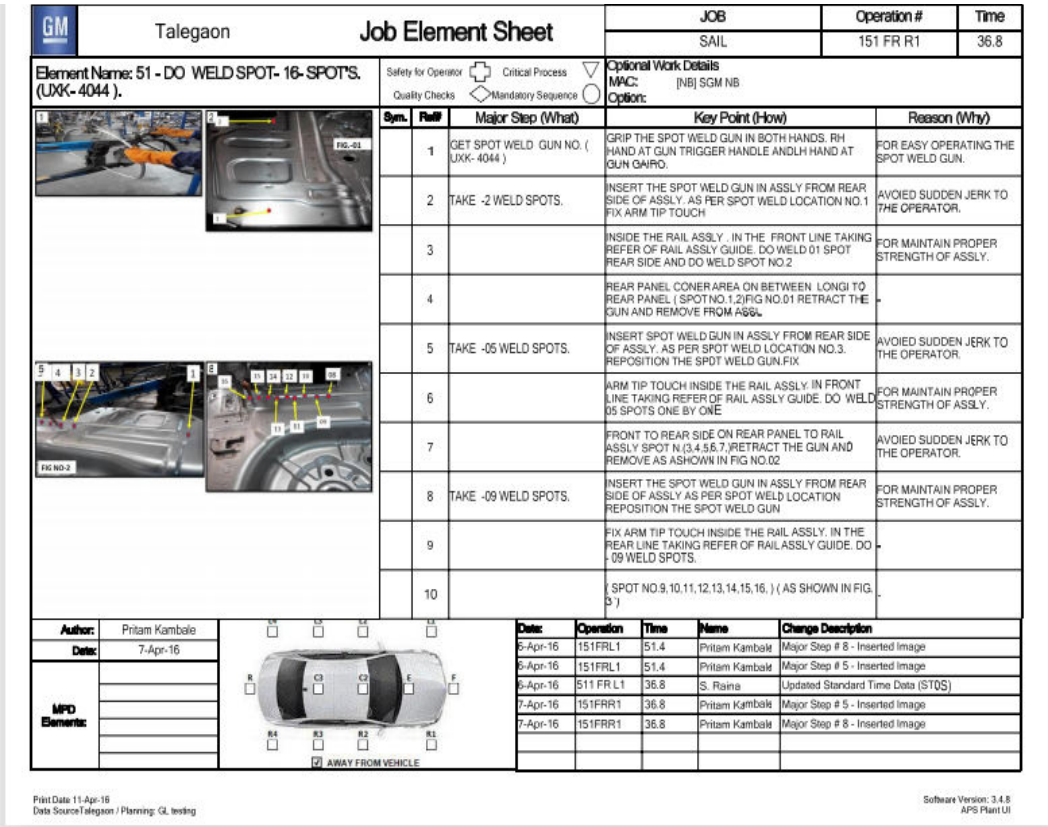


Figure 41 : APS Tracking Sheet for every SOS used during the implementation phase

4.8.1 APS completion - JES:

In the example shown below one of the Element is briefly explained as:



GM Talegaon **Job Element Sheet**

JOB	Operation #	Time
SAIL	151 FR R1	36.8

Element Name: 51 - DO WELD SPOT- 16- SPOT'S. (UXK- 4044).

Safety for Operator, Critical Process, Quality Checks, Mandatory Sequence

Optional Work Details
MAC: [NB] SGM NB
Option:

Sym.	Ref#	Major Step (What)	Key Point (How)	Reason (Why)
	1	GET SPOT WELD GUN NO. (UXK- 4044)	GRIP THE SPOT WELD GUN IN BOTH HANDS. RH HAND AT GUN TRIGGER HANDLE ANDLH HAND AT GUN GAIRO.	FOR EASY OPERATING THE SPOT WELD GUN.
	2	TAKE -2 WELD SPOTS.	INSERT THE SPOT WELD GUN IN ASSLY FROM REAR SIDE OF ASSLY. AS PER SPOT WELD LOCATION NO.1 FIX ARM TIP TOUCH	AVOIED SUDDEN JERK TO THE OPERATOR.
	3		INSIDE THE RAIL ASSLY . IN THE FRONT LINE TAKING REFER OF RAIL ASSLY GUIDE. DO WELD 01 SPOT REAR SIDE AND DO WELD SPOT NO.2	FOR MAINTAIN PROPER STRENGTH OF ASSLY.
	4		REAR PANEL CONER AREA ON BETWEEN LONGI TO REAR PANEL (SPOT NO.1,2)FIG NO.01 RETRACT THE GUN AND REMOVE FROM ASSY.	-
	5	TAKE -05 WELD SPOTS.	INSERT SPOT WELD GUN IN ASSLY FROM REAR SIDE OF ASSLY. AS PER SPOT WELD LOCATION NO.3. REPOSITION THE SPOT WELD GUN.FIX	AVOIED SUDDEN JERK TO THE OPERATOR.
	6		ARM TIP TOUCH INSIDE THE RAIL ASSLY. IN FRONT LINE TAKING REFER OF RAIL ASSLY GUIDE. DO WELD 05 SPOTS ONE BY ONE	FOR MAINTAIN PROPER STRENGTH OF ASSLY.
	7		FRONT TO REAR SIDE ON REAR PANEL TO RAIL ASSLY SPOT N.(3,4,5,6,7,)RETRACT THE GUN AND REMOVE AS ASHOWN IN FIG NO.02	AVOIED SUDDEN JERK TO THE OPERATOR.
	8	TAKE -09 WELD SPOTS.	INSERT THE SPOT WELD GUN IN ASSLY FROM REAR SIDE OF ASSLY AS PER SPOT WELD LOCATION REPOSITION THE SPOT WELD GUN	FOR MAINTAIN PROPER STRENGTH OF ASSLY.
	9		FIX ARM TIP TOUCH INSIDE THE RAIL ASSLY. IN THE REAR LINE TAKING REFER OF RAIL ASSLY GUIDE. DO - 09 WELD SPOTS.	-
	10		(SPOT NO.9,10,11,12,13,14,15,16,) (AS SHOWN IN FIG. 3)	-

Author: Pritam Kambale
Date: 7-Apr-16
MPD Elements:

AWAY FROM VEHICLE

Date:	Operation	Time	Name	Change Description
6-Apr-16	151FRL1	51.4	Pritam Kambale	Major Step # 8 - Inserted Image
6-Apr-16	151FRL1	51.4	Pritam Kambale	Major Step # 5 - Inserted Image
6-Apr-16	511 FR L1	36.8	S. Raina	Updated Standard Time Data (STDS)
7-Apr-16	151FRR1	36.8	Pritam Kambale	Major Step # 5 - Inserted Image
7-Apr-16	151FRR1	36.8	Pritam Kambale	Major Step # 8 - Inserted Image

Print Date 11-Apr-16
Data Source Talegaon / Planning: GL testing
Software Version: 3.4.8
APS Plant UI

Figure 42 : APS completion - JES (Example)

- Time shown in the upper right corner is the standard time we got from MODE software which is directly connected to APS.
- We have to completely define every step in the element which involves the Major step (what), Key point (how) and Reasons (why). For example in this element the 16 spots have been defined as per the repositions and the sequence.
- Along with the steps we have to also define the symbols that are for Quality, Safety, Critical Process and Mandatory sequence.
- As per the process the spots are shown in the picture on the left hand side. the number of spots and respective distances are clearly illustrated.
- JES also shows the work position taking place with respect to the car. For example in the current element of work it is away from the vehicle.
- The JES also shows the Author and date of completion on the left hand corner below.

4.8.2 APS completion - SOS:

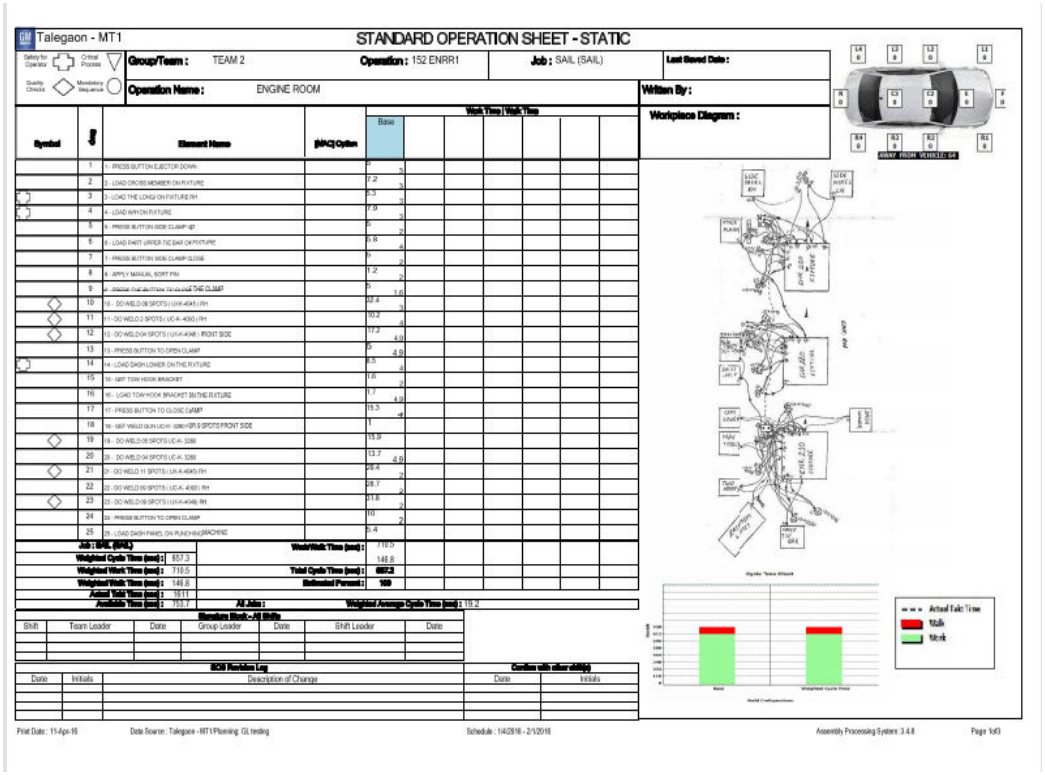


Figure 43 : APS completion - SOS (Example)

SOS is made of all the JES or all the work elements belonged to a particular workmen.

- Time shown for all the JES get adds up and the total time for performing all the elements is Weighted Time as shown in sec.
  It also shows the TT and ATT along with the available time.
- On the right hand side there is a work flow diagram, which helps us to understand the movement of the workmen between the fixtures and trolleys.
- On the right hand corner it shows the work and walk bar graph (Wall chart) comparing it with the ATT.
- SOS shows the timing for different variants or for base version as per the respective elements.
- The elements must be in proper sequence.
- Estimate Percentage Calculation based on the past volume of vehicles produced.

Chapter – 5

INTRODUCTION TO STDS AND MODE SOFTWARE

5.1 Introduction

Time Analysis provides engineering time information to the JES

- The Time Analysis screen in APS contains descriptions, codes, and times from various pre-determined time systems.
- There are three types of time analysis available in APS
  - Standard Time Data System
  - MTM/UAS
  - RSTS
- The type of time analysis is selected at the plant level.
- Toggle between the Job Element Major Steps and the Time Analysis by clicking on the Element Detail menu and selecting Major Steps or Time Analysis.

5.2 Time Analysis using STDS

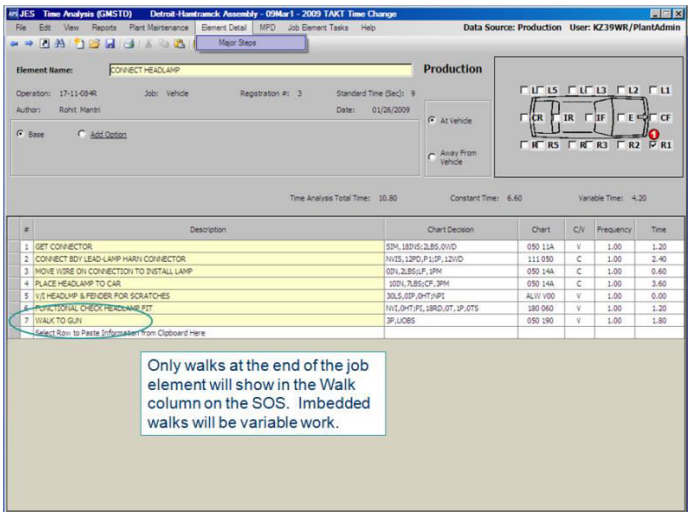
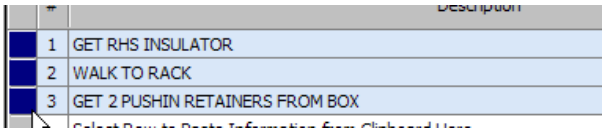
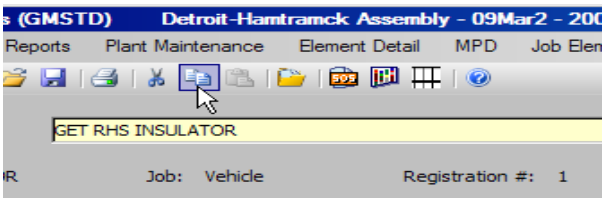


Figure 44 : APS - Time Analysis using STDS Screen

- Moving data from APS to STDS
  - Select the lines of detail in APS by dragging your mouse through the APS record selector.
    - The record selector boxes will turn blue
  - Click on the Cut or Copy icon at the top of the Time Analysis window
    - This places the lines of Time Analysis on the clipboard



Time Analysis with records selected



Cut and Copy icons

Figure 45 : APS - Moving data from APS to STDS

- Moving data from APS to STDS
  - Open STDS
  - Select a line in the STDS window
  - Click on the  icon or right click and select Import, From APS Plant.
    - The selected lines will be written to STDS
  - The user can modify the lines of detail as usual in STDS.
- Moving data from STDS to APS
  - Select lines of STDS data by dragging the mouse pointer through a series of chart decisions
    - The entire line of STDS data is selected.

- Click on the Export to APS icon  or right click and select Export, to APS Plant.
- Click OK
    - The STDS data is placed on the clipboard.
- Select a job element in APS and go to the Time Analysis screen
    - If the Job Element Sheet displays Major Steps, click the Element Detail, Time Analysis menu item.
- Select the final row on the Time Analysis screen.

- APS Time Analysis Page

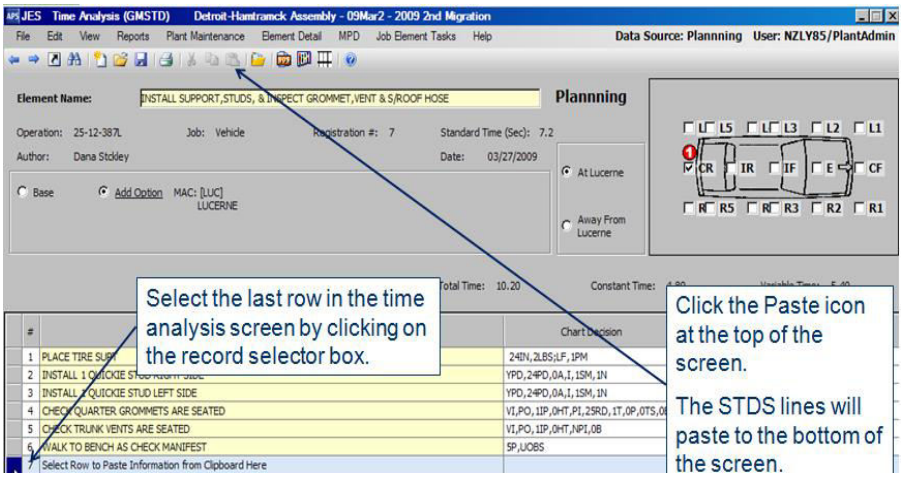
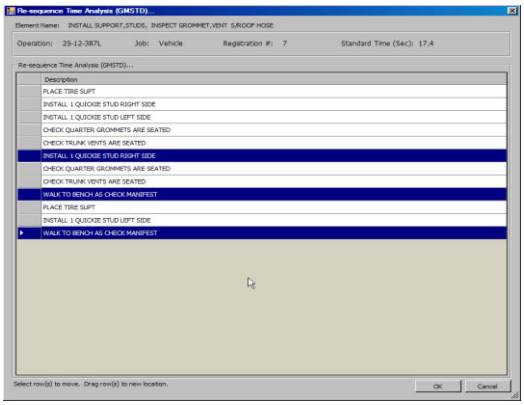


Figure 46 : APS - Time Analysis Page

- Time Analysis Re-sequence window



Select one or more rows by clicking on the record selector.

Drag the rows into the new sequence.

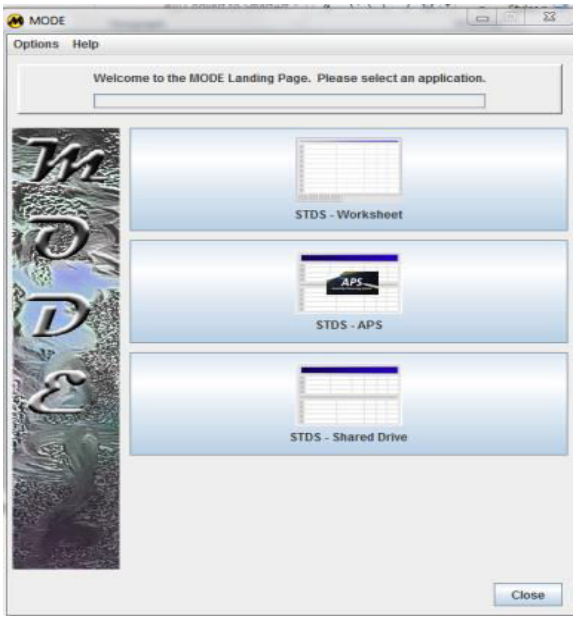
Click OK

Click Cancel to keep original sequence

Figure 47 : APS - Time Analysis Re-sequence Screen

5.3 Time Analysis using MODE (Manufacturing Operations Data Environment)

- Using MODE 



Double-Click MODE Icon on Desktop

Click STDS-APS to edit times and decisions in APS

Figure 48 : MODE - Initialization

- STDS – APS Input Screen

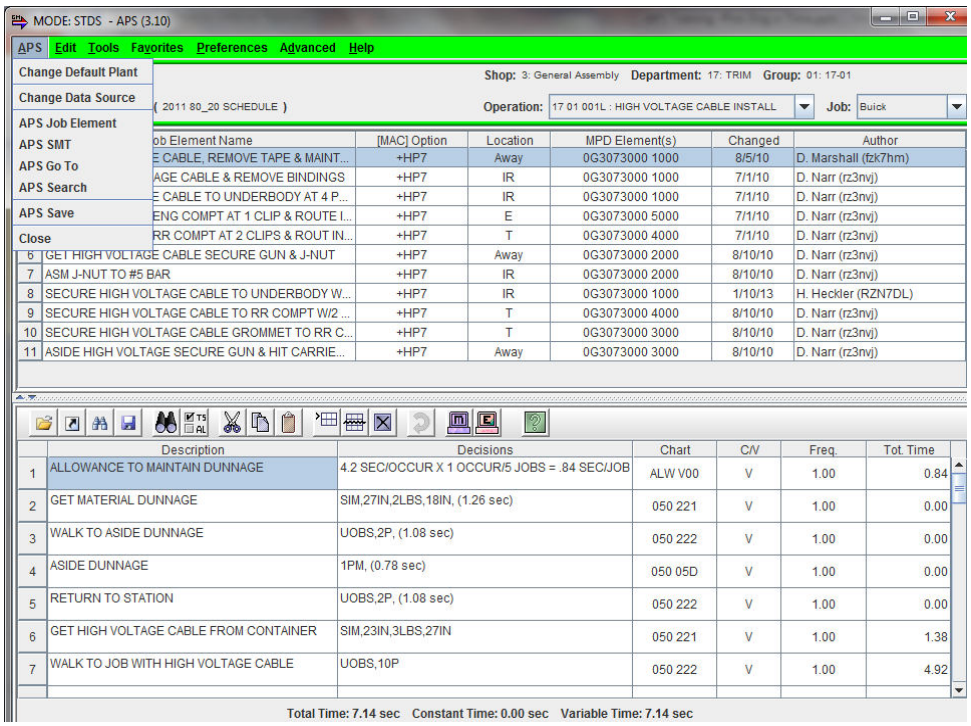


Figure 49 : MODE - STDS APS Input Screen

- Select the Job Element

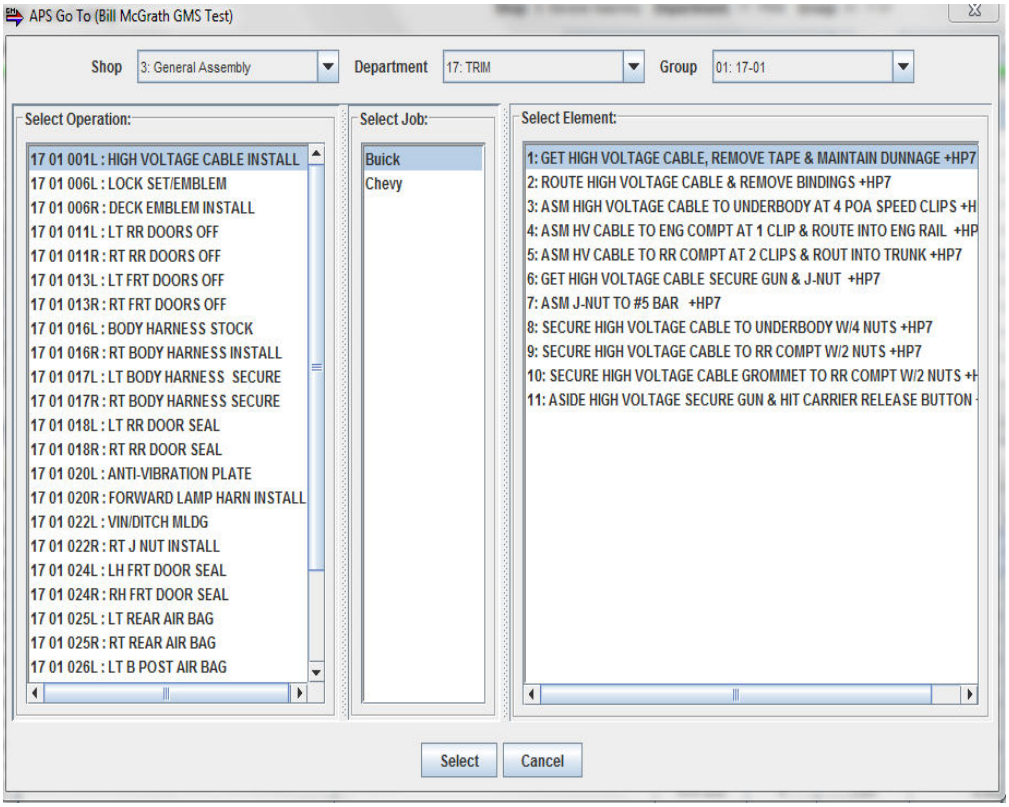


Figure 50 : MODE - Go To Screen

- Editing Time Analysis
  - The bottom part of the STDS-APS, is the time entry section
    - Edit the Description
  - Find the Charts and make appropriate chart decisions
- After making changes to time study, click save.

5.4 Mathematical Functioning of the Software:

Following are some of the Charts Information which explains the working of the MODE software.

For a particular activity we have at first find the chart.

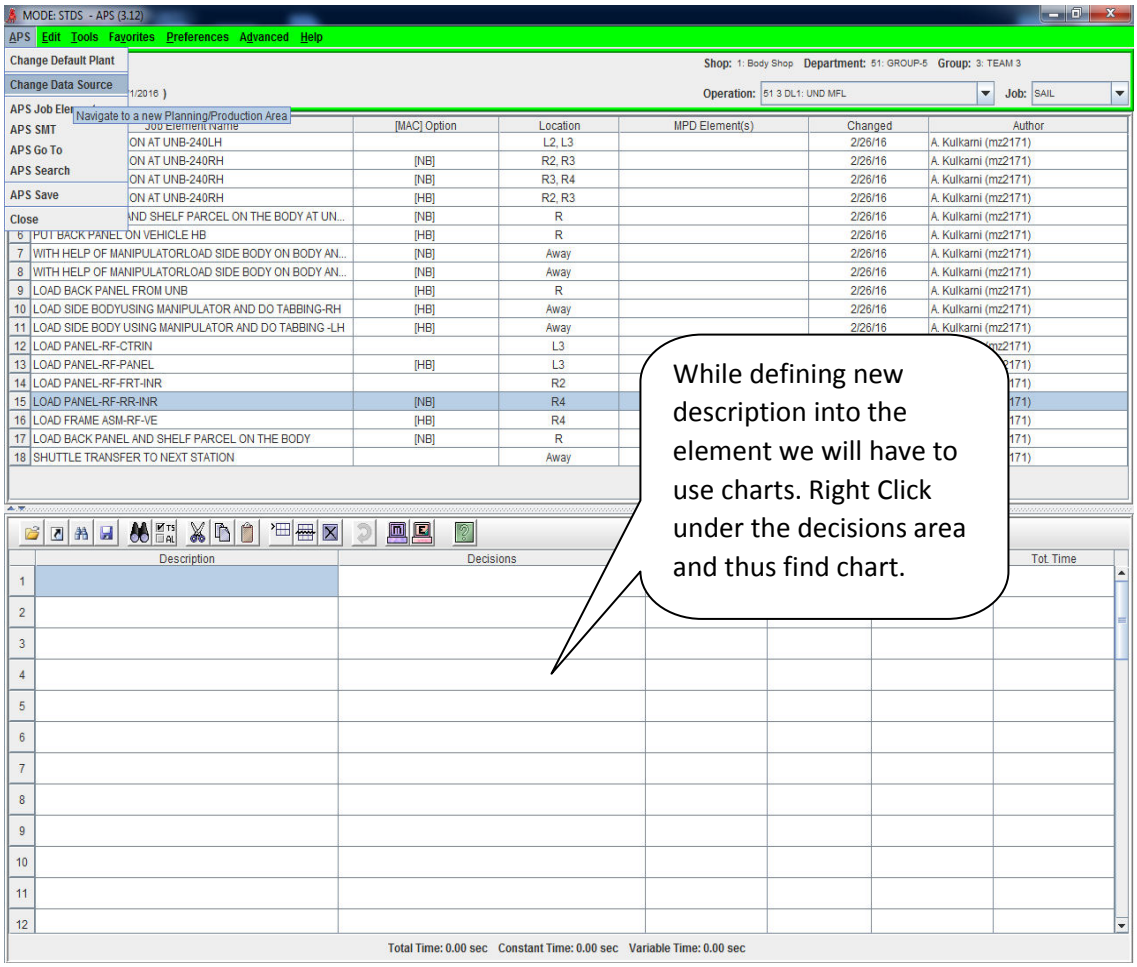


Figure 51 : MODE - Time validation Screen

For various activities there are different charts used. The information feed into the software was based on the observation of nearly 1000 people performing the same activity with different operator capability or efficiency. Using that data the timings in the software are being set. Along with it the software also provides us variety and in detail analysis of the activity. For example:

The operator has to walk to get an object. For this activity we have to use the following chart. The Chart information is given below:

➢ Chart Number: 050-222 (Walk)

Chart Includes:

- Unobstructed Walk
- Obstructed Walk
- Walk with creform cart
- Body turns in walk path

Chart Does Not Include:

- Walking with or moving a bank of tools

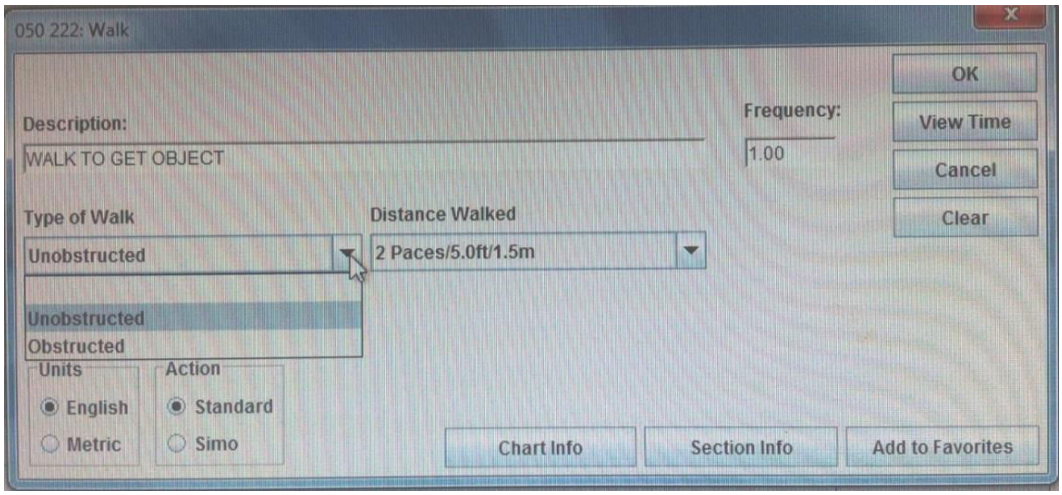


Figure 52 : MODE - Defining Walk Chart

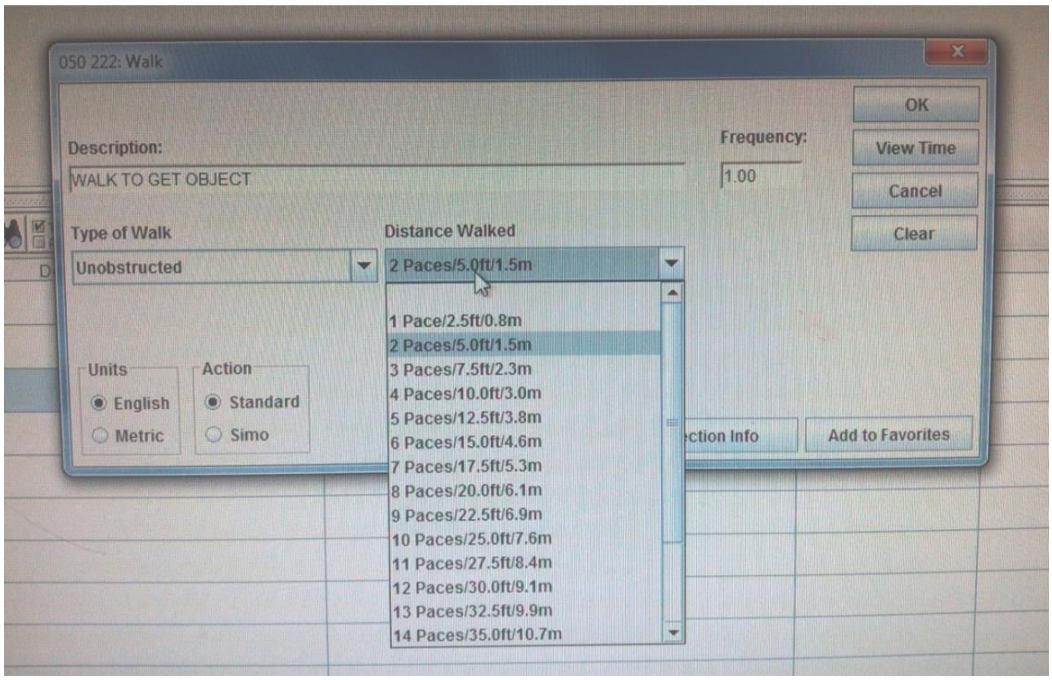


Figure 53 : MODE - Defining Walk Chart

Definitions:

- Distance Walked (P, FT, MX) - - Total length of the path traced by a series of footsteps including body turns at the beginning, middle, and/or end of the path.
- Pace (P) - The component of a walk consisting of relocation of one foot approx. 2.5 feet (0.8 meters) from the other foot.
- Unobstructed (UOBS) - An unrestricting surface is provided for the operator with a clear path for unhindered walking and/or turning.
- Obstructed or with Creform Cart (OBS) - Some feature of the environment provided for the walk hinders the ease of the walk. Conditions such as slippery floors, breaking stride to duck under tools overhead, stairs, inclines, and walking sideways through a narrow path are all examples of such features. An object in the operator's direct path (such as a waste receptacle) with a clear path around it would not result in an obstructed walk but a longer unobstructed walk.

Notes:

When counting foot movements to determine the number of paces, the last foot movement where the trailing foot joins the leading foot is generally not included as a pace. This is due to the fact that it often occurs simultaneously with some other activity such as reach or dispose.

In cases where the operator does not walk but makes a body turn of 90° or more consider the body turn as a pace. If two body turns are required at the beginning of the walk path, enter the chart twice - one pace for the first turn then the remaining number of paces, including the second turn, as a separate entry.

If an operator's walk appears to be obstructed for a portion of the walk and unobstructed for the remainder of the walk, enter the chart twice or use the chart decision that describes the greater portion of the walk cycle.

Generally, an operator's hands are not totally idle for the duration of the walk cycle. Getting fasteners from an apron pocket, getting a tool from a belt holster or overhead balancer, transferring parts from one hand to the other, or a portion of the reach distance to an object located at the end of the walk are all examples of work elements

that can occur simultaneously with walking. Care should be taken not to account for these items separately in the total work cycle.

In a high volume production situation, long walks are often the result of a poor method or inefficient workplace layout.

5.5 General Chart Information:

Similarly there are approximately 300 to 350 charts for various activities which are being performed in a manufacturing industries. Some of the charts are:

- Chart 050-221 Get Object

  Chart Includes:

  - Reach to object
  - Gain control of object
  - Withdraw object

  Chart Does Not Include:

  - Untangling of entwined wires, hoses, etc.
  - Extreme pressure to separate objects
  - Walk
- Chart 001-031 Reposition Gun

  Chart Includes:

  - Disengage gun from work
  - Move gun
  - Place gun

- Chart 001-011 Get Portable Spot welding Gun

  Chart Includes:

  - Reach to and gain control of gun
  - Remove spot welder from hook

- Longer reach distances include the required body turns and half paces that are slow with reaching for the spot welder

Chart Does Not Include:

- Walking to get the spot welder - use the Walk chart 050-222

➢ Chart 050-224 Place Object to Fixture or Final Location

Chart Includes:

- Move object to a fixture or final assembled location
- Align and position object (if necessary)
- Release control of object (unless place is followed by a process)

Chart Does Not Include:

- Get object
- Walk
- Tight fitting part engagements that typically require heavy pressure or the assistance of a mechanical device for proper placement
- Dispose object or place part(s) to a temporary location (See Charts 050-050 or 050-05A)

Chapter – 6

PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING TECHNIQUES

6.1 LINE BALANCING

6.1.1 History

Line Balancing means leveling the workload across all processes in a cell or value stream to remove bottlenecks and excess capacity. It is an effective tool to improve the throughput of assembly lines while reducing manpower requirements. Assembly Line Balancing or Line Balancing includes assigning operations to workstations along an assembly line in such a way that the assignment has to be optimal in some sense. Ever since Henry Ford's introduction of assembly lines, Line Balancing has been an optimization problem of significant industrial importance.

Before the "moving assembly line" was introduced in 1913, each chassis was assembled by a single worker and require 12.5 hours. As the new technology was installed, this time got reduced to 93 minutes. But continuous supply of material is must for moving assembly line. Line Balancing is a classic Operation Research (OR) optimization problem, having been tackled by OR over several decades. Each industry contains software through which help is provided to industry to optimize their lines.

6.1.2 Introduction to Assembly Line

Line balancing is a difficult optimization problem, so the approach taken by OR has typically been to simplify it, in order to bring it to a level of complexity amenable to OR tools.

The Standard Operation Sheets (SOS) proves very much helpful during the time of Line Balancing as they contain the details of standard operations carried out at that particular station. With the help of SOS the standard time requirement at that station can be found out using the software and similar technique is carried out at each station

of the assembly line and as a result it proves to be helpful in Line Balancing of the Assembly Line.

Thus Line Balancing technique is carried out to:-

1. Minimize the number of workstations on assembly line,
2. Minimize the cycle time required at workstation,
3. Maximize the workload smoothness at assembly line and
4. Minimize the manpower requirement on assembly line.

6.1.3 Why Line Balancing is used?

All factories that have a line such as traditional assembly line and new assembly line such as heuristic and U-type and also mixed model used a few technique such as genetic algorithms and fuzzy logic and also simulation method to improve a few parameter of line control. In other hand manager like has a productivity and high yield in their factory and for this goal get help from previous technique to locate a machine, employer and to assign employer to machine so as to select the best choose for control and work by machine. In few company one employer control 2 or more than 2 machines and this result is the output of Line Balancing. In another word, the company used Line Balancing for the growth of production rate, to decrease man power, idle time and buffer near machine and is also used to produce more than 2 products. Line Balancing is carried out on assembly lines with different shapes and thus the problem of Line Balancing is solved through different ways for different shapes of assembly lines. The Assembly Line Balancing Shapes are as follows:-

6.1.3.1 Simple Assembly Line Balancing Problem (SALBP)

It is relevant for straight single product assembly lines where only precedence constraints between tasks are to be considered. Type 1 of this basic problem (SALBP-1) consists of assigning tasks to work stations such that the number of stations are minimized for a given production rate. Type 2 (SALBP-2) is to maximize the production rate, or equivalently, to minimize the sum of idle times for a given number of stations. A more general type (SALBP-G) is obtained by minimizing the sum of idle times subject to varying production rates and number of stations.

6.1.3.2 U-Shaped Assembly Line Balancing Problem (UALBP)

It considers the case of U-Shaped (single product) assembly lines, where stations are arranged within a narrow U. As a consequence, workers are allowed to work on either side of the assembly line, i.e. on early and late tasks in the production process simultaneously. Therefore, modified precedence constraints have to be observed.

6.1.3.3 Mixed Model Assembly Line Balancing Problem (MALBP) and Model Sequencing Problem (MSP)

Mixed model assembly lines produce several modes of a basic product in an intermixed sequence. Besides the MALBP which has to assign tasks to stations considering the different task times for the different models, the MSP is relevant.MSP has to find a sequence of all model units to be produced such that the inefficiencies (work overload, line stoppage, off-line repair etc.) are minimized.

6.1.3.4 Generalized Assembly Line Balancing Problems (GALBP)

In the literature, all problem types which generalize or remove some assumptions of SALBP are called GALBP. This class of problems (including UALBP and MALBP) is very large and contains all problem extensions that might be relevant in practice including equipment selection, processing alternatives, assignment restrictions etc

6.1.4 Types Of Assembly Lines

a. Single-model assembly line

b. Mixed-model assembly line

c. Multi-model assembly line

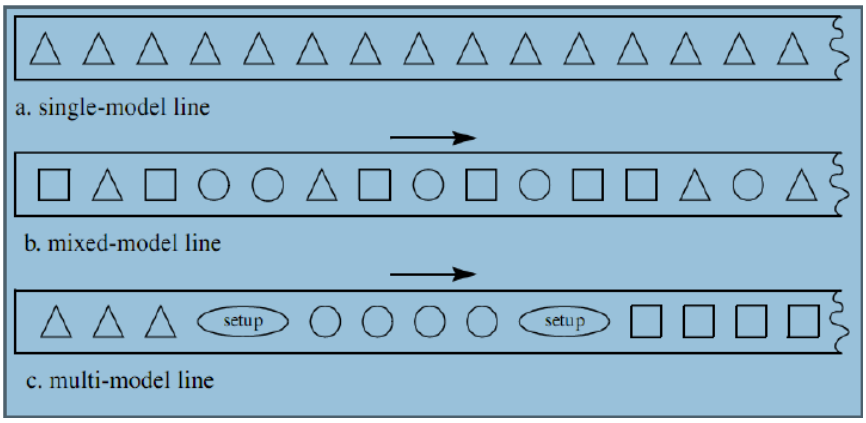


Figure 54 : Assembly lines for single and multiple products

6.1.4.1 Single Model Assembly Lines

On these assembly lines mass production of single commodity is carried out. If more than one product is assembled on the same line, but neither setups nor significant variations in operating times occur, the assembly system can be treated as a single model line, e.g. compact discs, drinking cans etc.

6.1.4.2 Mixed Model Assembly Lines

In mixed model production, setup times between models could be reduced sufficiently enough to be ignored, so that intermixed model sequences can be assemble on the same line. Here workload is minimized by assigning a high time task of one model with a low time task of another model to a pertaining station where workload occurs.

6.1.4.3 Multi Model Assembly Lines

On these lines different models are manufactured by the use of same resources such as machines, operators etc. To avoid the setup times and costs these assemblies are organized in batches.

6.1.4.4 Manual Assembly Lines

Are used in high-production situations where the work to be performed can be divided into small tasks and tasks assigned to the workstations on the line. Key advantage of

using manual assembly line is specialization of labor –By giving each worker a limited set of tasks to do repeatedly.

Apart from these there are also some Assembly Systems Major methods can be classified:

- Manual Single-Station Assembly

Consist of a single workplace to accomplish the product or some major subassembly of the product. Generally used on a product that is complex and produced in small quantities, one or more workers depending on the size of the product and the production rate. Such as machine tools, industrial equipment, aircraft, ships and complex consumer products (appliances, car...)

- Manual Assembly Lines

Consist of multiple workstations in which the assembly work is accomplished as the product (subassembly) is passed from station to station along the line.
At each workstation one or more human workers perform a portion of the total assembly work on the product, by adding one or more components to the existing subassembly.

- Automated Assembly System

Use of automated methods at the workstations rather than human beings.

- Transfer of Work between Workstations

There are two basic ways in which the work is moved on the line between operator workstations.

  - Non mechanical Lines :No belt or conveyor is used to move the parts. The parts are passed from station to station by hand.

    Problems:
    Starving at stations –wait for parts from the preceding station.
    Blocking of station –wait for the next operator to finish the task before passing along the part.

Results:

The flow of work is usually uneven

Cycle time vary

Buffer stocks of parts between workstations are often used to smooth out the production flow.

- Moving Conveyer Lines :Use a moving conveyor (e.g. belt, convey, chain-in-the-floor)

  Problems:

  Starving can occur as with none-mechanical lines

  Incomplete items are sometimes produced –unable to finish the current part

  To control the feed rate of the line:

  Fp: denote feed rate

  Vc: conveyor speed

  Sp: Spacing between parts on the moving conveyor

  $Fp = Vc / Sp$

  The time period (tolerance time) Tt

  Ls: is determined largely by the operator's reach at the workstation

  $Tt = Ls / Vc$

6.2 Line Balancing Problem

The line balancing problem is to arrange the individual processing and assembly tasks at the workstations so that the total time required at each workstation is approximately the same. If the work elements can be grouped so that all the station times are exactly equal, we have perfect balance on the line and we can expect the production to flow smoothly. In most practical situations it is very difficult to achieve perfect balance.

6.3 Introduction To Line Balancing

In this recession period, it is difficult to survive in the market with the normal (slow) speed. So basically, line balancing means to increase the line speed for the same work content. In other words it can be said that, line balancing means Increasing the speed of the line such that each station now had the same amount of work to be done but in shorter span of time. This is certainly very difficult because of the standardized nature of work. “Standardized work” definitions had been decided by industrial engineering professionals keeping in mind things like Bill of Process (BOP), error proofing, fatigue, human ergonomics, safety, etc. and could not be altered. Moreover it is software based. Standard time is calculated considering that the operator has to do repeated work for whole of the time.

Just for the sake of an example, suppose a human operator took 4 seconds to walk from the start of the station to the end. This is the standard time that was allotted for the task. Of course some humans can take lesser amount of time. But the operator was not supposed to take more than 4 seconds for that particular task. The allotted time was a result of careful observations, extensive time-studies and years of experience in industrial engineering.

Thus, the headline of the problem became: **How to do the same amount of work in lesser time!**

Takt Time

Takt Time is defined as "The rate at which the end product or service must be produced and delivered in order to satisfy a defined customer demand within a given period of time. It is calculated as:

$$\text{Takt Time} = \frac{Total\ Time\ Available\ (in\ period)}{Customer\ demand\ (in\ period)}$$

[NOTE: - The unit of time in the numerator & denominator must be the same.

The numerator, **Available Work Time**, is often expressed as Minutes/Shift, Seconds/Day, Minutes/Day and so on.

The denominator, **Customer Demand Rate**, is often expressed as Parts/Min, Units/Shift, Pieces/Day, and so on.]

For Example,

If a line runs for 8 hours in a shift and customer demand per shift is 253 parts,

Then

Takt Time = $\frac{8*60*60\ (\text{sec})}{253\ (units)}$ = 113.86 sec i.e. 114 sec

That is, the line should run with a speed such that the engine will pass through one station in 114 sec, so that at the end of shift the target of 253 parts will be achieved. All the operations to be performed at every station should be balanced in such a way that all operators finish their work in same time that is in 114 seconds.

But, practically this won't happen. In every system, there are some losses. For example, in assembly line some problems come repeatedly, like parts not available, torque not ok, machine not ok, over cycle at some stations, part not ok, etc. All these are losses. Calculating them from previous experience, Efficiency of the line is calculated.

For example,

If during one shift, 20mins is the total time loss during various downtimes, then

% UPTIME = $\frac{Actual\ Time\ Available - Time\ lost}{Actual\ Time\ Available}$

*(Time Lost = Downtime + Blocked + Starved

i.e. Uptime = 1-(Downtime + Blocked + Starved) = $\frac{28800-1200}{28800}$ = 95 %

That is, though the line is running at the speed of 114sec per station, but the target will not be achieved due to common losses. Therefore, Actual Takt Time is calculated and the line runs at the speed of ATT to achieve the target.

Actual Takt Time:

Actual takt time = Takt Time * Uptime

ATT = 114 (sec) * 0.95 = 109 sec

6.4 Line Balancing Methods

Line balancing can be done by applying numerous small and large changes in the assembly line. The changes can be broadly classified into the following:

- Work Shifting
- Layout Modification
- Manpower Increment
- Introduction of New Station
- Provision of new Tools
- Idle Time Utilization
- Setup Change

Work Shifting

Work Shifting is the method commonly used while line balancing because it is easier to implement, results can be seen quickly also it is a cost efficient method. Work Shifting is “transfer of activities to an under-utilized station from over cycled station”.

Layout Modification

Sometimes, work shifting is not useful for line balancing, may be due to work transfer is not possible or most of the stations are over cycled. In such cases, Layout change or sequence change is done to simplify the operations, (like rotating existing machinery, modifying workflow and thereby reducing walking time), etc.

Man Power Increment

If any other strategies don’t work, man power increment method is used at some stations to balance the line. But, it can be done only if the costs are justified.

Introduction of New Station

If one or more stations are over cycled and work shifting to another working station is not possible or change in operation sequence is also not possible to implement, in such cases new station is introduced in the line. Line balancing is a combination of two or more changes. For example, introduction of new station requires work shifting, provision of New Tools and some Setup Changes.

Provision of New Tools

New tools are provided to make the task easier and feasible. But, provision of new tools requires the study of rails, cost of the tool.

Idle Time Utilization

At some stations, machines also provided to perform some of the operations and in such situation, the operator at that station has to stand idle while machine doing its work, and after machine work get over the operator performs his task. This may result in over cycle. This idle time can be utilized in doing a few tasks of the same station or some nearby station. This way, many seconds can be saved on the assembly line.

Setup Changes

At some stations, the machine itself has a lot of "idle time". For example, a few machine movements may be non-productive and can be reduced by some setup changes. These movements and changes can be identified during the observation phase.

6.5 Line Balancing Steps

The main objective was to bring down the cycle time of each station below 109 sec. (and at lowest possible cost). The process is explained in a chronological order below and was done every day.

The Methods are given below:

1. Study of idle times

2. Cycle Time Measurement

3. Identification of Bottleneck Stations

4. Detailed Analysis of Operations on each station

5. Study of Transferable and Non-Transferable Work

6. Implementation of Effective Line Balancing Methods

7. Trial on the applied method

Study of idle time:

Study of labor routings should be done before going on the line for line balancing. Labor routing is the detailed analysis of all the stations of the line. It also contains

Standard Time for each operation. These standard timings should be studied before calculating the actual cycle time. Every operator on the assembly line has a set of standard activities that he needs to perform. The assembly line is designed in such a way that it can be used to assemble 5 different engine models. So, getting the knowledge about the standard timings makes it easier to understand the things while taking actual timings on line.

Cycle Time Measurement:

Cycle times for all the 5 models at each station of the assembly line were noted down. These readings were compared against the standard allotted values and few immediate corrections were made at some stations as a part of improving the cycle time. At least 10 readings each day were taken for each station and each engine model. This activity was the most "time-consuming" and tiring. In the end, we had a mini database of at least 20 cycle times for each of the 5 engine models at each of the stations on the assembly line. These readings were of immense importance since they formed the basis of the Line balancing process.

Identification of Bottleneck Station:

The station which requires the largest time of all is called as the "Bottleneck Station". Due to over cycle, the conveyor stops for each station and due to this the JPH target gets missed. Due to the Bottleneck Station, previous station gets blocked and next station gets starved, i.e. it doesn't get the part to perform the operation, which results in the wastage of time. Therefore, to understand the variation of the line, Cycle time data is analyzed.

Detailed Analysis of Operations on each station

To balance a line, various methods are applied. To apply those methods, detailed study is done of the cycle times at each station so as to understand the exact problem and the method to be applied.

Study of Transferable and Non–Transferable work:

Major problem occurs in line balancing is due to Non-Transferable work, due to which sometimes, shifting of work is difficult to apply. Therefore, study of transferable work is important parameter in line balancing.

Implementation of Effective Line Balancing Method:

After studying all the parameters mentioned above, the most effective method is applied on the respective stations.

Trial on the applied method:

After the implementation of the ideas, trials are taken to check the effectiveness of the applied method. If it succeeds then the final documentation is made about the change. If it does not, then the alternate possible method is thought of.

6.6 Line Balancing Calculations

As per the new production plan the proposal has been made that with reduction of JPH for SGM or Sail car i.e. from 6 JPH to 2 JPH, the net JPH of the M300 i.e. Beat/Spark will be increased from 18 JPH to 22 JPH. Both running for 2 Shifts. Hence forth the manpower reduced from the SGM will be utilized in the M300 after balancing completion.

Let losses be x and JPH be y then the ATT can be formulated in terms of TT as below:

TT = $\left(\frac{3600}{y}\right)$

ATT = $\left(\frac{100-x}{100}\right) * TT$ OR ATT = $\left(\frac{100-x}{100}\right) * \left(\frac{3600}{y}\right)$

To calculate the total manpower required at a station:

Let the total work content of the entire station for a variant be = z

Therefore, Number of workmen required at the complete station be = N

N = $\frac{z}{ATT}$ (Which is taken as the next Integer number)

To calculate over speed be = O = $\left(\frac{TT-ATT}{ATT}\right)$

Using this data we have to at first find out the minimum number of workmen who will be able to optimize the work and then perform the balancing among those workmen. There also can be some constraints because of which we may have to deploy more manpower to the station.

All the line balancing cases have been discussed below in detail with proper illustrations.

6.7 Line Balancing Implemented At Body Shop

6.7.1 After First Quarter :

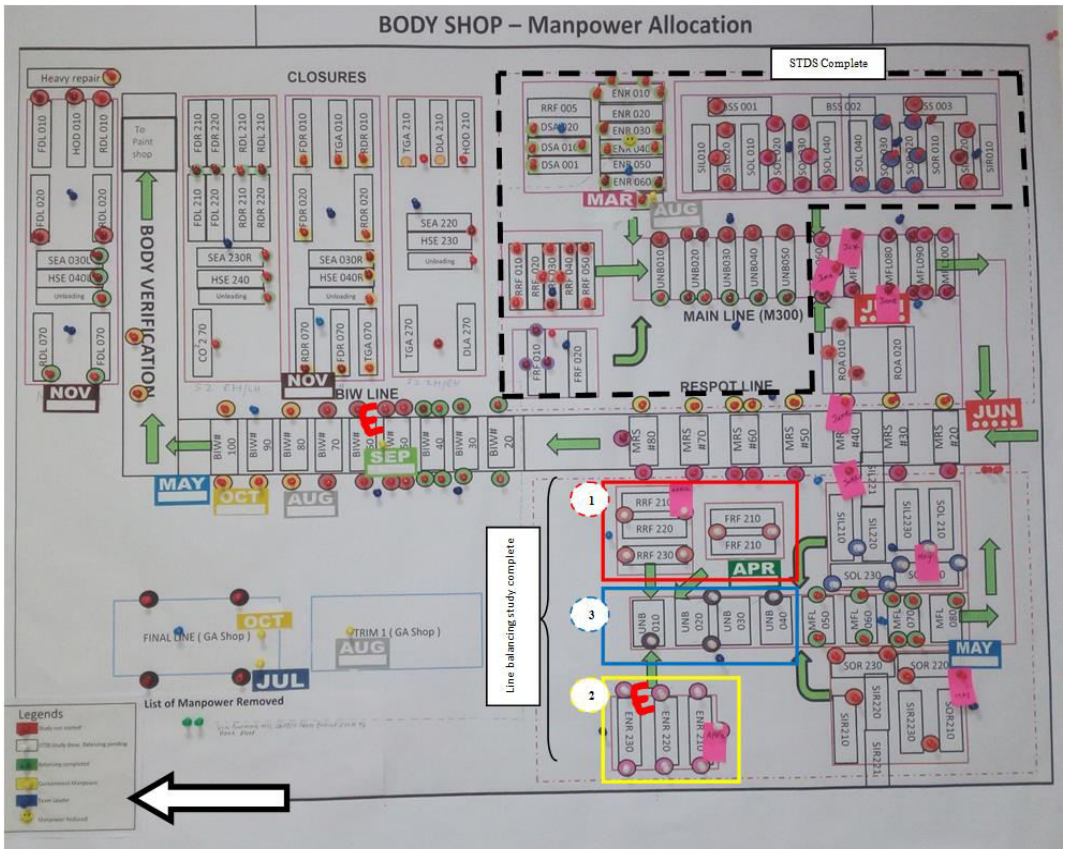


Figure 55 : Manpower Allocation - After First Quarter

As mentioned above the pictures illustrates the Cases of line balancing marked in colored boxes of which the studies have been completed and will be implemented very soon.

1. Front and Rear Floor
2. Engine Room
3. Underbody

With the help of STDs software we found out the timings required by the workmen to complete its job and to properly balance the work content for smooth functioning and no or very little Idle time. Also the layout for some stations have been proposed for better utilization in less time.

As per the new production plan there has been a decrement in the production of SGM i.e. Sail (notchback) car due to various reasons. So the vehicles production rate or Job Per Hour (JPH) is reduced from 6 JPH to 2 JPH.

Therefore for every hour there has to be 2 vehicles produced i.e. one vehicle in 30 min = 1800 sec.

The planned over speeding for the stations are :

For Underbody and Mainframe Line the Over speeding allowed is 10.1%. And for Front floor, Rear floor, Engine room and Side LH RH the Over speeding allowed is 10.5%.

Therefore, the Takt time (TT) is 1800 sec and Actual takt time (ATT) are

For Underbody and Mainframe line allowed time / ATT is 100 - 10.1 = 89.9% of TT which is equal to 1618 sec.

For Front floor, Rear floor, Engine room and Side LH RH allowed time / ATT is 100 - 10.5 = 89.5% of TT which is equal to 1611 sec.

Along with the reduction in JHP the Line balancing I did also helped in manpower optimization and reduction in cycle time. The software here played an important role in determining the timing and also simultaneously producing wall charts which makes us better understand the line balancing cases.

All the line balancing cases have been discussed below in detail with proper illustrations.

1. Front and Rear Floor SGM

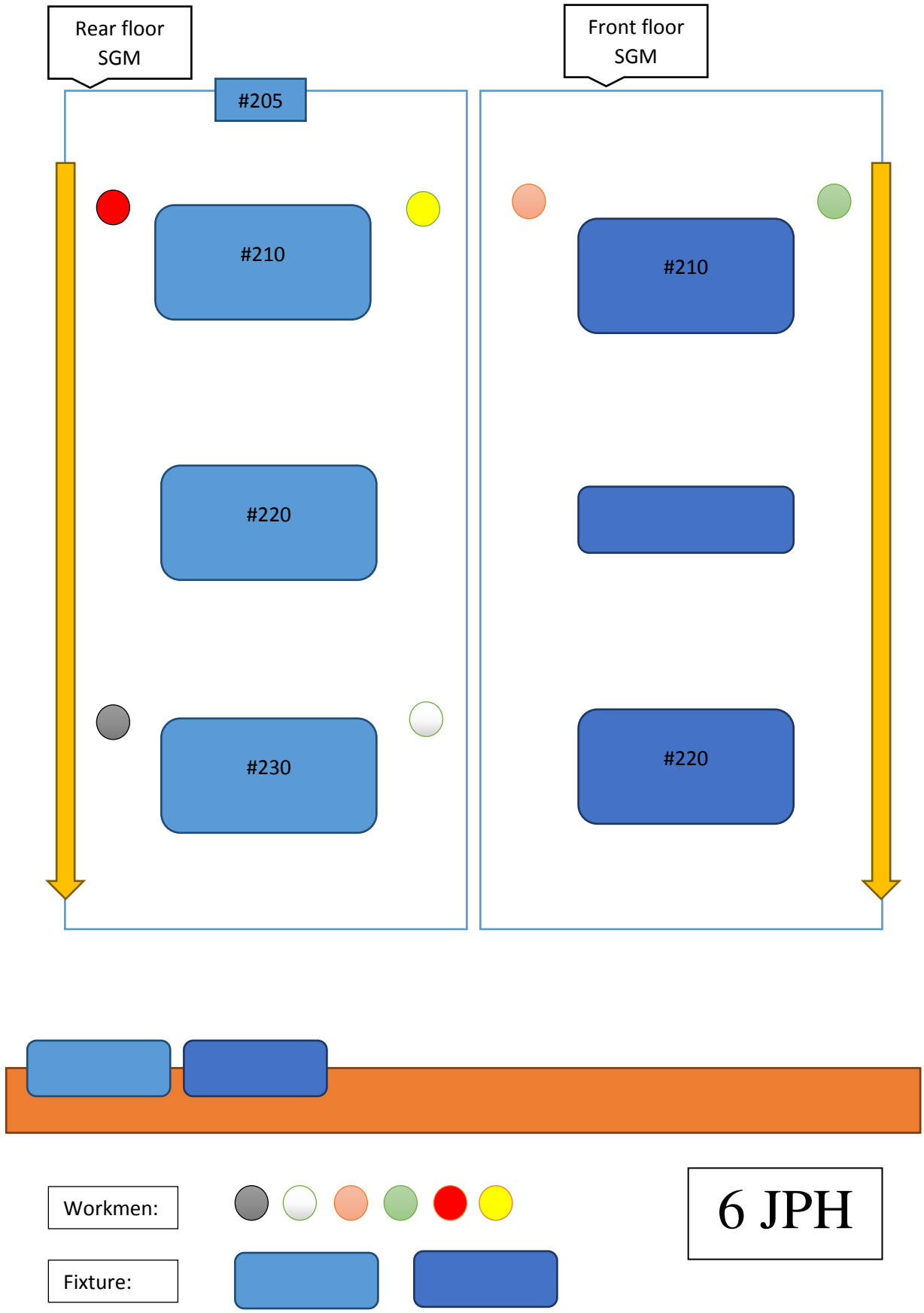


Figure 56 : Front and Rear Floor SGM Flow diagram - 6 JPH

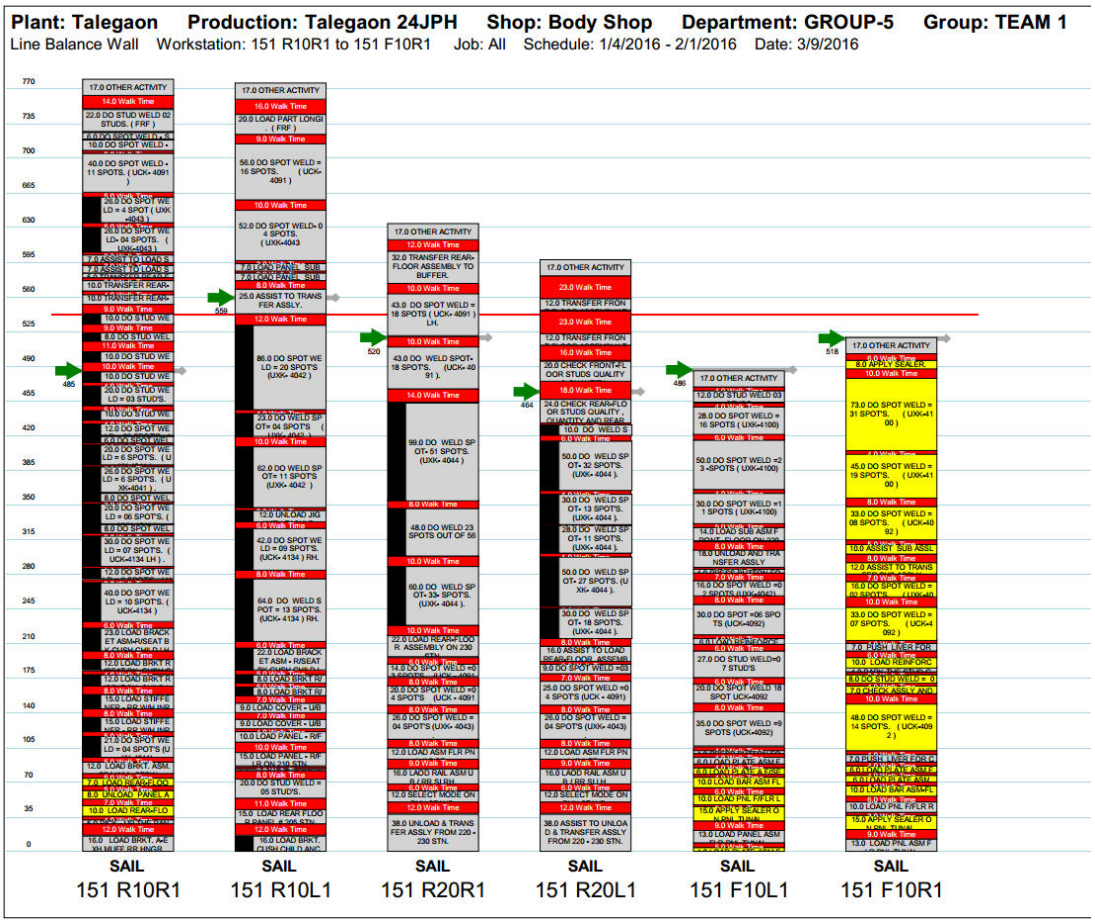


Figure 57 : Wall Chart - Front and Rear Floor SGM (Before)

Before the line balancing the manpower required for 6 JPH were 6. For every workmen the above wall chart illustrates the work content and time required. The station was balanced as below :

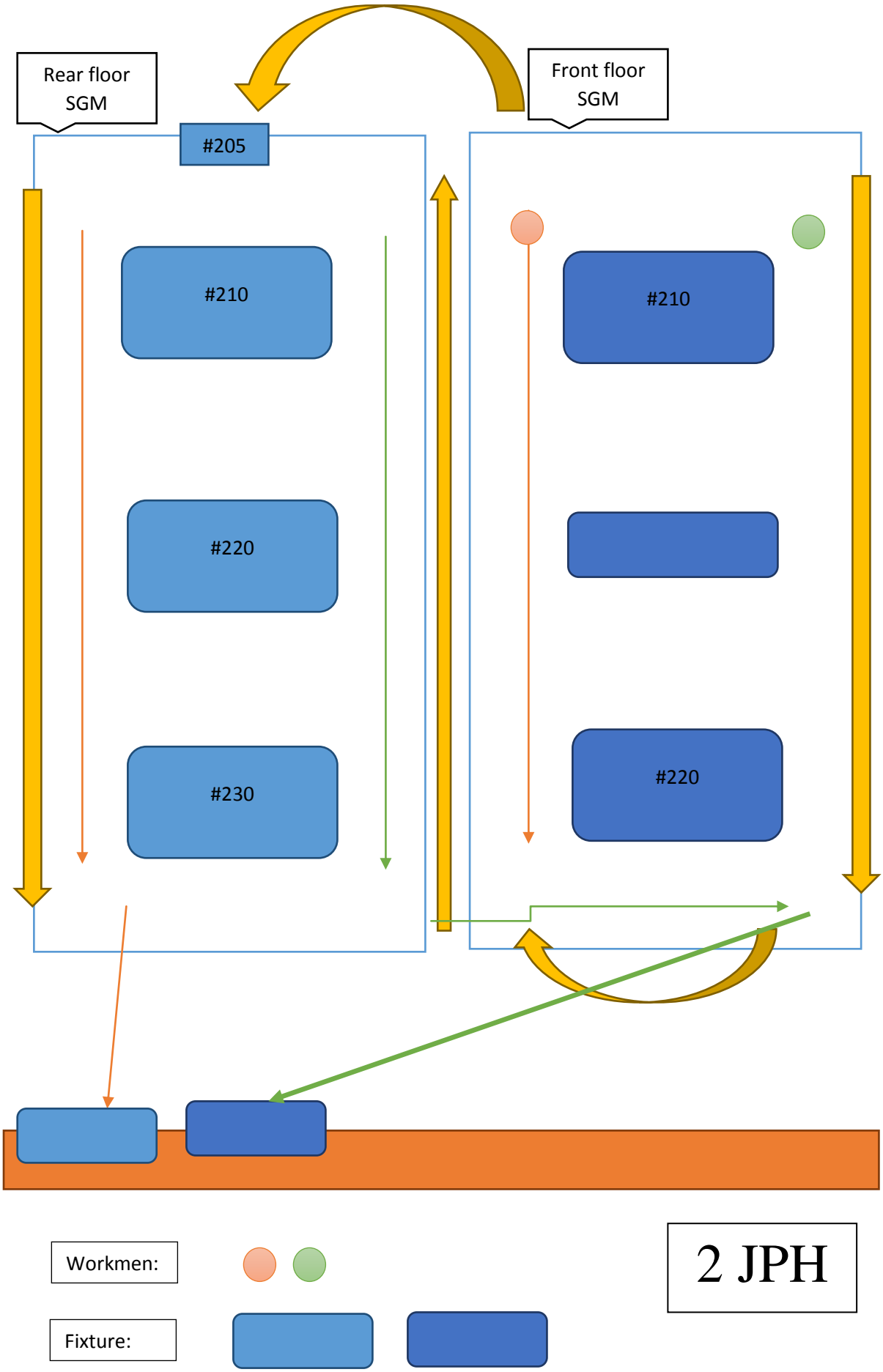


Figure 58 : Front and Rear Floor Flow diagram - 2 JPH

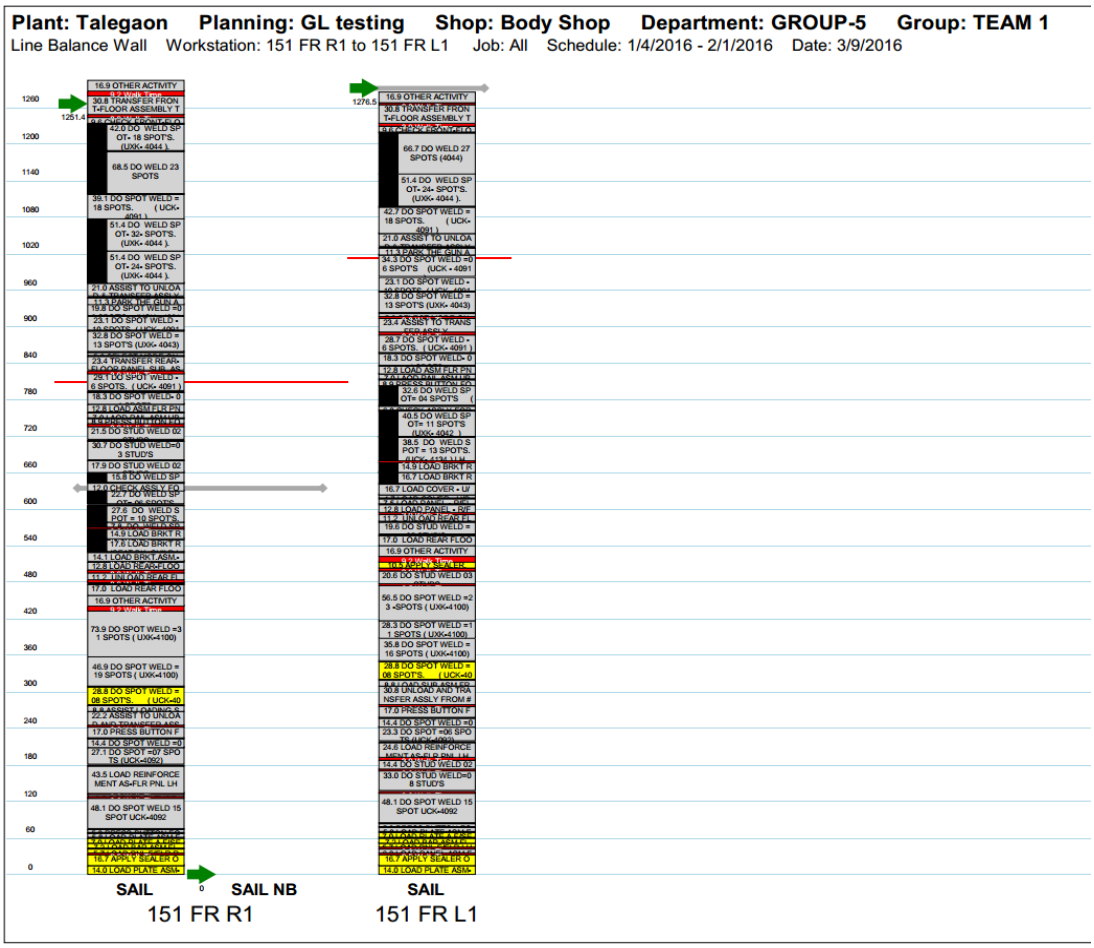


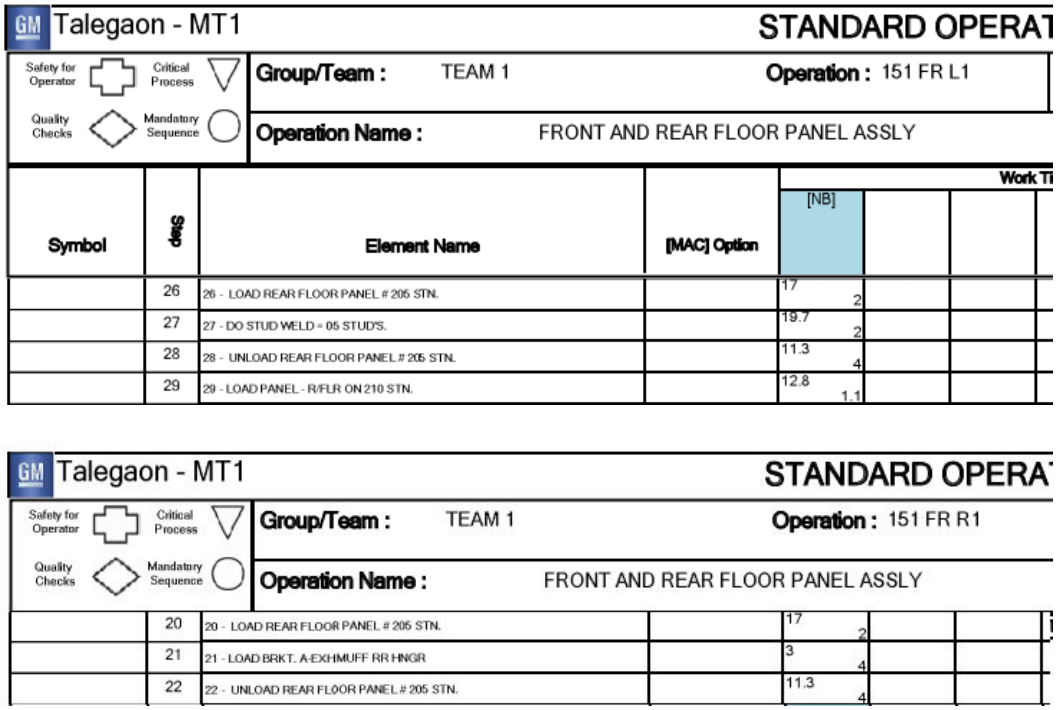
Figure 59 : Wall Chart - Front and Rear Floor SGM (After)

Prior the Front floor and the Rear floor use to work simultaneously. Using the STDs timing I proposed for 2 workmen and the sequence of operation. After balancing only two workmen will operate starting from front floor and then completing the rear floor. Thus new wall chart is formed as illustrated above.

The line balancing was done considering every activity at every station and thus many issues were solved among which the major balancing done are discussed below.

1. After completing the Rear floor it has to be transferred from the station #230 of the Rear floor to the #210 station of the Underbody. This job only required one person for transferring. Due to this the other person gets into high ideal time. The similar case is when one person transfers the Front floor. Thus I proposed that the workmen will complete both the jobs and when one person is transferring Rear floor the other can transfer the Front floor and thus the Ideal time was considerably reduced.

2. During the Spot welding at the #205 station 5 studs are to be welded. As per the prior work content the workmen has to pick up one stud every time from the fixture #210 and walk back to #205 for stud welding, which then proposed by me that instead of doing it 5 times the studs can be picked all at once and then the studs can be welded. Which reduced the walk time which is an non value added work.
3. Also during the operation at fixture #205 the process only requires a person to do Stud welding where as there was a pre-activity to be performed before placing the Assembly from the #205 fixture to #210 fixture i.e. of placing a Muff at the #210 fixture. Prior the LH person use to first perform the stud welding and also secondly use to place the Muff whereas the RH person was only assisting and had high ideal time. This was balanced as : Now One person performs the Stud welding and the other performs the Placing activity simultaneously.



GM Talegaon - MT1 STANDARD OPERAT

Safety for Operator | Critical Process | Quality Checks | Mandatory Sequence

Group/Team : TEAM 1 Operation : 151 FR L1

Operation Name : FRONT AND REAR FLOOR PANEL ASSLY

Symbol	Seq	Element Name	[MAC] Option	Work Ti [NB]			
	26	26 - LOAD REAR FLOOR PANEL # 205 STN.		17 2			
	27	27 - DO STUD WELD = 05 STUD'S.		19.7 2			
	28	28 - UNLOAD REAR FLOOR PANEL # 205 STN.		11.3 4			
	29	29 - LOAD PANEL - R/FLR ON 210 STN.		12.8 1.1			

GM Talegaon - MT1 STANDARD OPERA

Safety for Operator | Critical Process | Quality Checks | Mandatory Sequence

Group/Team : TEAM 1 Operation : 151 FR R1

Operation Name : FRONT AND REAR FLOOR PANEL ASSLY

	20	20 - LOAD REAR FLOOR PANEL # 205 STN.		17 2			
	21	21 - LOAD BRKT. A-EXHMUFF RR HNGR		3 4			
	22	22 - UNLOAD REAR FLOOR PANEL # 205 STN.		11.3 4			

Figure 60 : SOS Before and After for Line balancing

Thus the line was successfully balanced and new SOS (Standard Operation Sheets) was created as per the work content and the manpower was optimized.

2. Engine Room SGM

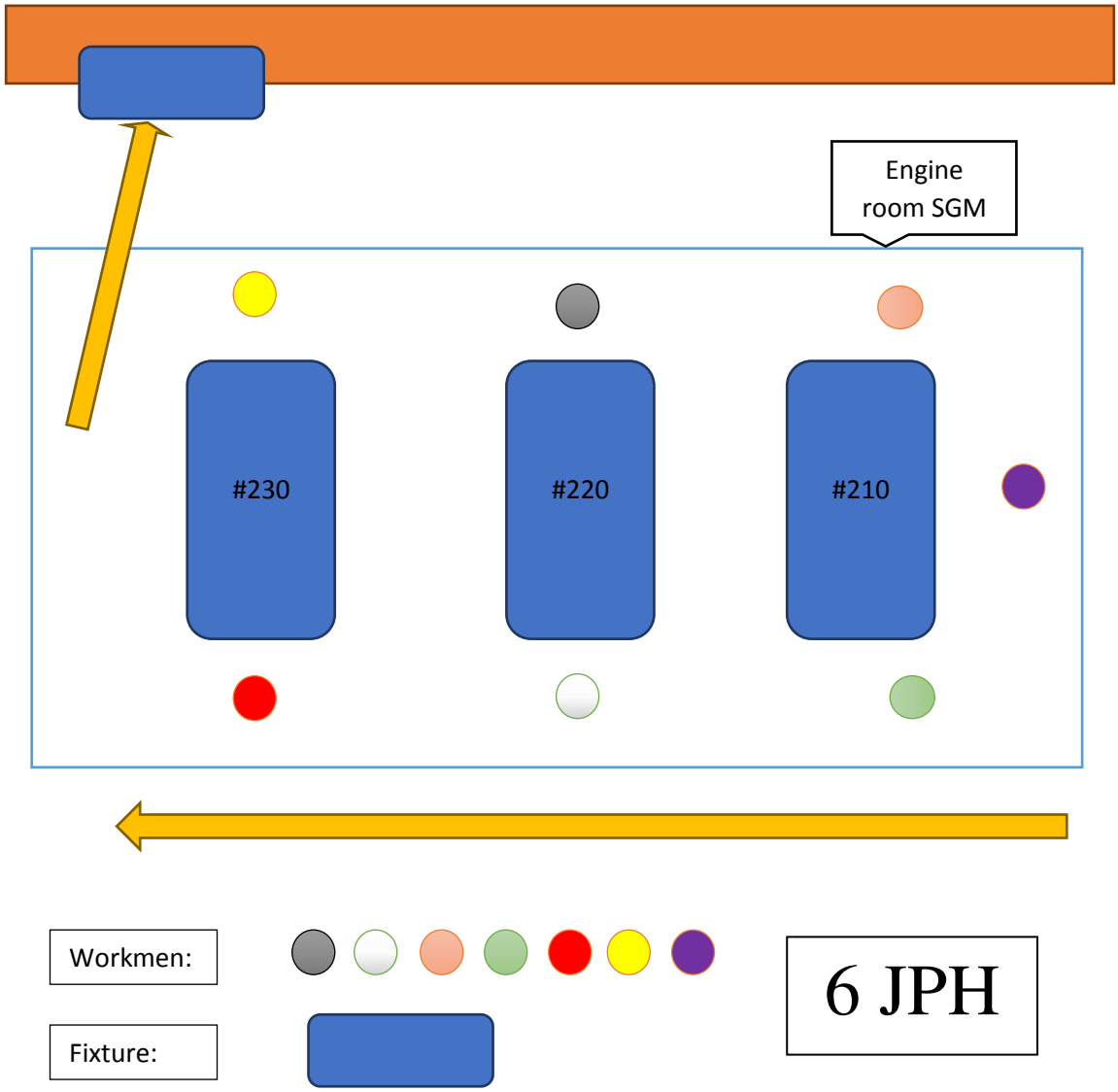


Figure 61 : Engine Room SGM Flow Diagram - 6JPH

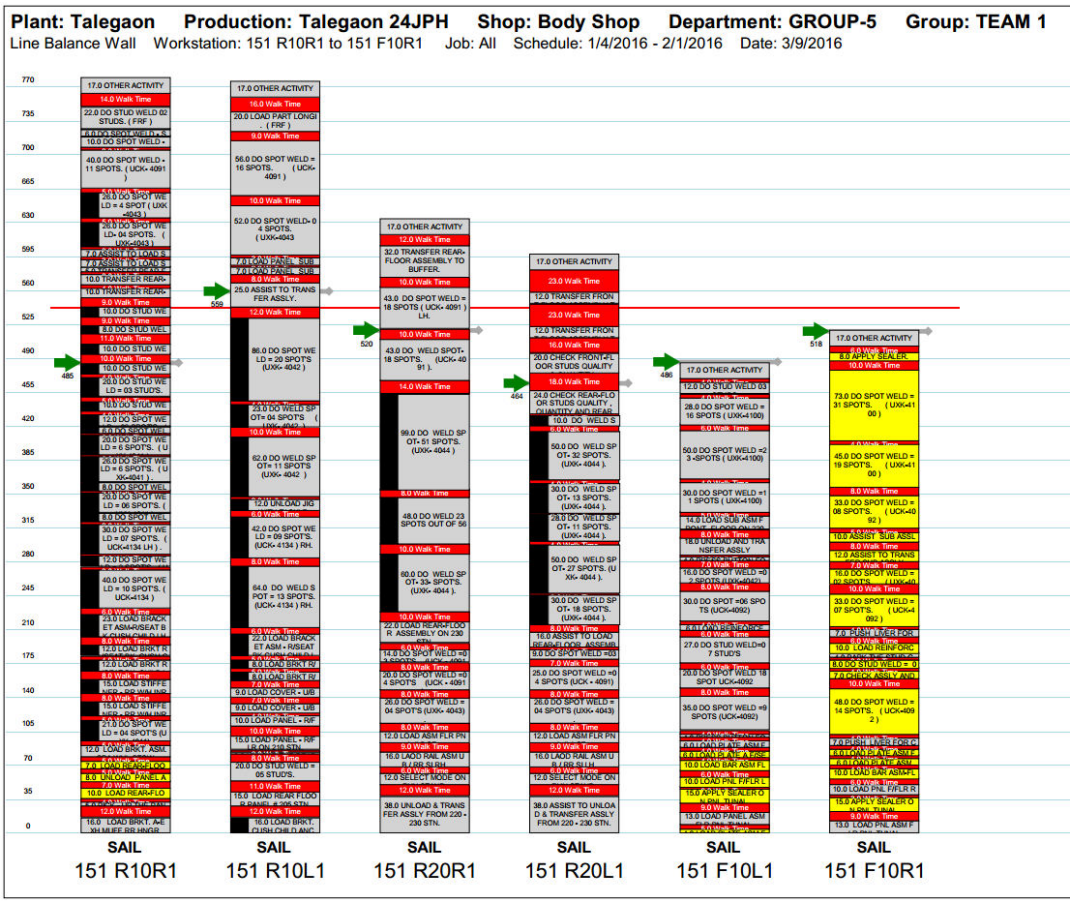


Figure 62 : Wall Chart - Engine Room SGM (Before)

Before the line balancing the manpower required for 6 JPH were 6. For every workmen the above wall chart illustrates the work content and time required. The station was balanced as below :

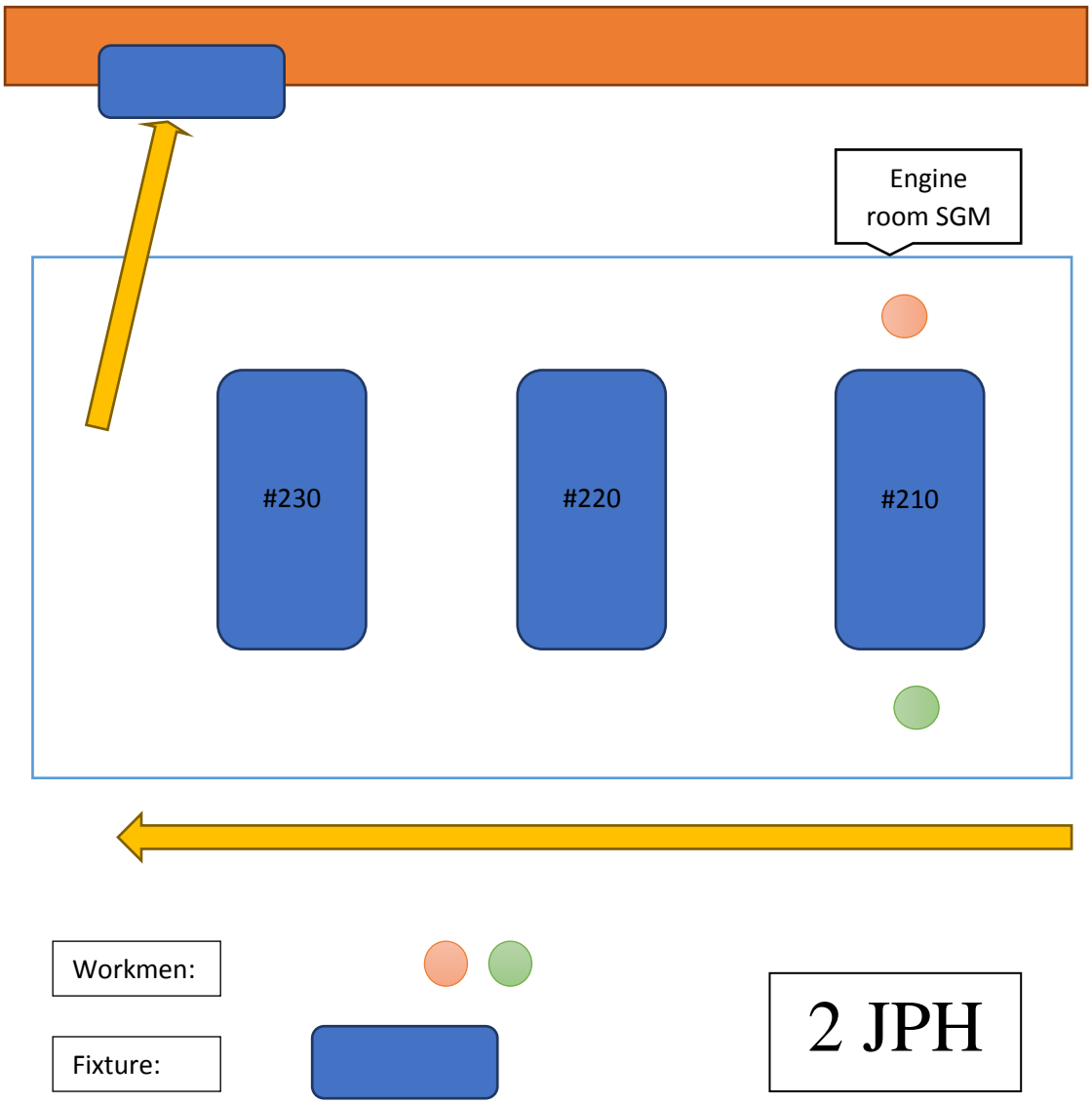


Figure 63 : Engine Room SGM Flow Diagram - 2 JPH

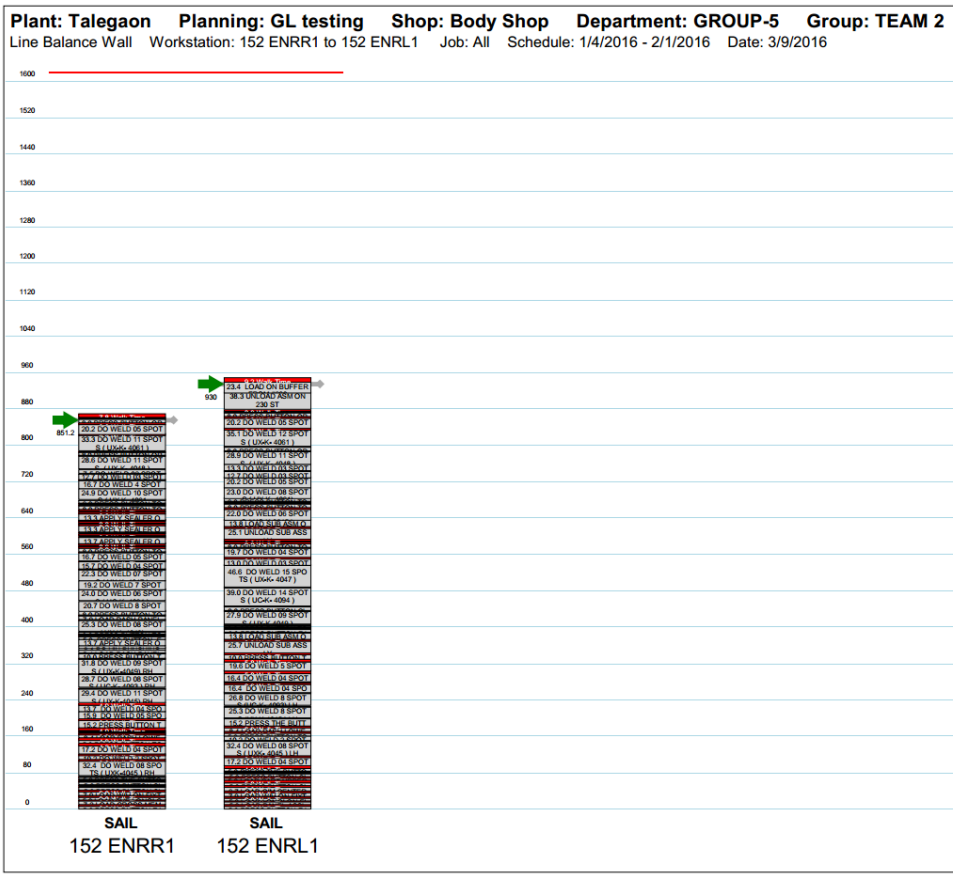


Figure 64 : Wall Chart - Engine Room SGM (After)

1. A very considerable manpower optimization took place with the help of line balancing. From 7 workmen to 2 workmen. The major line balancing was performed for the station #210 where in the work content of 3 workmen had to be divided among 2 workmen.

   Before :

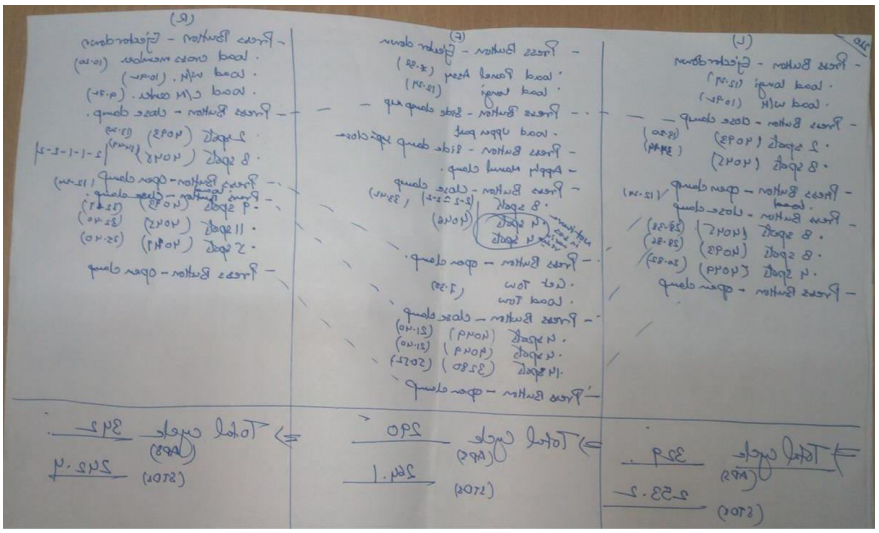


Figure 65 : Line balancing in Engine Room (Before)

After :

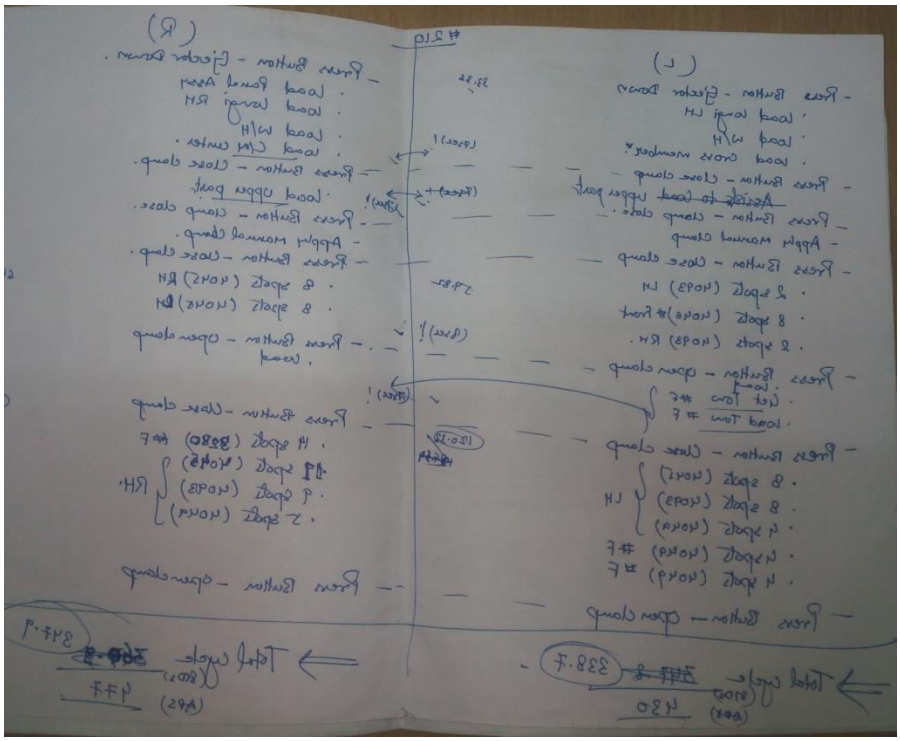


Figure 66 : Line balancing in Engine Room (After)

2. While transferring the assembly from #210 to #220 the RH person was ideal or use assist the LH person, but for transferring only RH person was sufficient. Hence during this period I proposed that the RH person can perform the Sealer and punching activities which was required late during the activities needed to be performed at #220 which would make the LH person ideal. Hence the cycle time was reduced.

3. Similar to the last point the balancing was performed for the #230 station also.

Thus the Engine room was balanced.

3. Underbody SGM

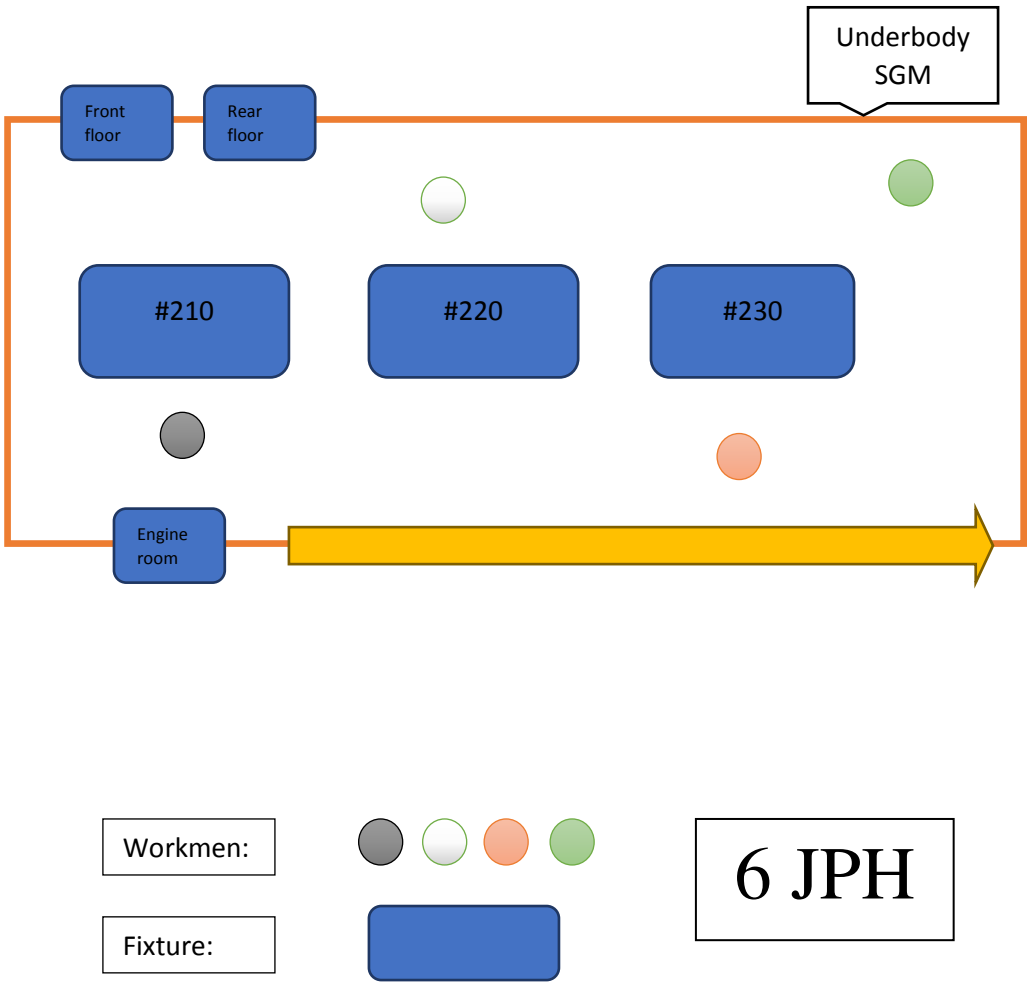


Figure 67 : Underbody SGM Flow Diagram - 6 JPH

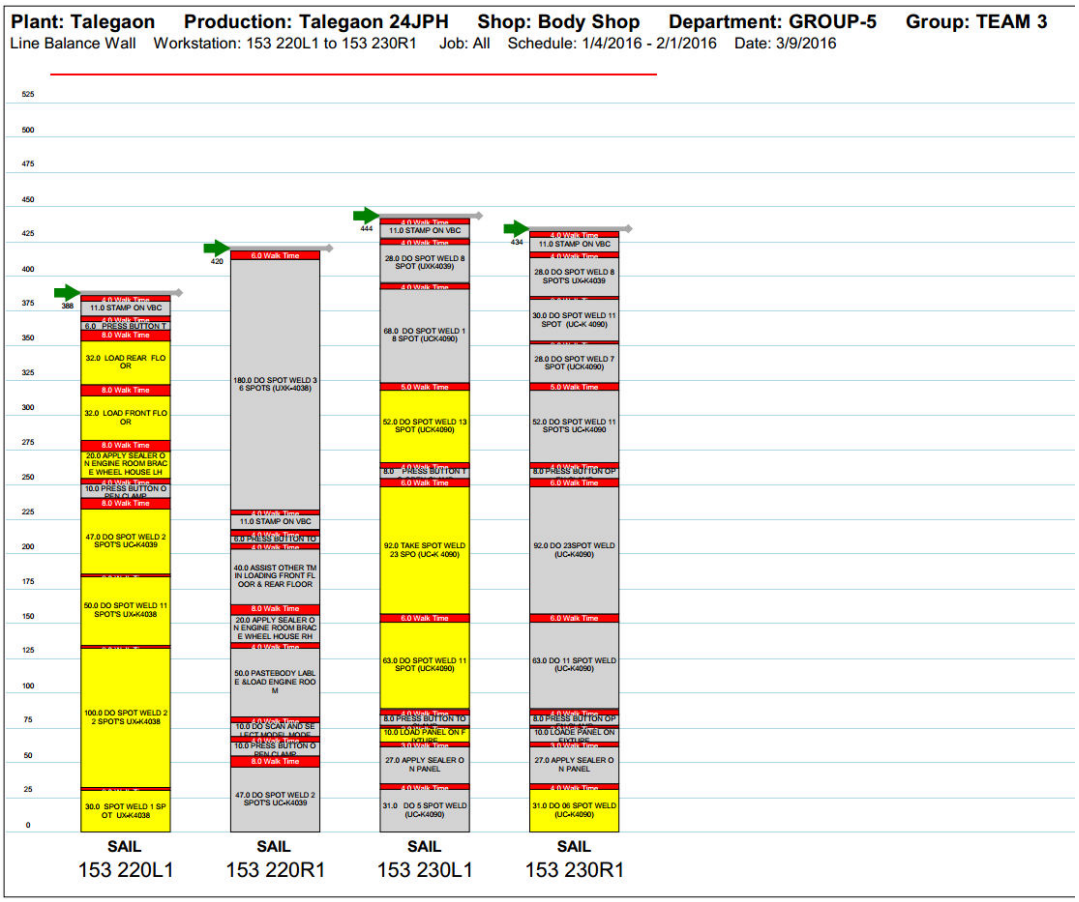


Figure 68 : Wall Chart - Underbody SGM (Before)

Before the line balancing the manpower required for 6 JPH were 6. For every workmen the above wall chart illustrates the work content and time required. The station was balanced as below :

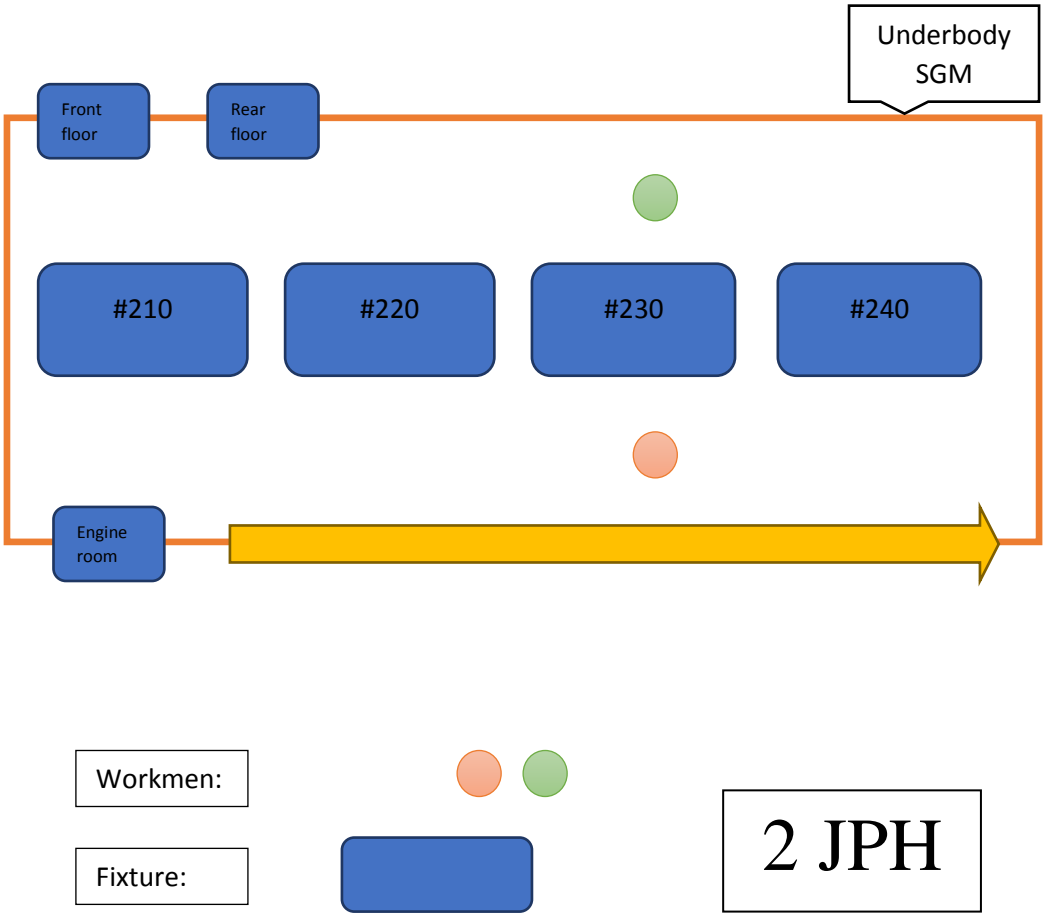


Figure 69 : Underbody SGM Flow Diagram - 2 JPH

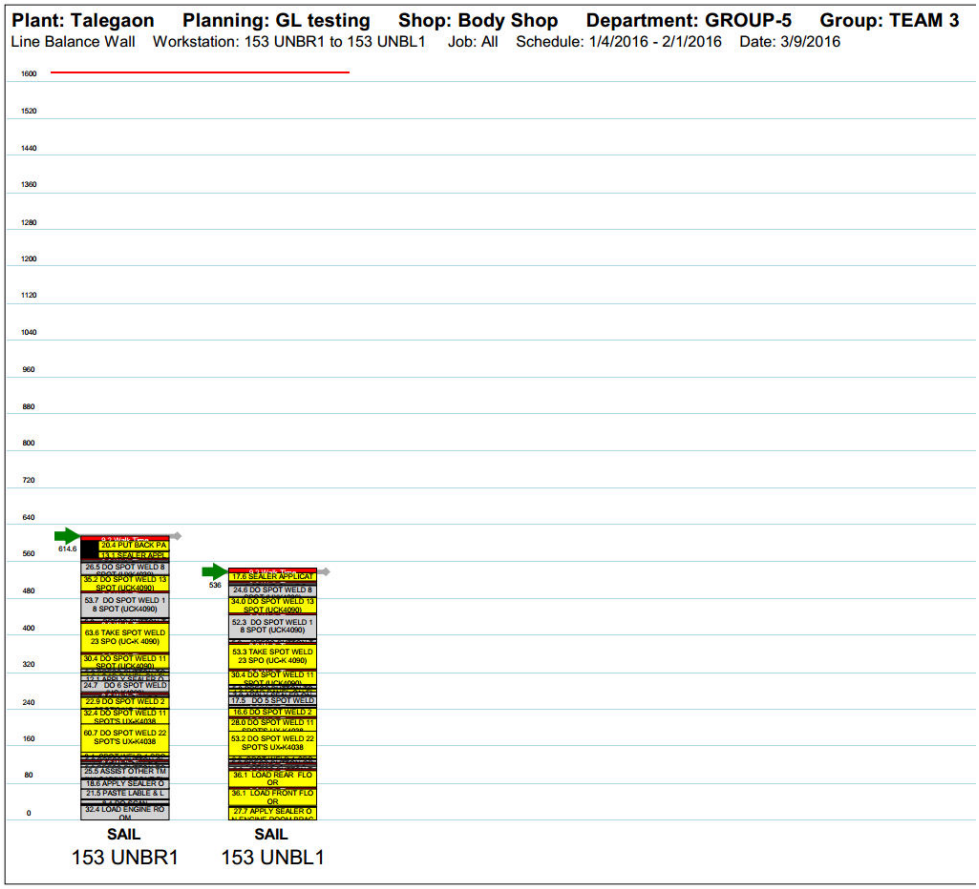


Figure 70 : Wall Chart - Underbody SGM (After)

Line balancing for Underbody was comparatively easier compared to others. Using the STDs timing I found out the time actually required was considerably less. Thus the manpower was optimized from 4 workmen to 2 workmen.

Along with it, due to less cycle time I proposed to add some of the Mainframe activities to Underbody work content.

Thus Underbody was balanced effectively.

6.7.2 After Second Quarter :

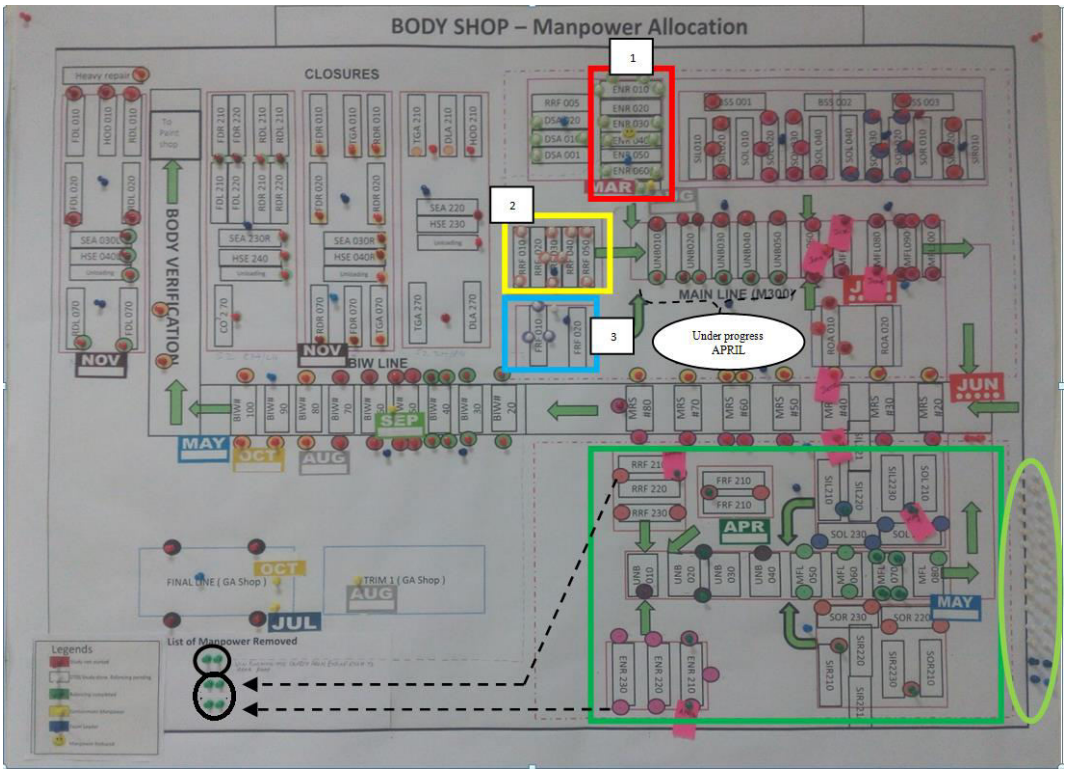


Figure 71 : Manpower Allocation Chart - After Second Quarter

As mentioned above the pictures illustrates the Cases of line balancing marked in colored boxes of which the studies have been completed and will be implemented very soon.

4. Engine Room M300
5. Rear Floor M300
6. Front Floor M300

With the help of STDs software we found out the timings required by the workmen to complete its job and to properly balance the work content for smooth functioning and no or very little Idle time. Also the layout for some stations have been proposed for better utilization in less time.

The planned over speeding for the stations are:

For Engine Room, Front Floor and Rear Floor the Over speeding allowed is 12 %.

Therefore, the Takt time (TT) will come out to be 163.4sec and therefore Actual takt time (ATT) will be 144 sec.

4. Engine Room M300

ENGINE ROOM M-300

APS				
JPH	TT	OVER SPEED		ATT
22	163.64	15	0.85	139.09

ENR	LHD	RHD	APS (18 JPH)	
10L1	150.00	127.00		
10R1	131.00	122.00		
10L2	120.00	120.00		
10R2	135.00	135.00		
30L1	123.00	123.00		
30L2	130.00	104.00		
30R1	144.00	129.00	14.16	10.12
40L1	168.00	150.00		
40R1	57.00	57.00		
40R2	170.00	151.00		
60L1	167.00	152.00		
60R1	153.00	0.00		
60R2	155.00	0.00		
60R3	167.00	37.00		
	1970.00	1407.00	3377.00	

MODE				
JPH	TT	OVER SPEED		ATT
22	163.64	12	0.88	144.00

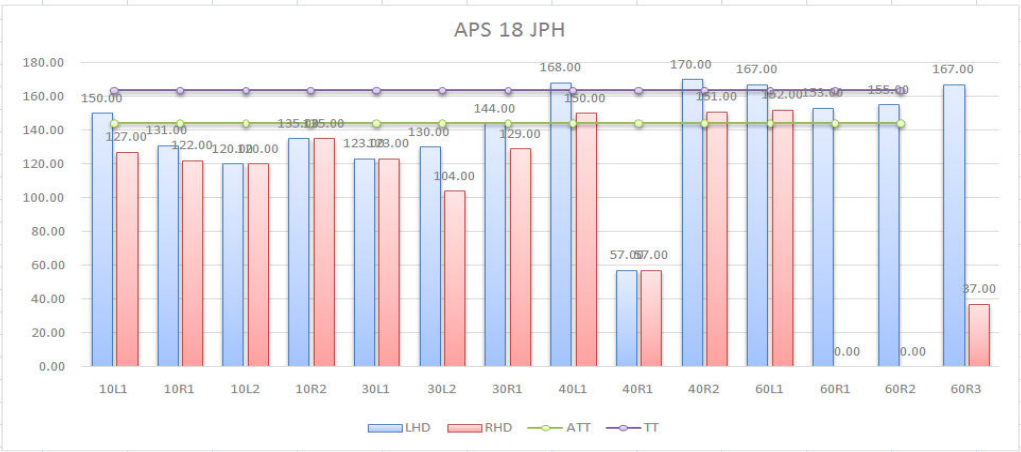
ENR	LHD	RHD	AFTER CHECK BALANCING	
10L1	136.00	129.10		
10R1	137.50	130.60		
10L2	128.50	128.50		
10R2	126.50	77.60		
30L1	122.10	115.20		
30L2	0.00	0.00		
30R1	113.40	107.30	10.50	9.40
40L1	139.10	128.80		
40R2	86.20	79.30		
40R1	135.90	125.60		
60L1	137.00	125.50		
60R1	0.00	0.00		
60R2	132.30	120.80		
60R3	117.50	85.20		
	1512.00	1353.50	2865.50	

IMPORTANT POINTS :

1. 10L2 will perform Other activities for 10R1 and 10L1, while they will be applying sealer ;

2. 60R3 WILL PERFORM Other activities for 60L1 only, while they will be loading the assly on to #60.

3. Station #10 & #40 needs a layout change,(#40 to shift the side panels from RH side to LH side, which will reduce the walk time) (#Dash panel can be shifted centrally and the longi on the sides)



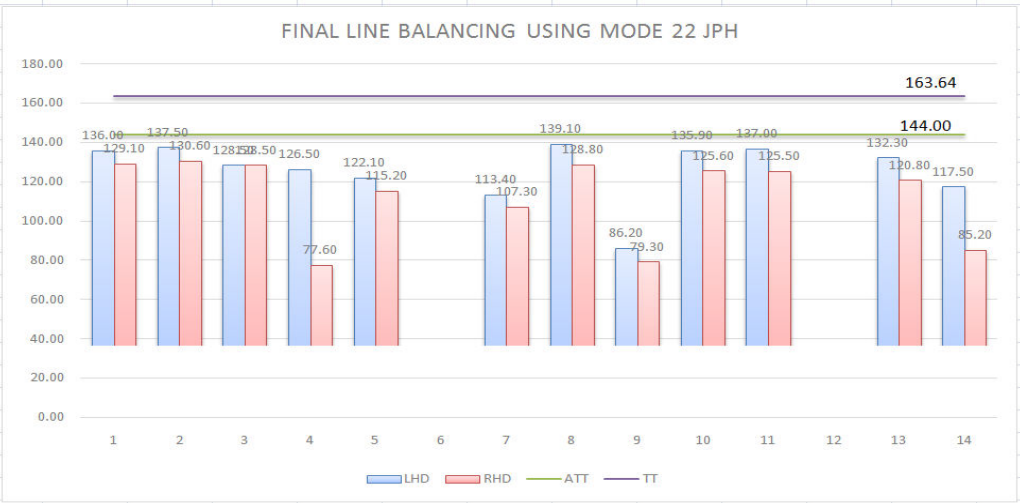


Table 8 : Engine Room M300 Line Balancing

The balancing performed at the Engine Room have been illustrated graphically. Engine room has 4 station where in 12 manpower were deployed. After completing the STDs for the complete station we found out that the total work content is = 1512.00 sec for LHD and 1353.50 sec for RHD. Thus by dividing the maximum work content we got by ATT we found out the minimum manpower required to perform the job. Which comes out to be = 11 for LHD and 10 for RHD number of workmen. But there are constraints, because of which we had to deploy 12 workmen.

The graph above shows the work content divided among the respective workmen. One of the graph is as per 18 JPH and the APS timing which was completed using the old process. Whereas the other graph is as per 22 JPH whose time was calculated using the MODE software analysis.

Among the balancing performed at Engine room the important issues resolved were :

1. The VIN punching is shifted from Engine room to Rear Floor.
2. The spots performed at the station #ENR30 have been distributed among the two operators. The 30L operator will start from the left side spots and then perform the remaining spots left in the Center. Whereas the Second operator 30R will start from Center spots and then perform the right side spots. Similar distribution was done at the #ENR40 station.
3. At station #ENR10 the Other activities performed by 10R1 and 10L1 after balancing will be performed by 10L2, during the time when 10R1 and 10L1 will be applying the sealer.
4. Similarly at #ENR60 the other activities for 60L1 only will be performed by 60R3, during the time when 60L1 will be loading the assembly on to the station #60.
5. A proposal for layout change was given for the stations #ENR10 and #ENR40. At #40 the side panel assembly will be shifted from RH side to LH side, which will reduce the walk time. At #10 the Dash panel trolley can be shifted centrally and the Longi trolleys on to the sides of it. This will reduce the Ergo rate faced by the operator, which in current situation two operators load the dash by hands.

There were several issues, which were then solved by balancing. For example the Sealer application time was corrected and cross check several times.

5. Rear Floor M300

REAR FLOOR M-300

APS

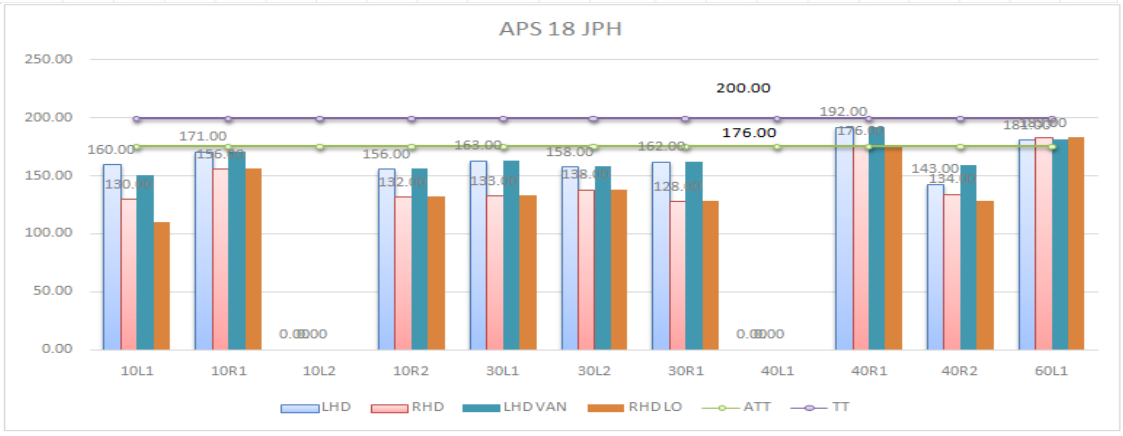
JPH	TT	OVER SPEED	ATT
18	200.00	12	0.88	176.00

Rear Floor	LHD	LHD VAN	RHD	RHD LO	LHD	LHD VAN	RHD	RHD LO	TOTAL SPOTS
R10L1	160.00	151.00	130.00	110.00					
R10R1	171.00		156.00						
R10L2	0.00		0.00						
R30L1	156.00		132.00						21
R30L2	163.00		133.00						22
R30R1	158.00		138.00		8.44	8.48	7.44	7.30	21
R30R2	162.00		128.00						22
R40L1	0.00		0.00						0
R40R1	192.00		176.00						40
R50L1	143.00	159.00	134.00	128.00					34
R50R1	181.00		183.00						29
	1486.00	1493.00	1310.00	1284.00					189

MODE

JPH	TT	OVER SPEED	ATT
22	163.64	12	0.88	144.00

Rear Floor	LHD	LHD VAN	RHD	RHD LO	LHD	LHD VAN	RHD	RHD LO	TOTAL SPOTS
R10L1	124.00	118.60	115.80	105.60					
R10R1	143.90		134.20						
R10L2	108.20		108.20						
R30L1	108.20		99.90						16
R30L2	136.00		127.70						20
R30R1	120.60		114.10		9.27	9.10	8.59	8.43	16
R30R2	141.60		133.30						20
R40L1	109.50		97.60						29
R40R1	104.70		93.10						28
R50L1	120.40	100.40	106.70	93.60					34
R50R1	118.40		106.50						29
	1335.50	1310.10	1237.10	1213.80					192



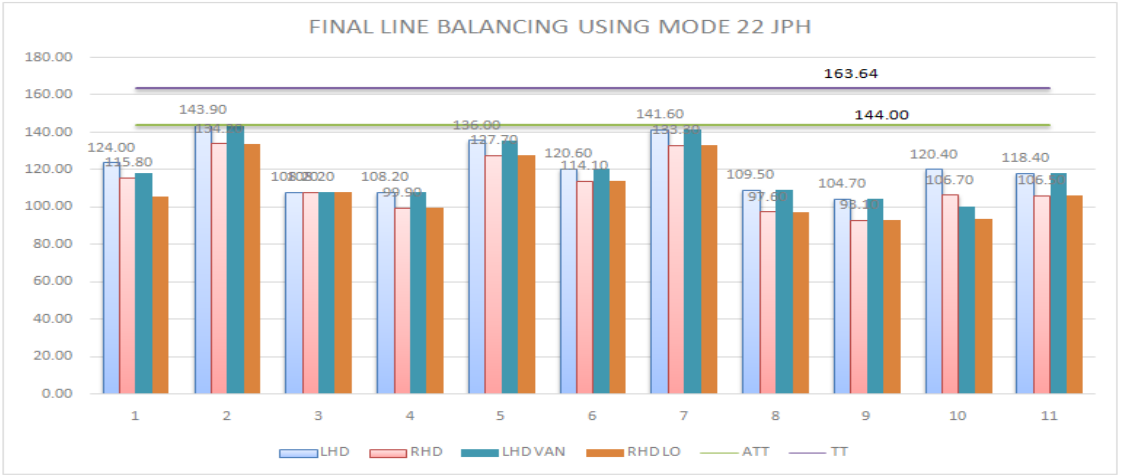


Table 9 : Rear Floor M300 Line Balancing

The balancing performed at the Rear Floor have been illustrated graphically. Engine room has 4 station where in 11 manpower were deployed. Rear Floor had different jobs elements for VAN and LO (Variants). After completing the STDs for the complete station we found out that the total work content is = 1335.50 sec for LHD, 1310.10 sec for LHD VAN, 1237.10 sec for RHD and 1213.80 sec for RHD LO. Thus by dividing the maximum work content we got i.e. 1335.50 sec by ATT we found out the minimum manpower required to perform the job. Which comes out to be = 10 for LHD number of workmen. But there are constraints, because of which we had to deploy 11 workmen.

The graph above shows the work content divided among the respective workmen. One of the graph is as per 18 JPH and the APS timing which was completed using the old process. Whereas the other graph is as per 22 JPH whose time was calculated using the MODE software analysis.

Among the balancing performed at Rear Floor the important points are discussed below:

1. An additional element 10L2 was added i.e. the VIN punching which was removed from Engine room and was balanced among the work content of the Rear Floor.
2. The Other activities of 10R1 and 10L1 after balancing will be performed by 10L2 during the time when 10R1 and 10L1 will be loading the sub assembly on to the fixture at#RRF10.
3. The spots distribution considering the whole Rear Floor were re distributed. By the Overall Spots at Rear Floor remained the same.

Thus the Rear Floor was smoothly balanced.

6. Front Floor M300

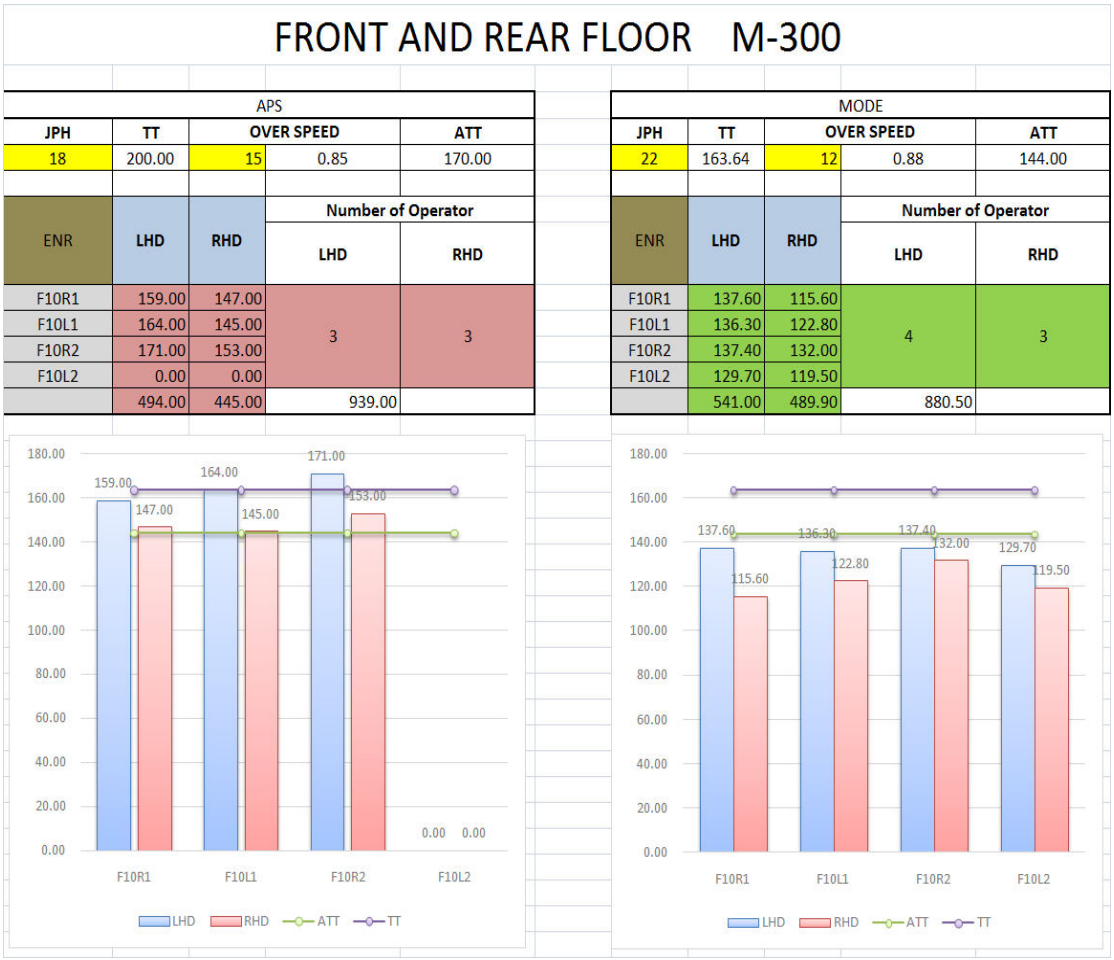


Table 10 : Front Floor M300 Line balancing

The balancing performed at the Front Floor was completely different from all other balancing. Front floor has only one station where in 4 manpower were deployed. Namely: L1, R1, L2, R2. At Front Floor the spots where balanced and also were re-sequenced. After completing the STDs for the complete station we found out that the total work content is = 541 sec for LHD and = 489.90 sec for RHD. Thus by dividing the work content by ATT we found out the minimum manpower required to perform the job. Which comes out to be = 4 for LHD and 3 for RHD number of workmen.

The graph above shows the work content divided among the respective workmen. One of the graph is as per 18 JPH and the APS timing which was completed using the old process. Whereas the other graph is as per 22 JPH whose time was calculated using the MODE software analysis.

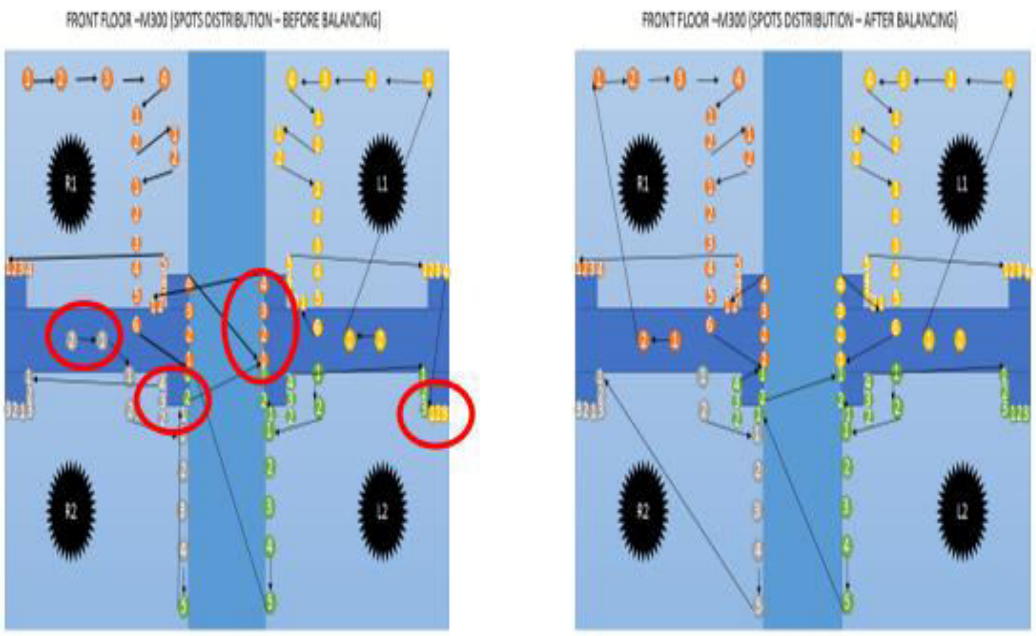
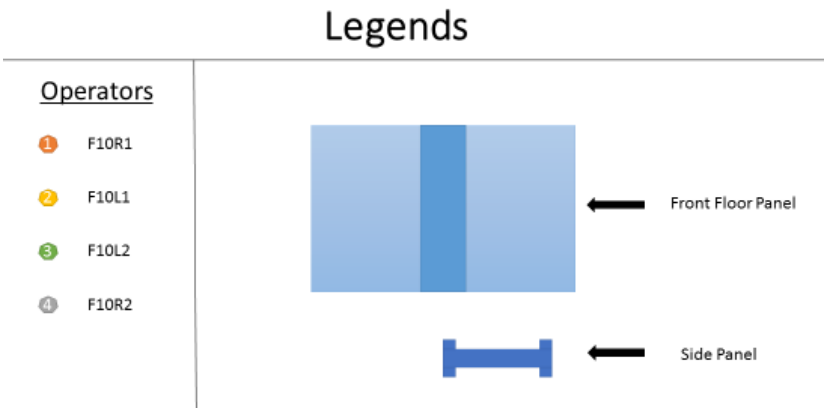


Figure 72 : Front Floor Spots Balancing



The picture above illustrates the spot balancing done at FFR10. The spots marked above by circles have been distributed to other operators. The arrows shows the sequence of the spotting. As shown in the Legends the spots performed by the operators are shown by different colors respectively.

The R2 Operator's spots were reduced so that the assembly transferring can be performed by the operator. Also the spots were symmetrically distributed on both the sides as for the operators R1 and L1. 6 additional spots from Underbody were balanced among the Front floor work content.

Whole balancing was presented to the Group Leader in the form of ppt. The overall difference in the spot sequence and distribution is shown in the picture above.

6.7.3 After Third Quarter :

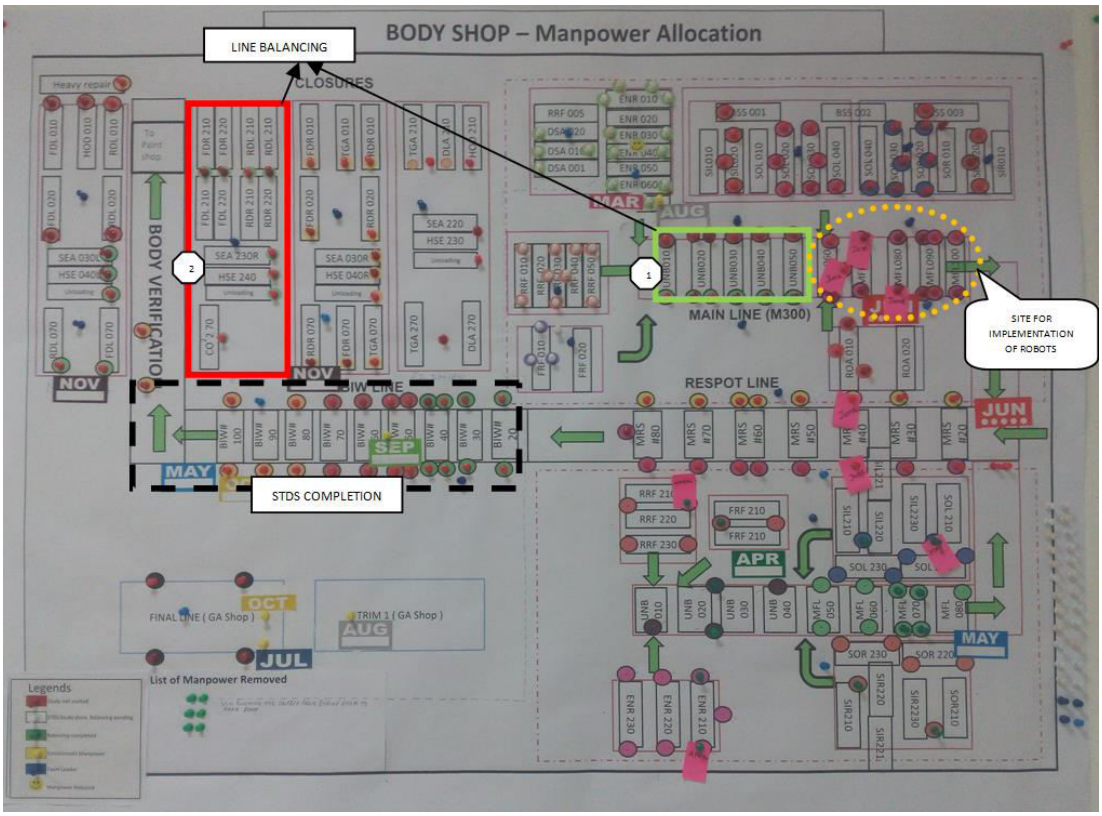


Figure 73 : Manpower Allocation Chart - After Third Quarter

As mentioned above the pictures illustrates the Cases of line balancing marked in colored boxes of which the studies have been completed and will be implemented very soon.

7. Underbody M300
8. Closure SGM

With the help of STDs software we found out the timings required by the workmen to complete its job and to properly balance the work content for smooth functioning and no or very little Idle time. Also the layout for some stations have been proposed for better utilization in less time.

By analysis of the losses as per the trend we decide the loss percentage which in case will decide the ATT for the stations.:

For Underbody the Losses allowed is 10.74 %. Therefore, the Takt time (TT) will come out to be 163.64sec and therefore Actual takt time (ATT) will be 146 sec.

7. Underbody M300

UNDERBODY M-300

JPH	TT	Losses		ATT
18	200.00	12	0.88	176.00

APS

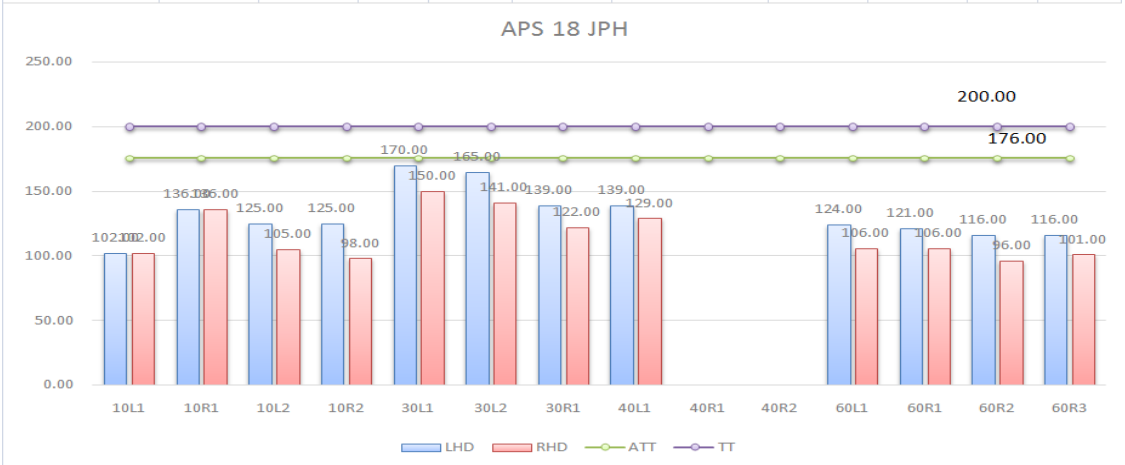
UNDERBODY	LHD	RHD	LHD	RHD
10L1	102.00	102.00	8.966	7.9091
10R1	136.00	136.00		
20L1	125.00	105.00		
20L2	125.00	98.00		
20R1	170.00	150.00		
20R2	165.00	141.00		
30L1	139.00	122.00		
30R1	139.00	129.00		
30L2				
30R2				
40L1	124.00	106.00		
40R1	121.00	106.00		
50L1	116.00	96.00		
50R1	116.00	101.00		
	1578.00	1392.00		

JPH	TT	Losses		ATT
22	163.64	10.74	0.893	146.06

UNDERBODY MODE

UNDERBODY	LHD	RHD	LHD	RHD
10L1	112.20	112.20	12.5	11.319
10R1	103.10	103.10		
20L1	129.60	113.70		
20L2	127.10	111.10		
20R1	129.00	113.10		
20R2	127.10	113.80		
30L1	143.00	132.60		
30R1	142.60	132.30		
30L2	121.00	106.40		
30R2	121.70	107.10		
40L1	147.50	123.90		
40R1	143.30	126.80		
50L1	139.20	128.60		
50R1	139.20	128.60		
	1825.60	1653.30		

3 SPOTS REMOVED FROM 50L1 AND SHIFTED TO FRONT FLOOR
3 SPOTS REMOVED FROM 50R1 AND SHIFTED TO FRONT FLOOR



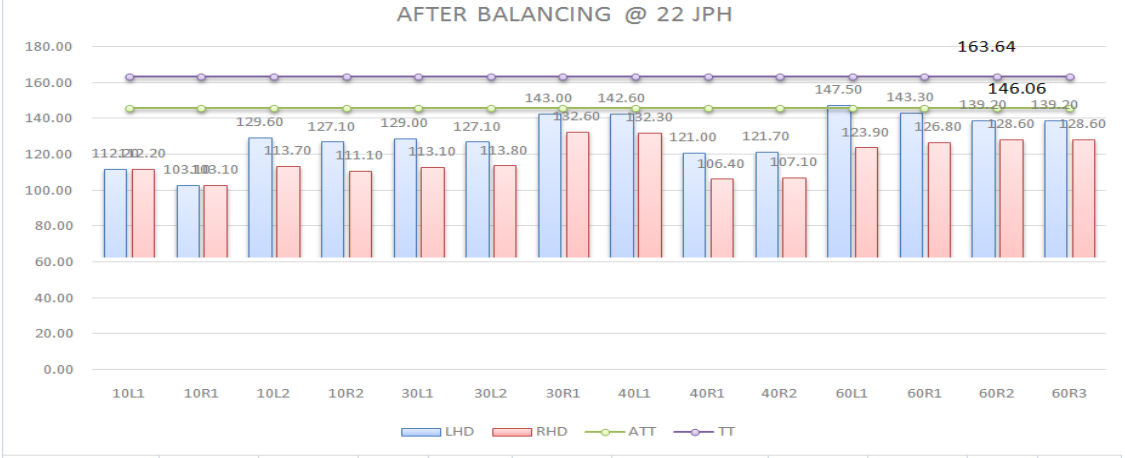


Table 11 : Underbody M300 Line Balancing

The balancing performed at the Underbody have been illustrated graphically. Underbody has 5 station where in 14 manpower were deployed. After completing the STDs for the complete station we found out that the total work content is = 1825.00 sec for LHD and 1653.30 sec for RHD. Thus by dividing the maximum work content we got by ATT we found out the minimum manpower required to perform the job. Which comes out to be = 12.5 for LHD and 11.4 for RHD number of workmen. But there are constraints, because of which we had to deploy 14 workmen.

The graph above shows the work content divided among the respective workmen. One of the graph is as per 18 JPH and the APS timing which was completed using the old process. Whereas the other graph is as per 22 JPH whose time was calculated using the MODE software analysis.

Among the balancing performed at Underbody for 40th and 50th stations the important points are discussed below:

1. Spots balancing was performed, wherein the 3 spots of Underbody were removed and shifted to Front floor from 50L1.
2. Similarly, Spots balancing was performed, wherein the 3 spots of Underbody were removed and shifted to Front floor from 50R1.

Thus the Stations were balanced and operational for smooth functioning.

8. Closure SGM

The Closure line was unable to meet up the JPH with the manpower deployed before. Due to which a Bottleneck was created at the line. To solve the problem we had deployed extra manpower and thus the work content was below the ATT. Initially there were 8 manpower at

FDL10	FDL20
RDL10	RDL20
FDR10	FDR20
RDR10	RDR20.

Table 12 : Closure SGM Manpower (Before)

After line balancing the manpower at the above stated stations were doubled and the work content was equally divided and balanced as per the time. Taking into consideration that none of the workmen has idle time. Thus now the manpower at the station becomes 16.

FDL10L1 & FDL10R1	FDL20L1 & FDL20R1
RDL10L1 & RDL10R1	RDL20L1 & RDL20R1
FDR10L1 & FDR10R1	FDR20L1 & FDR20R1
RDR10L1 & RDR10R1	RDR20L1 & RDR20R1

Table 13 : Closure SGM Manpower (After)

Thus the bottleneck was cleared and thus the problem was solved.

Chapter – 7

STUDY OF IMPLEMENTATION OF NEW MODELS ON LINE

7.1 Introduction

The New Model going to launch is MCM which was recently showcased at Auto Expo Delhi, 2016. The car is the Notch back version of M300 car.

There are couple of changes which are going to take place in the Body shop. These changes includes :

1. Implementation of the Robots at MFL line - for Both M00 & MCM
2. New Fixture going to be added at Front Floor for MCM
3. New Fixture going to be added at Engine Room i.e. at ENR20 for both M300 and MCM

Based on the above changes mentioned above the spots had to be balanced at every station. Thus a complete study was performed and analyzed the comparison of current situation and after changes situations.

7.2 Spots Distribution

Front Floor : Only comparing the before and after situation for LHD variant. (The spots were balanced for the after situation)

Spots Re-balancing - Front Floor HB/NB			
Before		After	
	LHD		LHD
F10R1	29	F10R1	24
F10L1	29	F10L1	21
F10R2	13	F10C1	21
F10L2	25	F20R1	26
		F20L1	26
		F20C1	28
	96		146

Table 14 : Front Floor HB/NB Spots Re-balancing

The comparison shows that 50 spots will be added at the Front floor after implementation of the New fixture or station FRF20. As per the balancing after the implementation there will be 2 stations with 3 workmen at each station. Thus there is also increment of manpower from 4 to 6. This increment in spots and manpower has to be reflected at some other station so that overall spots should remain equal.

Underbody : Comparing for both LHD and RHD variants we got the detailed report of the balanced spots as shown below.

Spots Re-balancing - Underbody								
Before			After					
	M300 - HB			M300 - HB			M300 - NB (MCM)	
	LHD	RHD		LHD	RHD		LHD	RHD
10L1	0	0	10L1	0	0	10L1	0	0
10R1	0	0	10R1	0	0	10R1	0	0
20L1	26	23	20L1	28	28	20L1	28	28
20L2	27	24	20R1	28	28	20R1	28	28
20R1	26	23	30L1	26	24	30L1	26	24
20R2	27	26	30L2	21	20	30L2	21	20
30L1	25	25	30R1	26	24	30R1	26	24
30L2	27	25	30R2	20	20	30R2	20	20
30R1	25	25	40L1	34	30	40L1	34	30
30R2	27	25	40R1	32	30	40R1	32	30
40L1	36	32	50L1	21	21	50L1	21	21
40R1	34	32	50R1	21	21	50R1	21	21
50L1	26	26						
50R1	26	26						
	332	312		257	246		257	246

Table 15 : Underbody Spots Re-balancing

The comparison shows that for both HB i.e. M300 and NB i.e. MCM the spots are distributed similarly and for LHD variant there is overall decrement in the spots by 75. There is also decrement in manpower by 2. Thus if we take Front floor and Underbody together there is no change in manpower whereas around 25 spots are reduced. These 25 spots are increased in the Side LH & RH areas.

The After situation has been discussed below in detail with the spots distribution along with the gun number they will be performed by :

HB					
LHD	SPOTS		RHD	SPOTS	
	LH	RH		LH	RH
BA010 HB STN			BA010 HB STN		
BA020 HB STN			BA020 HB STN		
Weld BA020 HB G01-02 (UX-K3033)	2	2	Weld BA020 HB G01-02 (UX-K3033)	2	2
Weld BA020 HB G03-04 (UX-K3249)	12	12	Weld BA020 HB G02-04 (UX-K3249)	12	12
Weld BA020 HB G05-06 (UX-K3248)	14	14	Weld BA020 HB G05-06 (UX-K3248)	14	14
BA030 HB STN			BA030 HB STN		
Weld BA030 HB G01-02 (UC-K3283)	9	9	Weld BA030 HBG01-02 (UC-K3283)	9	9
Weld BA030 HB G03-04 (UX-K3247)	17	17	Weld BA030 HB G03-04 (UX-K3247)	15	15
Weld BA030 HB G05-06 (UX-K3250)	10	10	Weld BA030 HB G05-06 (UX-K3250)	10	10
Weld BA030 HB G07-08 (UC-K3246)	11	10	Weld BA030 HB G07-08 (UC-K3246)	10	10
BA040HB STN			BA040HB STN		
Weld BA040 HB G01-02 (UC-K3022)	22	22	Weld BA040 HB G01-02 (UC-K3022)	22	22
Weld BA040 HB G03-04 (UX-K3518)	12	10	Weld BA040 HB G03-04 (UX-K3518)	8	8
BA050HB STN			BA050HB STN		
Weld BA050 HB G01-02 (UX-K3250)	17	17	Weld BA050 HB G01-02 (UX-K3250)	17	17
Weld BA050 HB G03-04 (UC-K3250)	4	4	Weld BA050 HB G03-04 (UC-K3250)	4	4
	130	127		123	123

Table 16 : Underbody Spots Re-balancing HB

NB					
LHD	SPOTS		RHD	SPOTS	
	LH	RH		LH	RH
BA010 STN			BA010 STN		
BA020 STN			BA020 STN		
Weld BA020 G01-02 (UC-K3033)	2	2	Weld BA020 G01_02 (UC-K3033)	2	2
Weld BA020 G03-04 (UX-K3249)	12	12	Weld BA020 G03_04 (UX-K3249)	12	12
Weld BA020 G05-06 (UX-K3248)	14	14	Weld BA020 G05-06 (UX-K3248)	14	14
BA030 STN			BA030 STN		
Weld BA030 G01-02 (UC-K3283)	9	9	Weld BA030 G01_02 (UC-K3283)	9	9
Weld BA030 G03-04 (UX-K3247)	17	17	Weld BA030 G03_04 (UX-K3247)	15	15
Weld BA030 G05-06 (UX-K3250)	10	10	Weld BA030 G05_06 (UX-K3250)	10	10
Weld BA030 G07-08 (UC-K3246)	11	10	Weld BA030 G07_08 (UC-K3246)	10	10
BA040HB STN			BA040 STN		
Weld BA040 G01-02 (UC-K3022)	22	22	Weld BA040 G01_02 (UC-K3022)	22	22
Weld BA040 G03-04 (UX-K3518)	12	10	Weld BA040 G03_04 (UX-K3518)	8	8
BA050 STN			BA050 STN		
Weld BA050 G01-02 (UX-K3250)	17	17	Weld BA050 G01_02 (UX-K3250)	17	17
Weld BA050 G03-04 (UC-K3250)	4	4	Weld BA050 G03_04 (UC-K3250)	4	4
	130	127		123	123

Table 17 : Underbody Spots Re-balancing NB

Rear Floor : Similarly the spots distribution for the Rear floor has been discussed below.

Spots Re-balancing - Rear Floor				
Before				
	M300 - HB			
	LHD	RHD	LHD VAN	RHD LO
R10L1	20	20	20	15
R10R1	24	24		
R10L2	0	0		
R30L1	16	16		
R30L2	20	20		
R30R1	16	16		
R30R2	20	20		
R40L1	29	29		
R40R1	28	28		
R50L1	40	42		
R50R1	29	29		
	242	244	20	15
After				
	Station	Operator	Guns	Total Spots
HB	10	3	3	42
	30	4	6	72
	40	2	6	58
	50	2	4	51
NB	20	3	6	70
	30	4	10	88
	40	2	8	82
	50	2	5	62

Table 18 : Rear Floor Spots Re-balancing HB/NB

7.3 Implementation And Planning

Due to an Audit going to take place in the month of August we have come to the conclusion that we will go as per the current scenario for all the stations stated above. And as per the requirement and launch timing the MCM balancing will be implemented in the next year.

During Implementation many changes took place which resulted into issues which needed to be solved. Some of them are discussed below :

Reason :

As the spots are redistributed an issue had occurred at the Main Respot Line (Common Line) .

Problem:

Some of the spots from MRS line has been shifted to MFL line (M300 Area) wherein 13 Robots have been added. So the Spots which had been taking place at MRS for M300 car now will be completed beforehand at MFL line (M300 Area).

But the situation is not same for SGM car. There have been no addition of Robots in the MFL line (SGM Area), because of which the spots for SGM have to be done at MRS line itself.

The Situation above can be illustrated as below:

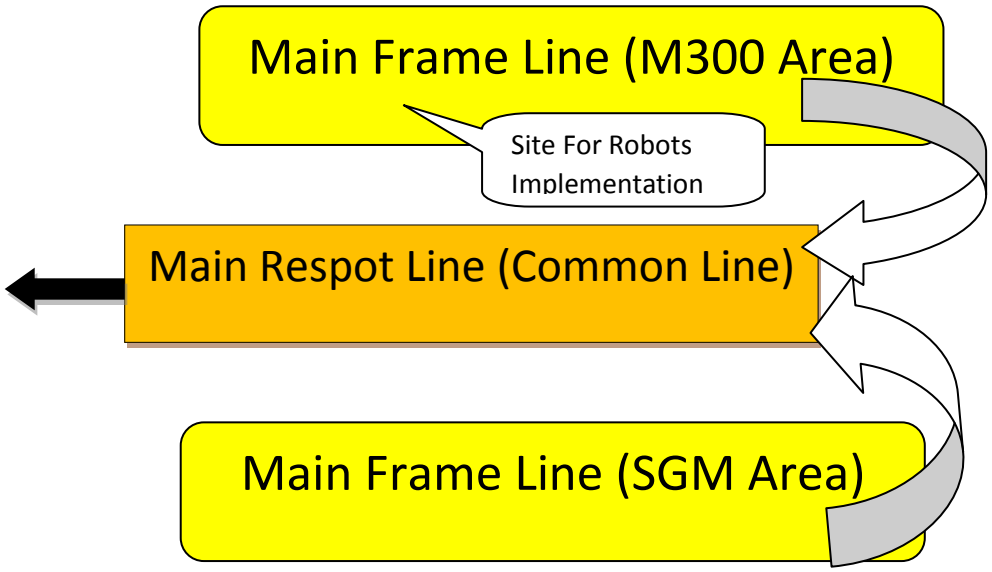


Figure 74 : Issue caused at the MRS

Solutions:

Two Proposal's were given for this problem

1. Addition of a Weld Gun at MFL (SGM Area) which can take the same amount of spots similar to the spots shifted to MFL (M300 Area) can reduce the load at MRS line and thus can be one of the solution. But this proposal is not Cost effective as it takes cost of Weld gun at the particular site, also at MFL (SGM Area) the gun are very much congested, so the addition of a Weld Gun does not fulfill all the requirements.

2. Difference between M300 LHD and RHD vehicles can help us to solve this problem. Setting up a proper sequence of the vehicles as below can be one of the solution.

   M300 at 22 JPH and thus SGM works at 2 JPH i.e. only 2 cars will come in an hour at MRS Line and the rest will be M300 vehicles. So every SGM car will be proceeded and followed by an RHD car. Thus the difference between the time for LHD - RHD will be utilized for SGM car.

   This proposal is cost effective as well as it will not create any further problems. It can also be molded as per the JPH also.

Chapter – 8
STANDARDIZATION GUIDE

8.1 Introduction

The purpose of this document is to provide guidelines and requirements which support standards and examples of General Motors Global Manufacturing Systems.

- **Standardization** is a dynamic process by which we document, follow and perform our work according to the core standards, terminology, principles, methods and processes to achieve a common base from which to improve.
- **Workplace Organization** is to put order to and maintain the workplace by making "out of standard" conditions readily visible.
- **Visual Management** is a process in which standards and actual conditions become quickly visual in the workplace.
- **Continuous Improvement** is a set of clear and understood standards which must be enforced if change is going to take place.

8.1.1 Purpose:

- The purpose of standardization is to reduce variation and stabilize, so as to achieve a base from which to grow and improve.

- To allow for quick, easy effective maintenance of the workplace organisation process.

8.1.2 Definition:

- Standardization is a *dynamic process* by which we set standards of terminology, principles, methods and processes within our organization.

8.1.3 Principles of GMS

1. Standardization
2. Built in Quality
3. Short Lead Time
4. Continuous Improvement
5. People Involvement

8.2 The Content of the Guide includes :

1. Introduction
2. GM India-Talegaon Policies
3. Safety
4. Floor Markings
5. Column Markings
6. WFG Visual Signage
7. Work Station
8. Business Plan Deployment (BPD)
9. ANDON Board
10. Group Room
11. Nerve Center
12. Visitor Information Center
13. Material Standards
14. Office 5S Standards
15. Revisions
16. Annexure

Standardization Guide is located in following areas -

1. Nerve centre of Respective shops
2. IE- GMS (Admin. Block)
3. Group areas
4. Shop Offices

8.3 Standardization Examples :

For Example : 1

FPS and Work envelope Marking for Moving Line

Work Envelope Floor Marking Specifications:

- **FPS (Fixed Position Stop)** : 50 mm x --- mm (Length up to stock position line) in **Orange Color** with FPS lettering in Black color
- **Start** : 50mm x 500mm in Green Color (Start point for TM to work on vehicle)
- **70%** : 50mm x 500mm in Yellow color (70% of Actual Takt time line on SOS)
- **Finish** : 50mm x 500mm in Red color (Last point for TM to finish his/her work on vehicle)
- **Stock Position**: 100mm width line in Yellow color

This markings can be painted or taped as per the requirement.

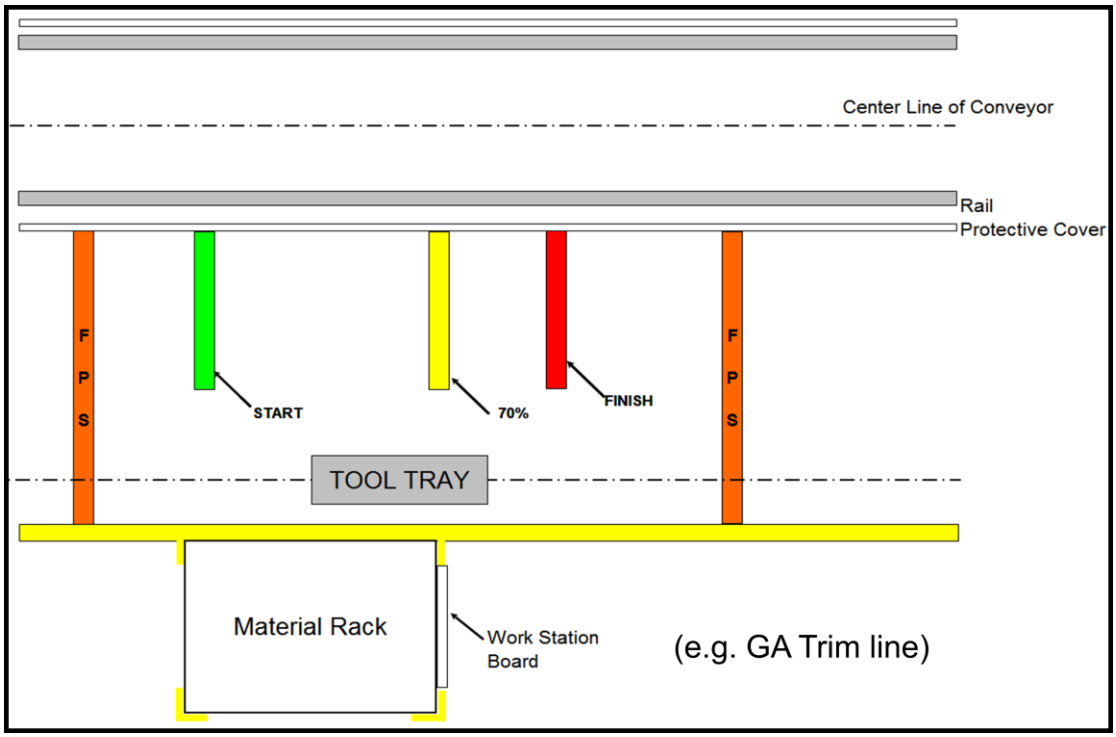


Figure 75 : Standardization - Marking on the Line

For Example : 2

Floor Markings

Aisles must have support for safety reasons. The standard applies to all pedestrian walkway in the plant.

Aisles must indicate areas assigned to pedestrian with 3’ wide aisle marked with two 4” wide Yellow lines at one side.

Cautions signs for both pedestrians and drivers must also be installed at aisle intersections and other areas.

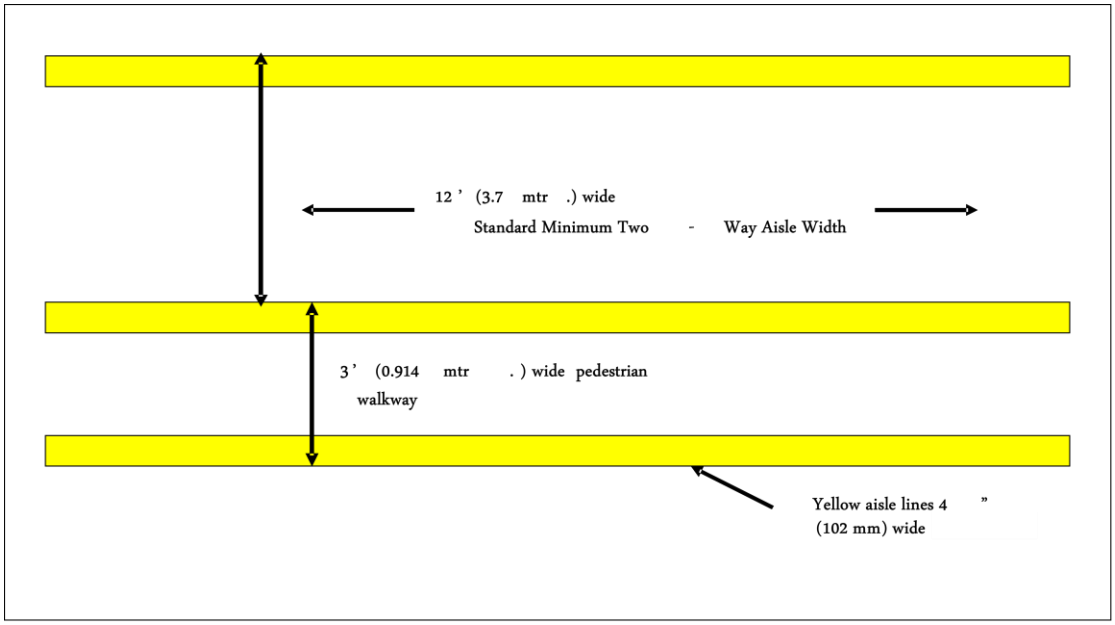


Figure 76 : Standardization - Cautions signs

Best Practice for Intersections:

Each main intersection or intersections which have significant traffic should be equipped with stop signs posted (octagonal red with white letters).

Where possible corners should be cut at 45 degrees to prevent storing of material which obstructs the view of either a fork truck driver or a pedestrian.

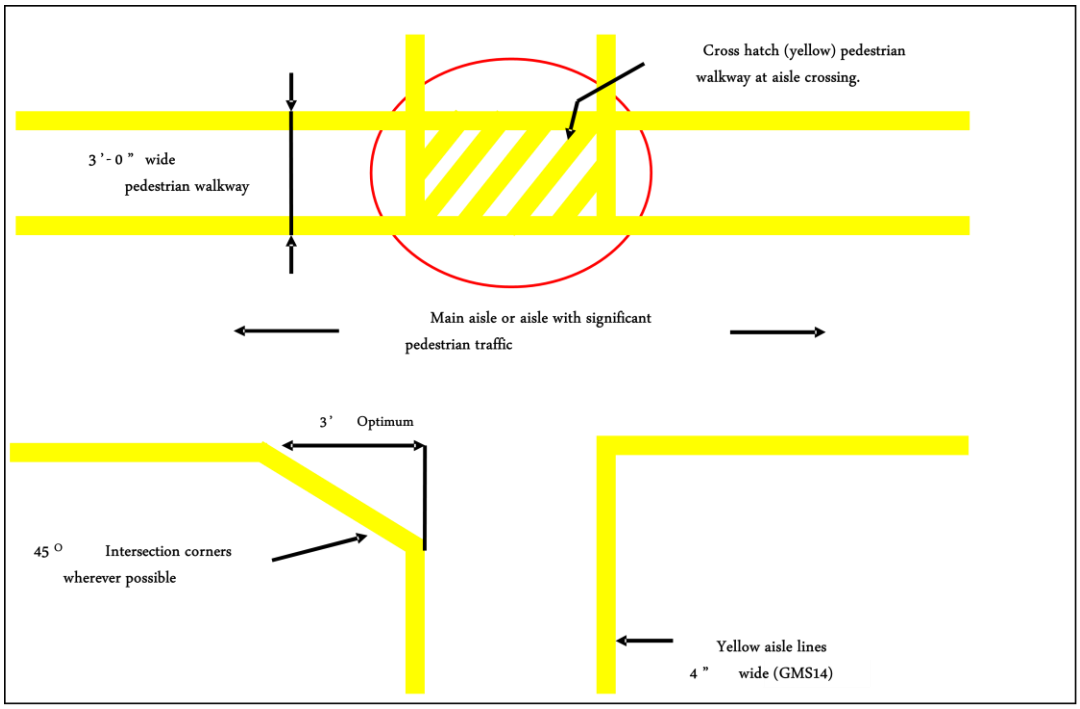


Figure 77 : Standardization - Cautions sign for Intersections

8.4 Updation & Audit:

Based on the change request feedbacks we had to publish new edition of the Standardization Guide which now is called as the 9th edition.

As stated above there are 42 station where in the guides are placed and becomes the first and basic visual guides used for any process going to take place within the plant.
A Pre-Audit was conducted on our level where in we had to check the procedure which are taking place as per the guide or not. Also we had cross questioned the operators to check there acknowledge about the updation taken place.

8.5 Introduction To Tip:

8.5.1 Tip Definition :

TIP is a Common Process Used throughout General Motors to Increase Profit by Improving Throughput through the Elimination of Waste.

8.5.2 Tip Provides :

- Quick identification and prioritization of process constraints (bottlenecks)
- Elimination of constraints using cross-functional problem solving teams
- Quantifiable results

8.5.3 Tip Objectives :

- TIP (Throughput Improvement Process) is used to influence Responsiveness through Continuous Improvement
- Data determines bottlenecks and supports issue identification to assist in problem solving
- Targeting specific bottlenecks allows the team to focus their efforts on the jobs that impact throughput the most
- Both speed and uptime play a role in improved throughput, focus needs to be on both

- Throughput is within our control, and is a significant contributor to GM's success

8.5.4 Tip Key Terms :

Throughput: The rate at which a system produces product. Always expressed in terms of parts, (or units) per unit of time. E.g. Strokes Per Hour (SPH)

Bottleneck: The Process or equipment that most inhibits the system's ability to produce more product within a period of time (throughput)

Waste: Anything or Process that does not add value to the product. Can significantly impact throughput

8.5.5 Tip Wall / Board :

- TIP Walls may optimised to suit the local Business Process
- TIP meetings are intended to be lean. The minimum documents should be used
- May have TIP walls at each line, or just a shop TIP wall, or both
- Should minimise data replication on line and shop walls

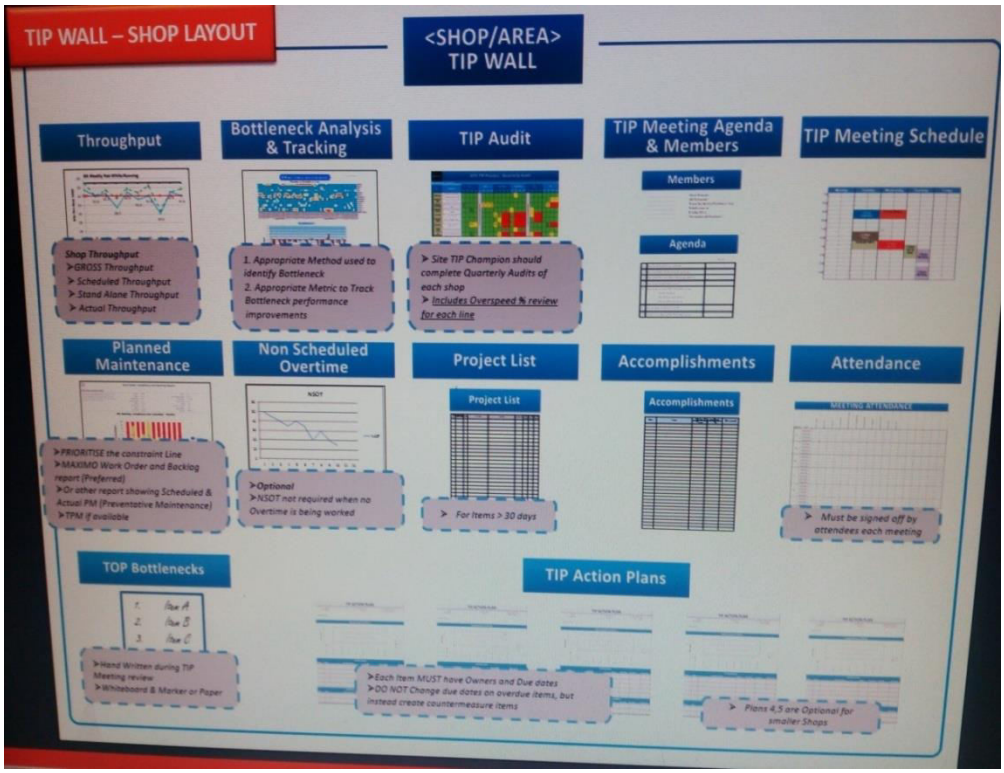


Figure 78 : TIP Wall Standard Format

- **MEETING MEMBERS AND AGENDA**

  Description

  Defines required attendees and provides an agenda to follow

  Purpose

  Ensures cross-functional team support, and all topics are covered

- **MEETING ATTENDANCE**

  Description

  Attendance log

  Purpose

  Ensures accountability of required attendees

- **ACCOMPLISHMENTS**

  Description

  Lists recent accomplishments, may remove after a couple weeks of tracking to ensure it is truly eliminated

  Purpose

  - Provides positive feedback on the TIP system
  - Allows team to ensure bottleneck is eliminated by tracking it for a couple of weeks past completion

- **PROJECT LIST**

  Description

  Provide a location for Projects over 30 days

  Purpose

  - Aids in the prioritization and awareness of large scale projects that are not within the team's control
  - Ensures the TIP process remains dynamic from week to week, not waiting on long term project improvements

- **ACTION PLANS**

  Description:

  Track steps being taken to problem solve and eliminate a bottleneck

  Purpose:

  - Defines task ownership and accountability

- Sets expected due dates
- Provides place for everyone to see the progress and which tasks they are assigned

- **ACTION PLANS – HOW TO**
  - Tasks should be 30 days or less implementation time
    - Keeps the process Dynamic with weekly improvements
    - Applies to the individual tasks, in order to keep teams focused on solutions they can implement without capital investment
    - Tasks > 30 days should be moved to the project board
    - Red or Yellow task status (missed or risk of missing due date) requires countermeasure
  - Action Plans can be completed by hand or on computer
    - The form is continuous for a specific problem, and teams may continue using an action plan for more than a month to eliminate a bottleneck
    - Completed Action Plans should be maintained for future reference
    - A MS Access database is available for managing Action Plans

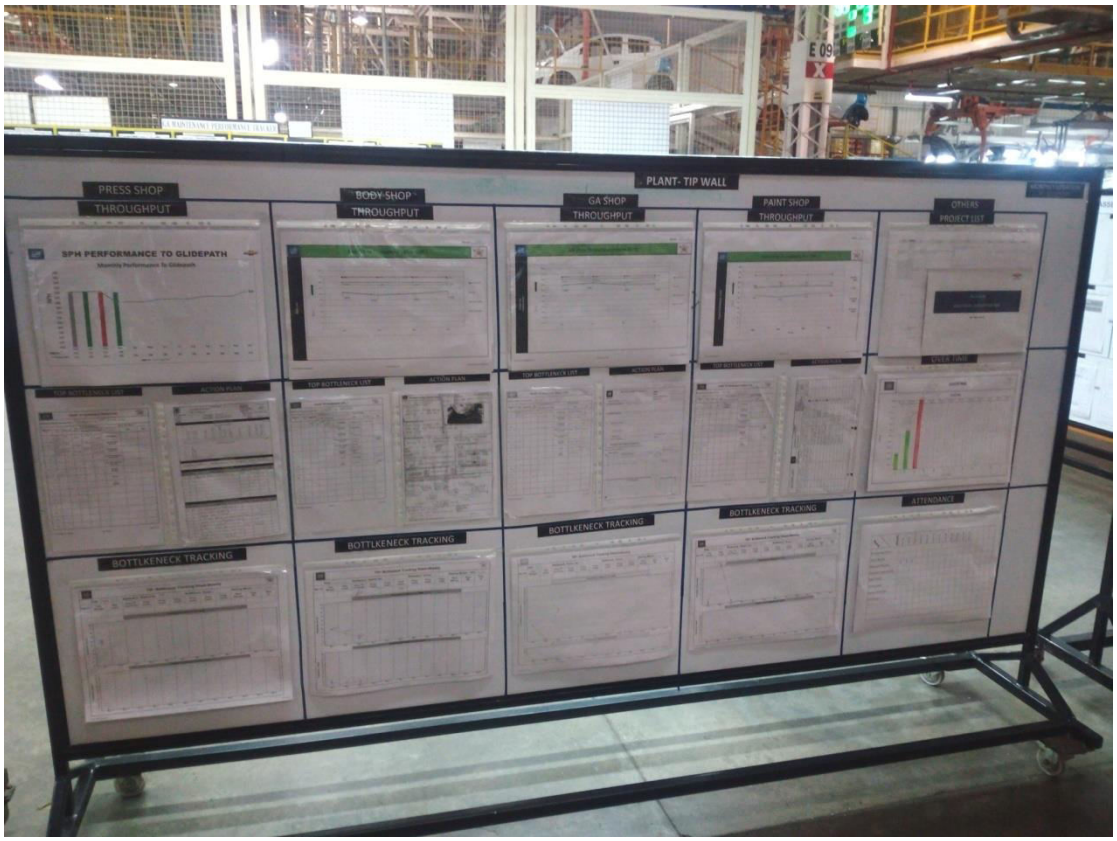
- **BOTTLENECK ANALYSIS – Line level only**

  Description: Data Analysis to identify target CSPC's
    - The 'TIP Dashboard' has been developed specifically to identify the biggest improvement opportunities

  Purpose: Need to focus resources on the biggest improvement opportunities

8.5.6 Plant Tip Board

All the TIP data of the respective shops are summarized at the Plant TIP bard as showed in the picture below.



Picture 12 : Plant TIP Board

Chapter – 9
INTRODUCTION TO ERGONOMICS

9.1 Introduction :

Ergonomics is the study of human abilities and characteristics which affect the design of equipment, systems, and jobs.

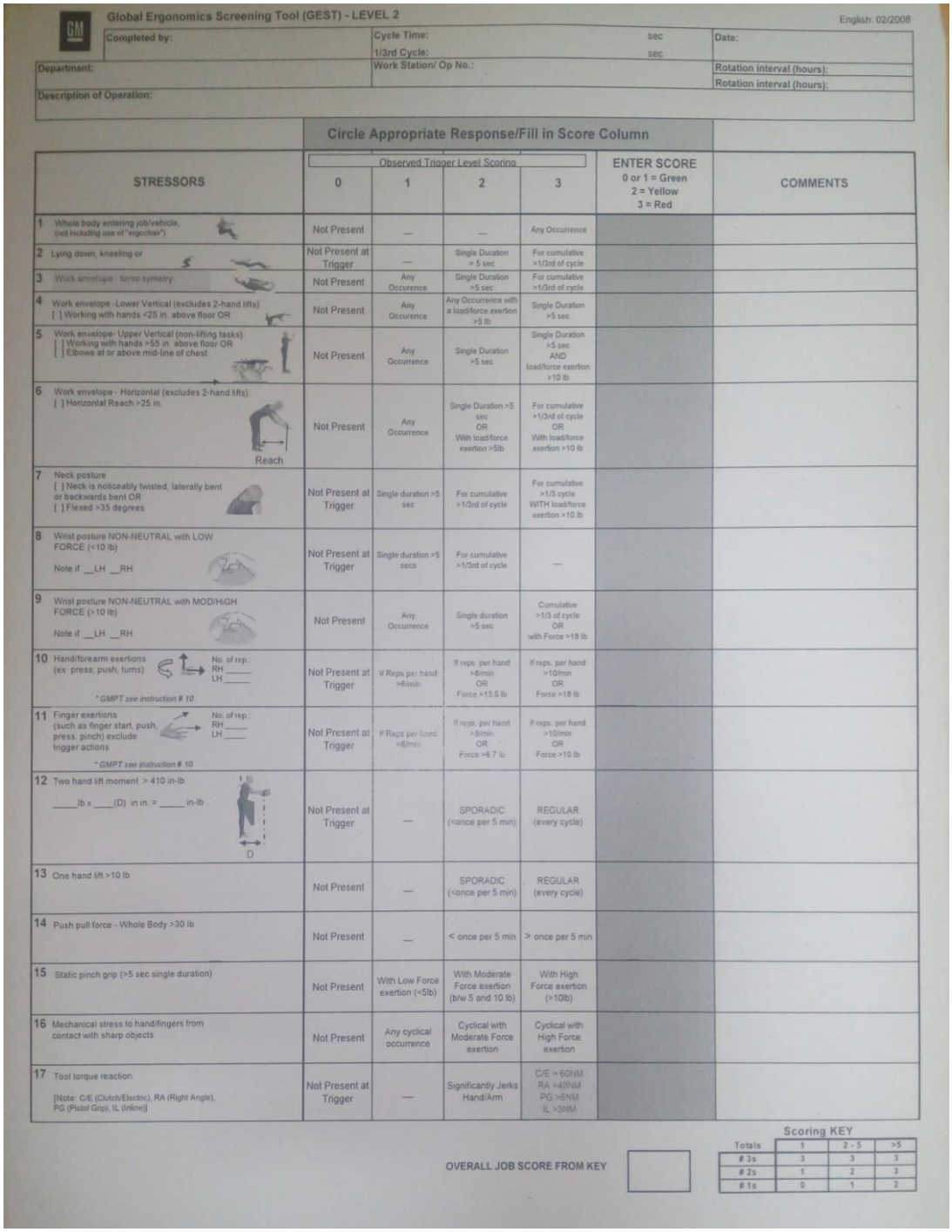
The aim of ergonomics is to improve efficiency, safety and employee well being.
To **match** the Design of Parts, Equipment, Tools and Work Tasks to the Capabilities and Limitations of the Operators
To **optimize:**

- Human Performance
- Product Quality
- Productivity
- Health and Safety

9.2 Global Ergonomics Screening Tool (GEST)

Sections/Questions Covered in GEST Study

- Header and job title information
- Lying down, kneeling, squatting
- Work envelope, lower vertical
- Work envelope, horizontal
- Wrist posture, low force
- Hand/forearm exertion
- Two hand lift moment
- Push pull force, whole body
- Mechanical stress to hand/fingers
- Whole body entering job
- Work envelope, torso symmetry
- Work envelope, upper vertical
- Neck posture
- Wrist posture, moderate/high force
- Finger exertion
- One hand lift
- Static pinch grip
- Tool torque reaction



Global Ergonomics Screening Tool (GEST) - LEVEL 2

English: 02/2008

Completed by:	Cycle Time: sec 1/3rd Cycle: sec	Date:
Department:	Work Station/ Op No.:	Rotation interval (hours): Rotation interval (hours):
Description of Operation:		

Circle Appropriate Response/Fill in Score Column

STRESSORS	Observed Trigger Level Scoring 0	1	2	3	ENTER SCORE 0 or 1 = Green 2 = Yellow 3 = Red	COMMENTS
1 Whole body entering job/vehicle, (not including use of "ergochair")	Not Present	—	—	Any Occurrence		
2 Lying down, kneeling or	Not Present at Trigger	—	Single Duration > 5 sec	For cumulative >1/3rd of cycle		
3 Work envelope - torso symetry	Not Present	Any Occurence	Single Duration >5 sec	For cumulative >1/3rd of cycle		
4 Work envelope -Lower Vertical (excludes 2-hand lifts) [ ] Working with hands <25 in. above floor OR	Not Present	Any Occurence	Any Occurrence with a load/force exertion >5 lb	Single Duration >5 sec		
5 Work envelope- Upper Vertical (non-lifting tasks): [ ] Working with hands >55 in. above floor OR [ ] Elbows at or above mid-line of chest	Not Present	Any Occurrence	Single Duration >5 sec	Single Duration >5 sec AND load/force exertion >10 lb		
6 Work envelope - Horizontal (excludes 2-hand lifts): [ ] Horizontal Reach >25 in. Reach	Not Present	Any Occurrence	Single Duration >5 sec OR With load/force exertion >5lb	For cumulative >1/3rd of cycle OR With load/force exertion >10 lb		
7 Neck posture [ ] Neck is noticeably twisted, laterally bent or backwards bent OR [ ] Flexed >35 degrees	Not Present at Trigger	Single duration >5 sec	For cumulative >1/3rd of cycle	For cumulative >1/3 cycle WITH load/force exertion >10 lb		
8 Wrist posture NON-NEUTRAL with LOW FORCE (<10 lb) Note if __LH __RH	Not Present at Trigger	Single duration >5 secs	For cumulative >1/3rd of cycle	—		
9 Wrist posture NON-NEUTRAL with MOD/HIGH FORCE (>10 lb) Note if __LH __RH	Not Present	Any Occurrence	Single duration >5 sec	Cumulative >1/3 of cycle OR with Force >18 lb		
10 Hand/forearm exertions (ex: press, push, turns) No. of rep.: RH ____ LH ____ * GMPT see instruction # 10	Not Present at Trigger	If Reps per hand >6/min	If reps. per hand >6/min OR Force >13.5 lb	If reps. per hand >10/min OR Force >18 lb		
11 Finger exertions (such as finger start, push, press, pinch) exclude trigger actions No. of rep.: RH ____ LH ____ * GMPT see instruction # 10	Not Present at Trigger	If Reps per hand >6/min	If reps. per hand >6/min OR Force >6.7 lb	If reps. per hand >10/min OR Force >10 lb		
12 Two hand lift moment > 410 in-lb ____lb x ____(D) in in. = ____ in-lb D	Not Present at Trigger	—	SPORADIC (<once per 5 min)	REGULAR (every cycle)		
13 One hand lift >10 lb	Not Present	—	SPORADIC (<once per 5 min)	REGULAR (every cycle)		
14 Push pull force - Whole Body >30 lb	Not Present	—	< once per 5 min	> once per 5 min		
15 Static pinch grip (>5 sec single duration)	Not Present	With Low Force exertion (<5lb)	With Moderate Force exertion (b/w 5 and 10 lb)	With High Force exertion (>10lb)		
16 Mechanical stress to hand/fingers from contact with sharp objects	Not Present	Any cyclical occurrence	Cyclical with Moderate Force exertion	Cyclical with High Force exertion		
17 Tool torque reaction [Note: C/E (Clutch/Electric), RA (Right Angle), PG (Pistol Grip), IL (Inline)]	Not Present at Trigger	—	Significantly Jerks Hand/Arm	C/E >60NM RA >40NM PG >8NM IL >3NM		

OVERALL JOB SCORE FROM KEY

Scoring KEY

Totals	1	2 - 5	>5
# 3s	3	3	3
# 2s	1	2	3
# 1s	0	1	2

Table 19 : Global Ergonomics Screening Tool

Based on the criteria every job can be scored

Green	= value falls within acceptable limits for cumulative stressors
Red	= value has been reviewed by Ergonomist and exceeds acceptable
Blue	= Ergonomics review required
White	= no data for this Ergonomic stressor for this operation
<border>	= possible static posture Ergonomic stressor

9.3 Sites For Implementation:

Following are the critical stations facing the Ergo issues which need to be solved:

1. BIW 60 R

At this station the operator has to walk a considerable distance to get the tailgate and then to assemble it. The picture below shows the Ergo issue which illustrates the loading of heavy objects by carrying it by hand.

Picture 13 : Ergonomics - BIW 60 R

The issue can be solved by various means like designing a hoist or tackle etc.

2. ENR 230 L

At this station the operator has to bend down and perform 4 spots. The regular bending is an Ergo issue.

Picture 14 : Ergonomics - ENR 230 L

This issue can be solved by transferring the spots to Underbody as the fixture at the Underbody is at an considerable level.

Chapter – 10

INTRODUCTION OF DOWNTIME ANALYSIS

10.1 Introduction:

Being a part of IE-GMS team, we are now improving productivity via Downtime Analysis. The term downtime is used to refer to periods when a system is unavailable. Downtime or outage duration refers to a period of time that a system fails to provide or perform its primary function. Reliability, availability, recovery, and unavailability are related concepts. The unavailability is the proportion of a time-span that a system is unavailable or offline. This is usually a result of the system failing to function because of an unplanned event, or because of routine maintenance (a planned event).

The term is also commonly applied in industrial environments in relation to failures in industrial production equipment. Some facilities measure the downtime incurred during a work shift, or during a 12 or 24-hour period. Another common practice is to identify each downtime event as having an operational, electrical or mechanical origin. Downtime can be caused by failure in hardware (physical equipment), software (logic controlling equipment), interconnecting equipment (such as cables, facilities, routers), wireless transmission (wireless, microwave, satellite), and/or capacity (system limits).

Based on our monitoring we make the daily loss report which contains the information about the actual vehicles produced along with the target and the capacity. We thus make a note of every activity causing the loss. On the basis of Daily report we analyze the top 5 losses taking place weekly department wise. These top losses are being sent to the respective department who in against out Weekly report creates the Action plan need to be taken to improve. Based on the Weekly report we make the Monthly report constituting the top 5 losses for the top 5 departments..

Then the appropriate departments are then alerted on those issues and spread awareness to their workers thus effectively reducing the downtime significantly.

- Daily Report :

DAILY PRODUCTION LOSS REPORT - Talegaon

31-Dec

SHOP	Shif	JPH	Capacity	Target	Actual	Loss wrt	Mins	Unit	Resp.	Model	Reason for Loss	Remarks
							4	1.6	Body		Backglass to tail lamp gap high (Trim-2)	
							2	0.8	GA		RHF window regulator not working	
							5	2.0	GA		Windshield damage	
							1	0.4	Maint.		AGV not release at shift start	
							2	0.8	Maint.		Brake oil & ABS fitting not ok	
							7	2.8	Maint.		Brake oil M/C idendification fault	
							3	1.2	PE		Striker bolt washout	
	A	25.2	189	138	160	-29	32	12.8	QE		Tailgate to bumper A/V gap	
							3	1.2	QE		Selector cable fitment hard	
							4	1.6	SQA		Roof lamp not working	
							3	1.2	SQA/GSC		Front bumper scratch	
								0.0				
								0.0				
								0.0				
								0.0				
								0.0				
							3	1.2	Body		Cowl to fender flushness not Ok	
							3	1.2	Body		Bodyshop repair activity done at APD station	
							20	8.0	Body		Line stopped for various dent issues	
							4	1.6	Maint.		APD fail	
							4	1.6	Maint.		Coolent machine metering fault	
							3	1.2	QE		Power window inoperative	
	B	25.2	189	138	130	-59	3	1.2	QE		Window glass inoperative	
							3	1.2	SQA		Seat sliding hard	
							95	38.0			Scheduled stop	
								0.0				
								0.0				
								0.0				
								0.0				
								0.0				
								0.0				
	Total		378	276	290	-88		81.6				

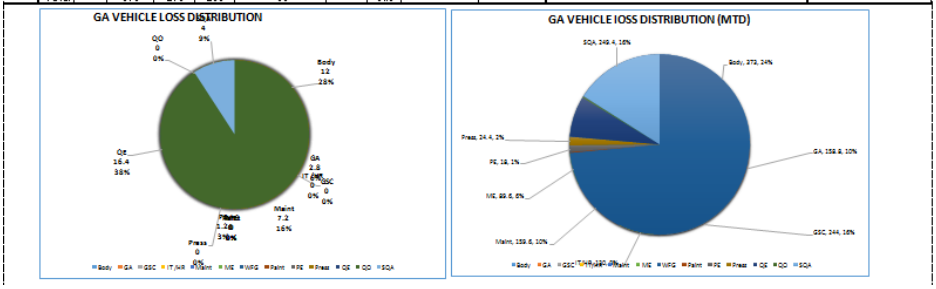
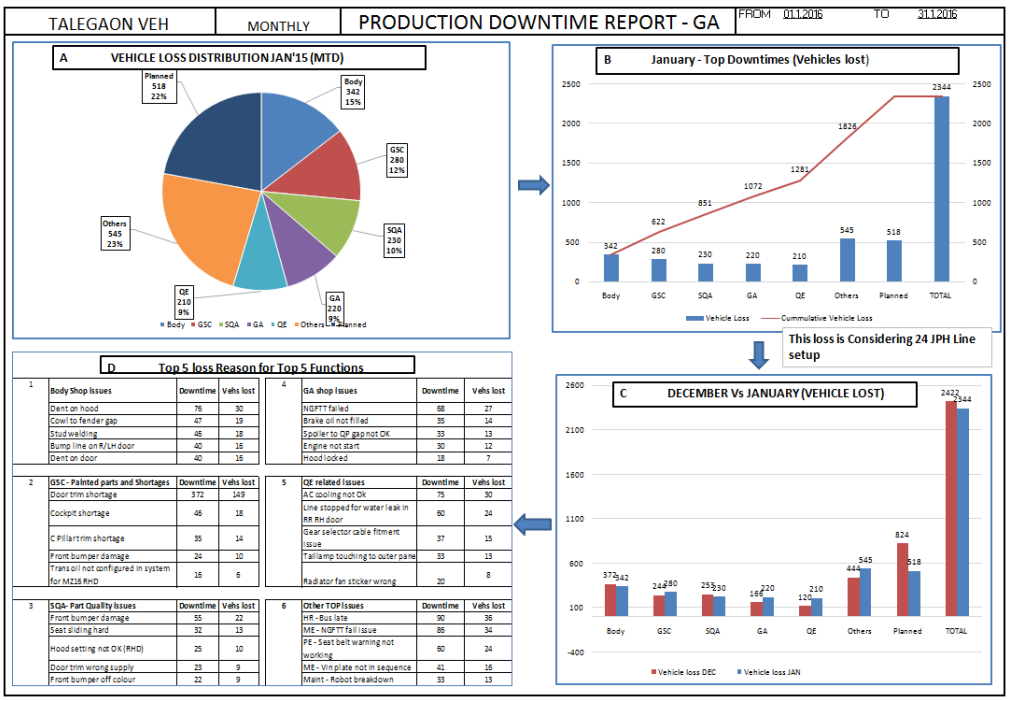


Figure 79 : Downtime Monitoring - Daily Report

- Monthly Report :



	Body Shop Issues	Downtime	Vehs lost
	Dent on hood	76	30
	Cowl to fender gap	47	19
	Stud welding	46	18
	Bump line on R/LH door	40	16
	Dent on door	40	16

	GSC - Painted parts and Shortages	Downtime	Vehs lost
	Door trim shortage	372	149
	Cockpit shortage	46	18
	C Pillar trim shortage	35	14
	Front bumper damage	24	10
	Trans oil not configured in system for MZ16 RHD	16	6

	SQA- Part Quality Issues	Downtime	Vehs lost
	Front bumper damage	55	22
	Seat sliding hard	32	13
	Hood setting not OK (RHD)	25	10
	Door trim wrong supply	23	9
	Front bumper off colour	22	9

	GA shop Issues	Downtime	Vehs lost
	NGFTT failed	68	27
	Brake oil not filled	35	14
	Spoiler to QP gap not OK	33	13
	Engine not start	30	12
	Hood locked	18	7

	QE related Issues	Downtime	Vehs lost
	AC cooling not Ok	75	30
	Line stopped for water leak in RR RH door	60	24
	Gear selector cable fitment issue	37	15
	Tail lamp touching to outer pane	33	13
	Radiator fan sticker wrong	20	8

	Other TOP Issues	Downtime	Vehs lost
	HR - Bus late	90	36
	ME - NGFTT fail issue	86	34
	PE - Seat belt warning not working	60	24
	ME - Vin plate not in sequence	41	16
	Maint - Robot breakdown	33	13

Figure 80 : Downtime Monitoring - Monthly Report

- Weekly Report :

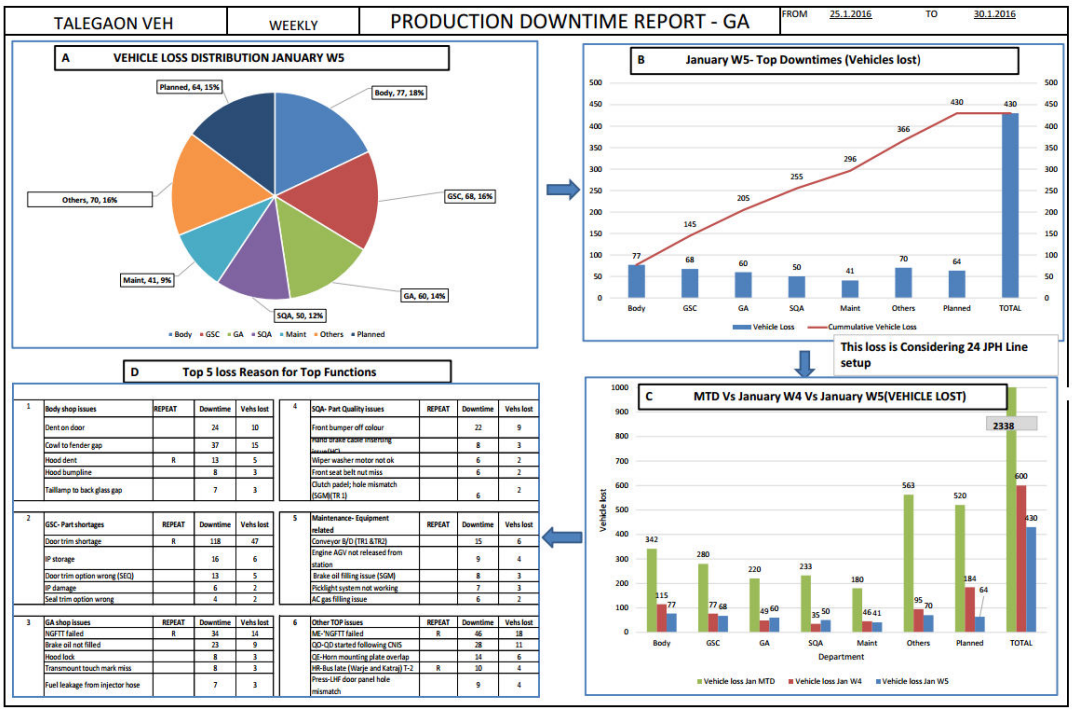
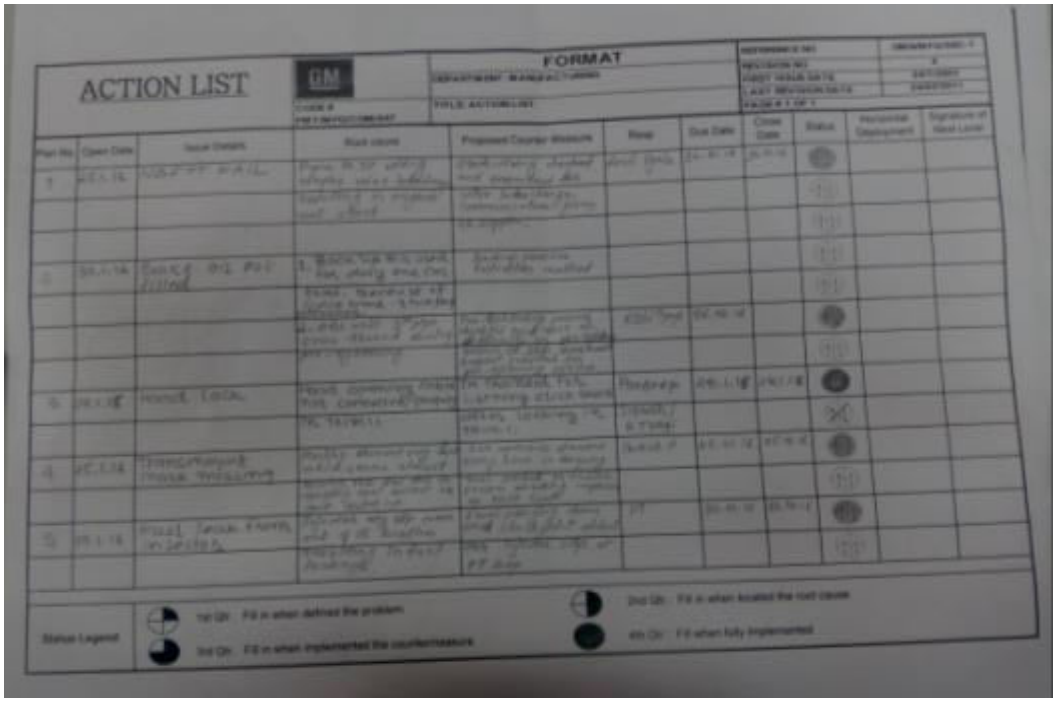


Figure 81 : Downtime Monitoring - Weekly Report

- Action Plan



Picture 15 : Downtime Monitoring - Action Plan

10.2 Downtime Monitoring Report :

10.2.1 Vehicle Losses :

Analyzing the downtime for 4 months i.e. from Jan 2016 to April 2016, we get the following department wise Vehicle loss count. The data has been summarized in tabulated and graphical form as shown below :

Vehicle Losses	Jan	Feb	Mar	Apr
Body	341.6	370.4	301.6	369.6
GA/ME/MAINT	518.4	714.4	177.2	320.0
GSC	280.0	137.6	533.6	225.2
IT/HR	80.0	139.2	83.2	142.0
WFG	0.0	0.0	55.6	52.8
Paint	9.2	13.2	5.2	5.6
PE	63.2	18.0	90.4	63.6
Press	64.4	27.6	22.4	76.4
QE/SQA	439.2	364.0	376.6	508.8
QO	22.0	12.0	12.0	6.0
Scheduled Stop	520.4	194.6	390.0	294.0
Total	**2338.4**	**1991**	**2047.8**	**2064**

Table 20 : Vehicle Losses

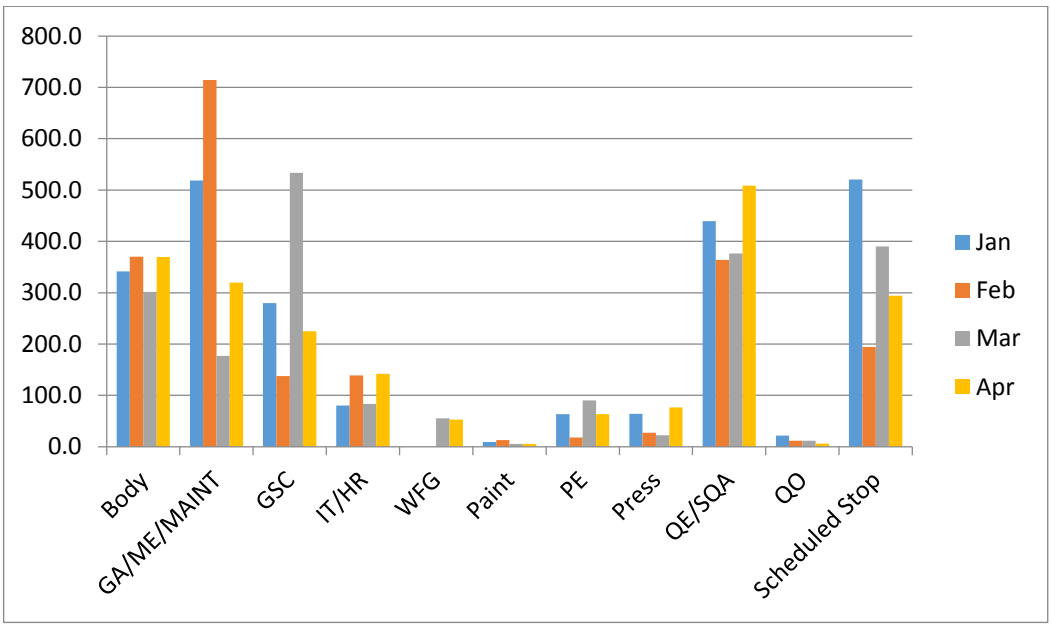


Figure 82 : Vehicle Losses

The major departments responsible for vehicle loss are Body, GA/ME/MAINT, QE/SQA and GSC during these 4 months. The overall vehicle losses has been on a decreasing scale which shows improvements taking place in the organization.

10.2.2 Target Vs Actual Production :

The graph below shows the variation between the Target and the Actual Production considering the Capacity of the plant during 4 months from Jan to April 2016.

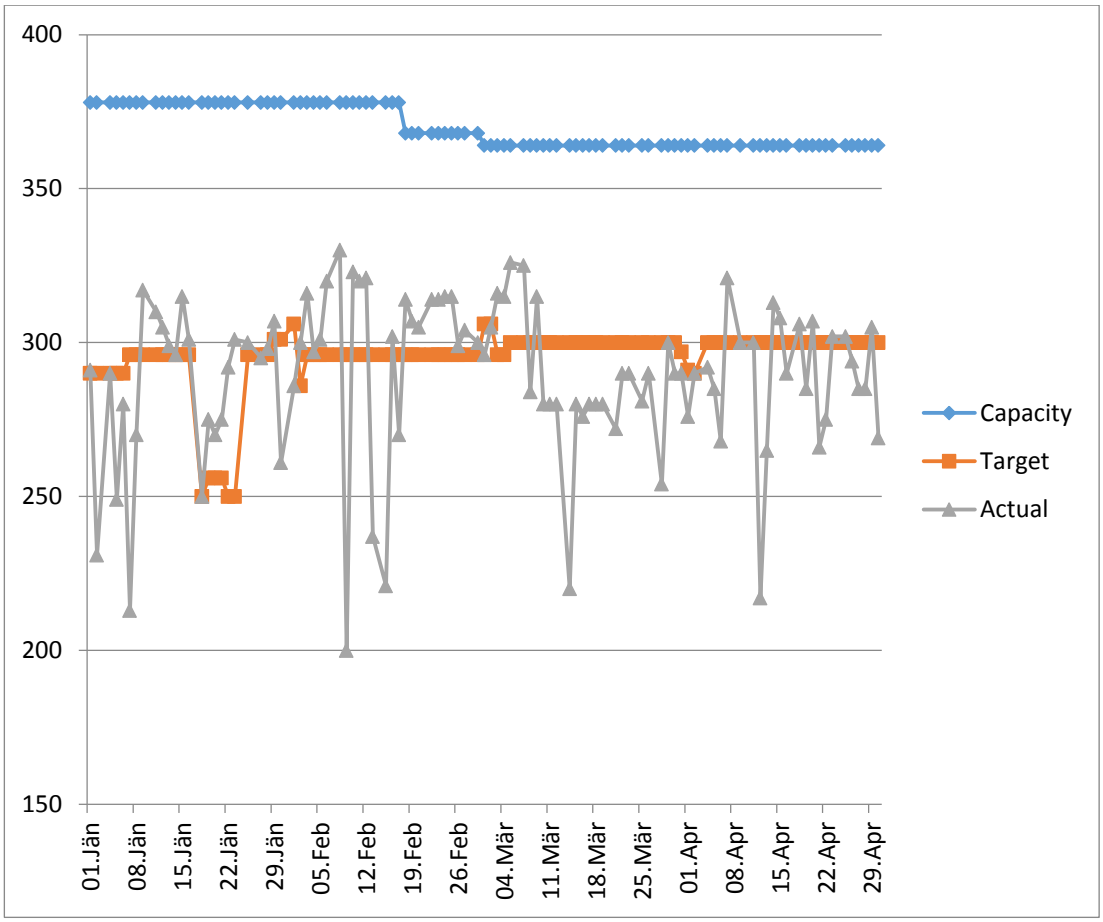


Figure 83 : Target Vs Actual Production

If we consider Average of the Actual Production per month then:

	Jan	Feb	Mar	Apr
Average Actual Production	283.64	297.24	288.23	288.24

Table 21 : Average Actual Production

It shows that the production capability has been improved from the month of Jan to April 2016.

10.2.3 Summary :

All the above data can be summarized in the table below :

	Jan	Feb	Mar	Apr
Capacity	9450	9350	9464	9100
Target	7122	7400	7801	7481
Actual	7091	7431	7495	7206
Vehicle Losses	2338.4	1991	2047.8	2064
% Target Achieved	99.56%	100.42%	96.08%	96.32%

Table 22 : Downtime Analysis Summary

% Target Achieved shows that how much percentage of target has been achieved and Actually Produced. Capacity depends on how many shifts the plant operate and Machine and Manpower availability.

In the month of Feb the Actual Production was more than that of target, thus the % Target Achieved is more than 100%.

The above table has been graphically represented below :

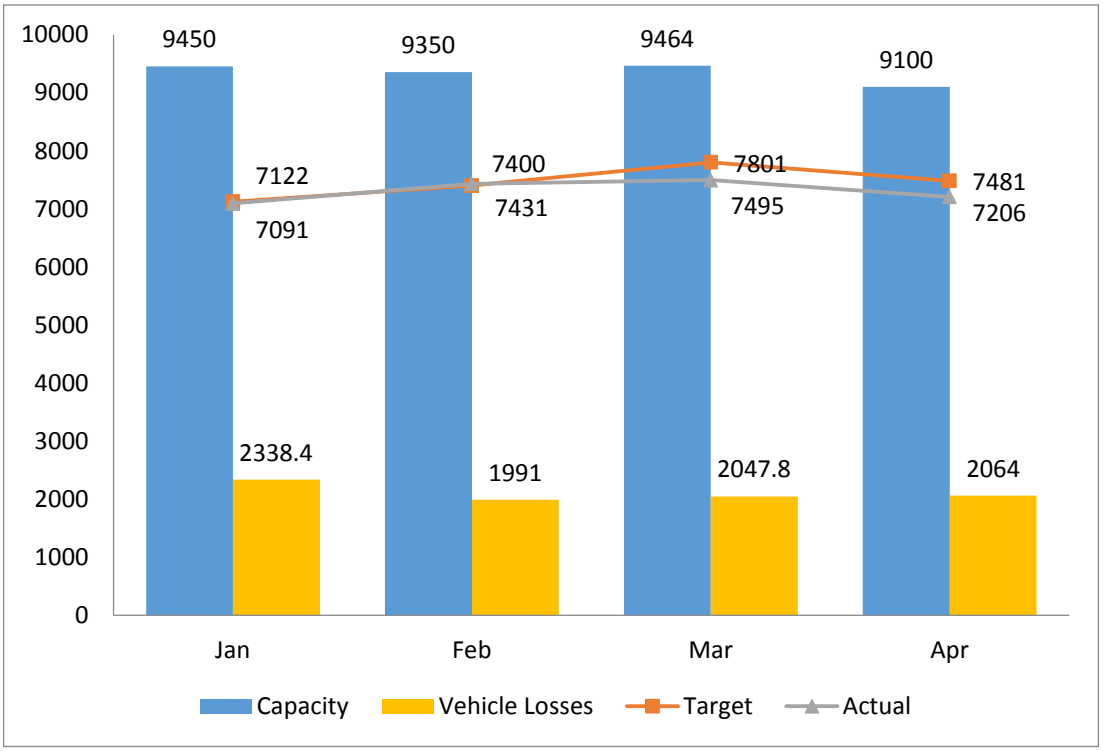


Figure 84 : Downtime Analysis Summary

10.3 Introduction to TIP Downtime Report :

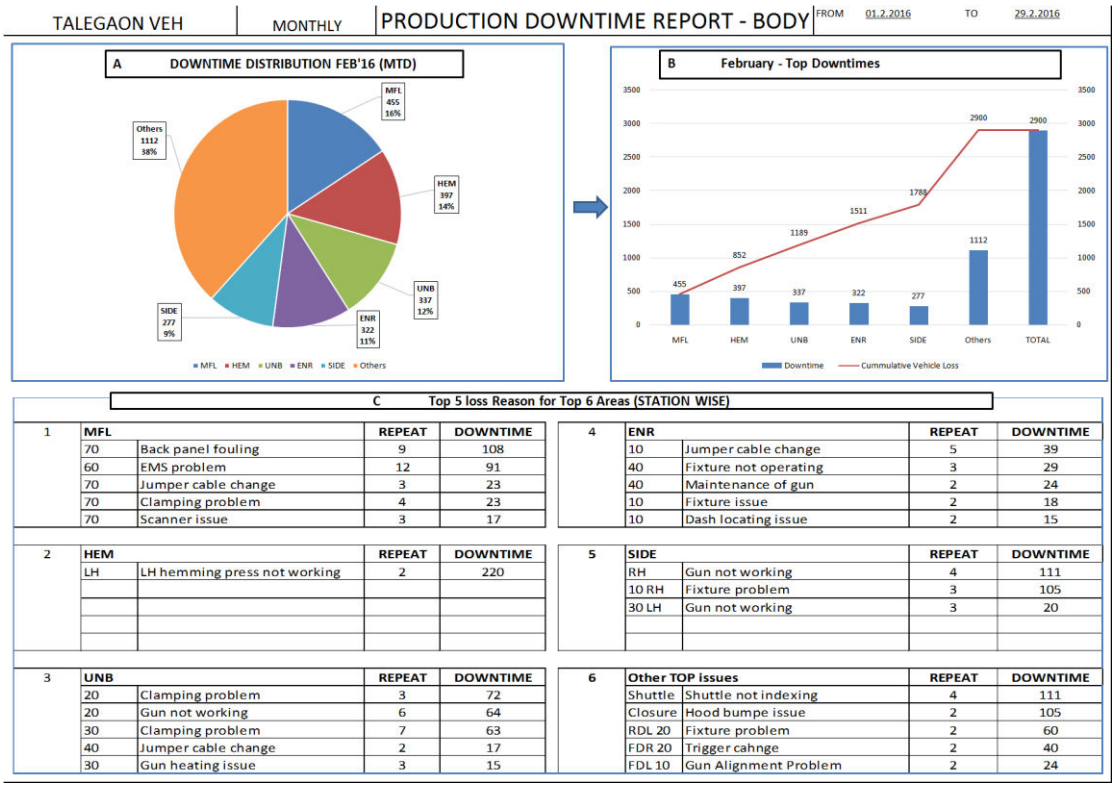
For Downtime Monitoring on the TIP board in the Body Shop new report had to be generated. Based on this report High downtime issues like Bottleneck stations, Regular Breakdown of Machines etc. are being found out and proper actions are taken for its cure. Thus this report plays an important role for Downtime Monitoring.

Thus for its implementation two types of reports were proposed which on approval will be implemented in Paint Shop as well as in General Assembly too.

A complete summary along with this report is also being placed on the Plant TIP board which are weekly monitored by the Plant Head and high authorities.

10.3.1 Station Wise Report:

The following report has been proposed which illustrates the downtime Station wise. Using this report we can track down each and every station where the downtime or losses are coming up from.



C Top 5 loss Reason for Top 6 Areas (STATION WISE)

1	MFL		REPEAT	DOWNTIME
	70	Back panel fouling	9	108
	60	EMS problem	12	91
	70	Jumper cable change	3	23
	70	Clamping problem	4	23
	70	Scanner issue	3	17

2	HEM		REPEAT	DOWNTIME
	LH	LH hemming press not working	2	220

3	UNB		REPEAT	DOWNTIME
	20	Clamping problem	3	72
	20	Gun not working	6	64
	30	Clamping problem	7	63
	40	Jumper cable change	2	17
	30	Gun heating issue	3	15

4	ENR		REPEAT	DOWNTIME
	10	Jumper cable change	5	39
	40	Fixture not operating	3	29
	40	Maintenance of gun	2	24
	10	Fixture issue	2	18
	10	Dash locating issue	2	15

5	SIDE		REPEAT	DOWNTIME
	RH	Gun not working	4	111
	10 RH	Fixture problem	3	105
	30 LH	Gun not working	3	20

6	Other TOP issues		REPEAT	DOWNTIME
	Shuttle	Shuttle not indexing	4	111
	Closure	Hood bumpe issue	2	105
	RDL 20	Fixture problem	2	60
	FDR 20	Trigger cahnge	2	40
	FDL 10	Gun Alignment Problem	2	24

Figure 85 : TIP Report - Station Wise

Row Labels	Sum of DOWNTIME
MFL	455
HEM	397
UNB	337
ENR	322
SIDE	277
RRF	127
(blank)	120
SHUTTLE	111
CLOSURE	105
FDR	75
RESPOT	70
BIW	64
MRS	61
RDL	60
TAIL GATE	60
HR	56
HSE	55
FDL	52
VDL	30
SAFETY	15
ROOF	12
DASH	10
RDR	10
ER	10
VS	7
DSA	2
Grand Total	2900

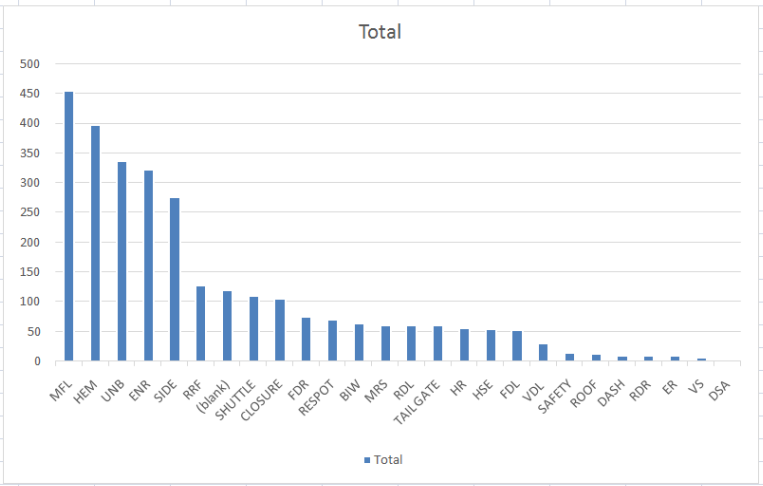


Figure 86 : Graph above shows the downtime station wise in descending order

Row Labels	Sum of DOWNTIME
MFL	455
HEM	397
UNB	337
ENR	322
10	219
40	58
30	25
20	12
60	8
SIDE	277
RRF	127
(blank)	120
SHUTTLE	111
CLOSURE	105
FDR	75
RESPOT	70
BIW	64
MRS	61
RDL	60
TAIL GATE	60
HR	56
HSE	55
FDL	52
VDL	30
SAFETY	15
ROOF	12
DASH	10
RDR	10
ER	10
VS	7
DSA	2
Grand Total	2900

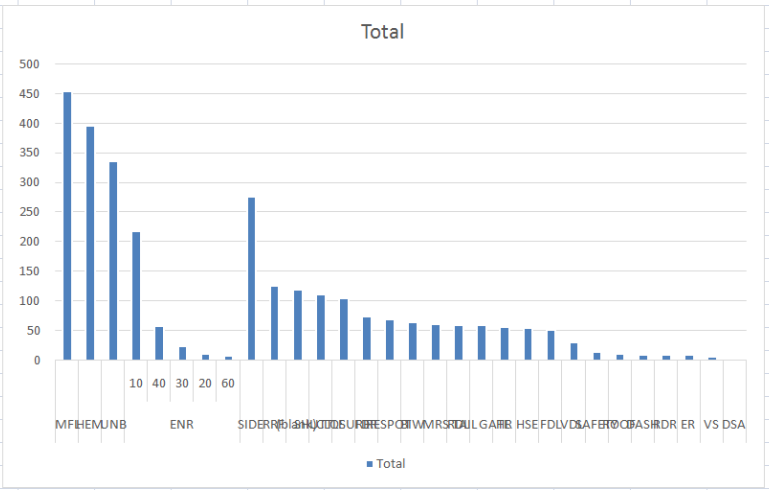


Figure 87 : Graph above shows the downtime for stations belonging to ENR in descending order

10.3.2 4M report:

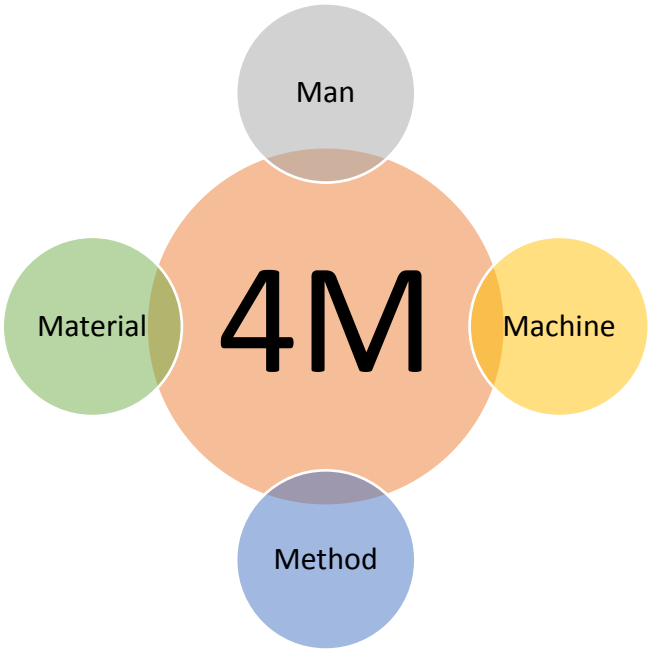


Figure 88 : 4M

Using 4M's I had improvised the downtime report in all the department. These report are monthly updated and put up in the TIP board. It also summarizes the data in the form of pie char which shows the percentage downtime of every M in 4M's and bar chart which shows the total downtime as per the 4M.

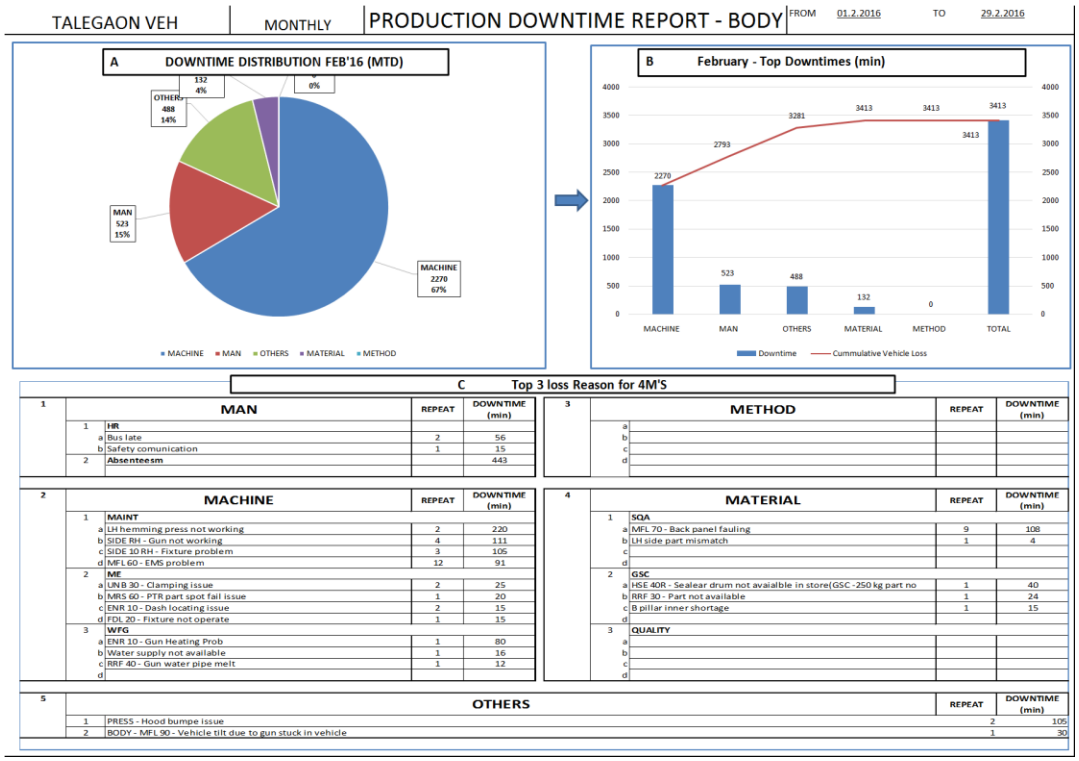


Figure 89 : TIP Report - 4M

Chapter – 11

WEEKLY PROJECT PROGRESS REPORT

11.1 Introduction :

Based on the daily activities we perform at the Company we maintained the log book, on the basis of which the Weekly report is created which is nothing but the log report of my activities in detail.

11.2 Weekly Progress Report :

Month	Week	Date	Day	Nature of Activity / Salient Points to be highlighted
Dec. 2015		10/12/2015		Received acceptance letter from the Company
		16/12/2015		Visited General Motors; Meet HR head Ms. Poonam Yekad, given a brief introduction about the company
	1	21-12-15	Monday	Had safety training ; Industrial Engineering department assigned under the guidance of Mr. Sachin Kulkarni sir and Mr. Sanjay Raina sir; An overall Introduction about the project; Personal protective's and ID card allotted.
		22-12-15	Tuesday	Senior Intern gave us an overview of the GA and Paint shop.; Study of the daily production loss report and HPU sheet; Introduction to STDs, APS and MODE software

		23-12-15	Wednesday	Practiced software : APS; Introduced SOS and JES sheets; Sanjay sir gave an orientation for Body shop and I prepared an layout of the shop
		24-12-15	Thursday	Presentation given by Sanjay Sir (Software, SOS, JES GMS, TT, ATT, Scroll dig); TIP wall responsibility; APS filled with the help of existing JES & SOS
		25-12-15	Friday	Interaction with Senior interns; Assigned daily jobs for 6 months i.e. Daily production loss report and HPU sheet
		26-12-15	Saturday	Weekly off : Robocon
	2	27-12-15	Sunday	Weekly off : Robocon
		28-12-15	Monday	Daily loss report and HPU, Learnt Weekly production loss report and made for the week of Dec W4. Created file to keep track of the completed work
		29-12-15	Tuesday	Daily loss report and HPU, APS deployment for station : Group 1, Team 1 : (10L1) (Importing from STD's to MODE and then comparing with APS)
		30-12-15	Wednesday	Daily loss report and HPU, APS deployment for station : Group 1, Team 1 : (10L1,10R1,10L2,10R2); Sanjay sir cross checked the work and suggested few corrections.

		31-12-15	Thursday	Daily loss report and HPU, APS deployment for station : Group 1, Team 1 : (30L1,30R1,40L2), Took videos for the 10th station and interacted with 10L1 worker, Resurrected the station JES as per the video and timings; Helped in making OT sheet/report for overtime
Jan. 2016		1/1/2016	Friday	Holiday
		2/1/2016	Saturday	Weekly off : Robocon/GRE class
	3	3/1/2016	Sunday	Weekly off : Robocon/GRE class
		4/1/2016	Monday	Daily loss report and HPU, Prepared Weekly loss report for Jan W1, Prepared Monthly loss report for the month of Dec, APS deployment for station : Group 1, Team 1 : (30R,40L1)
		5/1/2016	Tuesday	Daily loss report and HPU, APS deployment for station : Group 1, Team 1 : (30L1,40R1,40R2), Team 2 : (01L1)
		6/1/2016	Wednesday	Daily loss report and HPU, APS deployment for station : Group 1, Team 2 : (10L1,10R1,20L1,60L1); *I oriented to new intern at GA and Body shops;* **Assigned Six Projects for the 6 months Internship**
		7/1/2016	Thursday	Daily loss report and HPU, Action sheet understanding oriented by Amit Sir, APS deployment for station : Group 1, Team 2 : (60R1,60R2,60R3)

		8/1/2016	Friday	Daily loss report and HPU, APS deployment for station : Group 1, Team 3 : (R10L1,R30L1,R30L2,R50L1,F10L1, F10L2)
		9/1/2016	Saturday	Weekly off : Robocon/GRE class
	4	10/1/2016	Sunday	Weekly off : Robocon/GRE class
		11/1/2016	Monday	Daily loss report and HPU, Weekly report prepared for Jan W2, Reviewed APS deployment report, APS deployment for station : Group 1, Team 4 : (R10R1,R30R1,R30R2)
		12/1/2016	Tuesday	APS deployment for station : Group 1, Team 4 : (R40L1,R50R1) ; Team 5 : (10L1,20L2,30L1,40L2,50L1,20L1); Team 6 : (10R1,20R1,20R2,30R1,40R1,50R1) Made a report for Group 1 including MODE and APS timings along with my review.
		13-01-16	Wednesday	Visited all stations for my first review check and found out errors at many stations related to timings. *Gave an Body shop orientation to Colleague*
		14-01-16	Thursday	APS deployment for station : Group 2, Team 1 : (10L1,10R1,10R2,01L1)
		15-01-16	Friday	APS deployment for station : Group 2, Team 1 : (02R1,10L1,10R1,10R2)
		16-01-16	Saturday	Weekly off : Robocon/GRE class
	5	17-01-16	Sunday	Weekly off : Robocon/GRE class

		18-01-16	Monday	Helped in preparing Weekly report for Jan W3, Helped in calculating and analyzing the burr formation and took videos for line balancing. Helped : took video for Engine room sealer application to cross check the work time
		19-01-16	Tuesday	Helped in calculating and analyzing the formation of burr also filled STDs for calculating actual time, APS deployment for station : Group 2, Team 2 : (20L1,20R1)
		20-01-16	Wednesday	APS deployment for station : Group 2, Team 2 : (30R1,30L1,30L2,20R2) also corrected the errors in APS
		21-01-16	Thursday	APS deployment for station : Group 2, Team 2 : (40L1); Team3: (20L1,20R1,20L2)
		22-01-16	Friday	APS deployment for station : Group 2, Team 3 : (30R1,30L1,30L2,40L1,30R2)
		23-01-16	Saturday	Weekly off : Robocon/GRE class
	6	24-01-16	Sunday	Weekly off : Robocon/GRE class
		25-01-16	Monday	On Leave for Sister's marriage
		26-01-16	Tuesday	Holiday : Republic day
		27-01-16	Wednesday	On Leave for Sister's marriage
		28-01-16	Thursday	
		29-01-16	Friday	
		30-01-16	Saturday	Weekly off : Robocon/GRE class
	7	31-01-16	Sunday	Weekly off : Robocon/GRE class
Feb.		1/2/2016	Monday	On Leave for Sister's marriage

2016		2/2/2016	Tuesday	Daily loss report and HPU, Monthly report filled
		3/2/2016	Wednesday	Helped in preparing (HPU) improvement report and Layout presentation
		4/2/2016	Thursday	
		5/2/2016	Friday	
		6/2/2016	Saturday	Weekly off : Robocon/GRE class
	8	7/2/2016	Sunday	Weekly off : Robocon/GRE class
		8/2/2016	Monday	Line balancing case for Rear and Front floor SGM process study by taking videos and pictures
		9/2/2016	Tuesday	
		10/2/2016	Wednesday	
		11/2/2016	Thursday	STDs completion in MODE software for Rear and Front floor SGM
		12/2/2016	Friday	STDs completion in MODE software for Rear and Front floor SGM
		13-02-16	Saturday	Weekly off : Robocon/GRE class
	9	14-02-16	Sunday	Weekly off : Robocon/GRE class
		15-02-16	Monday	Weekly Report prepared, Line balanced using MODE software for Rear and Front floor SGM
		16-02-16	Tuesday	Line balancing using MODE & APS software's for Rear and Front floor SGM
		17-02-16	Wednesday	Line balancing for Underbody SGM
		18-02-16	Thursday	Line balancing for Underbody SGM
		19-02-16	Friday	Leave taken for Reverb
		20-02-16	Saturday	Weekly off : Robocon/GRE class
	10	21-02-16	Sunday	Weekly off : Robocon/GRE class
		22-02-16	Monday	Weekly report prepared, STDs made for Engine room SGM

		23-02-16	Tuesday	Leave taken for Interview for Semester Exchange program for Fall semester
		24-02-16	Wednesday	Line balancing for Engine room station #210 SGM, **Assigned four projects for Ergo rate in Body shop**
		25-02-16	Thursday	Line balancing for Engine room station #220
		26-02-16	Friday	Line balancing for Engine room station #230
		27-02-16	Saturday	Weekly off : Robocon/GRE class
		28-02-16	Sunday	Weekly off : Robocon/GRE class
		29-02-16	Monday	MENTOR VISIT Made reports for Engine room, Rear & front floor and Underbody for the implementation of the Line balancing
March. 2016	11	1/3/2016	Tuesday	Got all the Balanced reports corrected by Team leader and made the corrections required
		2/3/2016	Wednesday	Created NEW SOS for all the stations and thus balanced the line. Hence also optimized the manpower.
		3/3/2016	Thursday	Robocon Competition
		4/3/2016	Friday	
		5/3/2016	Saturday	Weekly off : Robocon/GRE class
	12	6/3/2016	Sunday	Weekly off : GRE class
		7/3/2016	Monday	Preparation of TIP board at Body shop as per Standardization/Process flow. Also prepared the Project board too. Documents format preparation and calculations done.
		8/3/2016	Tuesday	

		9/3/2016	Wednesday	
		10/3/2016	Thursday	Line balancing case for Engine Room M300 process study by taking videos and pictures of SOS. Specially focused on station ENR10
		11/3/2016	Friday	Line balancing case for Engine Room M300 for 10R1, 10L1 & 10L2
		12/3/2016	Saturday	Weekly off : GRE class
	13	13-03-16	Sunday	Weekly off : GRE class
		14-03-16	Monday	Line balancing case for Engine Room M300 for 30R1 & 30L1
		15-03-16	Tuesday	Line balancing case for Engine Room M300 for 40R1 & 40L1
		16-03-16	Wednesday	Line balancing case for Engine Room M300 for 60L1, 60R2 & 60R3
		17-03-16	Thursday	Report submitted for the stations mentioned above. After corrections and due to constrains further more Line balancing was done for Engine Room M300 and added 10R2 & 40R2
		18-03-16	Friday	Helped in preparing Body Shop TIP board along with documentation.
		19-03-16	Saturday	Weekly off : GRE class
	14	20-03-16	Sunday	Weekly off : GRE class
		21-03-16	Monday	Weekly report prepared. Also prepared the New TIP report as per 4M. Helped in preparing Body Shop TIP board along with documentation.

		22-03-16	Tuesday	Line balancing case for Front floor M300 process study by taking videos and pictures of SOS.
		23-03-16	Wednesday	Line balancing case for Front floor M300 for 10R1 & 10L1
		24-03-16	Thursday	Holiday
		25-03-16	Friday	Line balancing case for Front floor M300 for 10R2 & 10L2
		26-03-16	Saturday	Weekly off : GRE class
	15	27-03-16	Sunday	Weekly off : GRE class
		28-03-16	Monday	Prepared a Presentation to explain the balancing of spot for Front Floor M300. Implementation of SGM line balancing: APS completion of Engine Room SGM along with Team leader.
		29-03-16	Tuesday	Implementation of SGM line balancing: APS completion of Engine Room SGM along with Team leader.
		30-03-16	Wednesday	Line balancing case for Rear Floor M300 process study by taking videos and pictures of SOS. Line balancing case for Rear floor M300 for 10L1, 10R1 & 10L2
		31-03-16	Thursday	Line balancing case for Rear Floor M300 for 30L2 & 30R2
April. 2016		1/4/2016	Friday	Line balancing case for Rear floor M300 for 30L1 & 30R1
		2/4/2016	Saturday	Weekly off : GRE class
	16	3/4/2016	Sunday	Weekly off : GRE class

		4/4/2016	Monday	Line balancing case for Rear floor M300 for 40L1 & 40R1. Helped in Preparation of Plant TIP board.
		5/4/2016	Tuesday	Line balancing case for Rear floor M300 for 50L1 & 50R1. Conducted a meeting with Manager for explaining the New 4M TIP Monthly report and to handover the responsibility of TIP board.
		6/4/2016	Wednesday	Implementation of SGM line balancing: APS completion of Front and Rear Floor SGM along with Team leader.
		7/4/2016	Thursday	Implementation of SGM line balancing: APS completion of Front and Rear Floor SGM along with Team leader.
		8/4/2016	Friday	Holiday
		9/4/2016	Saturday	Weekly off : GRE class
	17	10/4/2016	Sunday	Weekly off : GRE class
		11/4/2016	Monday	Implementation of SGM line balancing : All SGM stations Recheck. Closures line balancing.
		12/4/2016	Tuesday	Gave APS training to Team Leader. Implementation of SGM line balancing : Final Check and Correction for all JES for Print Out.
		13-04-16	Wednesday	Worked on GMS book/ Standardization Guide.
		14-04-16	Thursday	Line balancing case for Underbody M300 process study by taking videos and pictures of SOS.
		15-04-16	Friday	Line balancing case for Underbody

				M300 for 40L1, 40R1.
		16-04-16	Saturday	Weekly off
	18	17-04-16	Sunday	Weekly off
		18-04-16	Monday	Line balancing case for Underbody M300 for 50L1, 50R1.
		19-04-16	Tuesday	Made changes in the Standardization Guide for 9th Edition.
		20-04-16	Wednesday	Updated Standardization Guide at all the 42 Group rooms and conducted a pre-audit.
		21-04-16	Thursday	New Model line balancing for MCM by Spots distribution planning (changes after adding new fixture).
		22-04-16	Friday	New Model line balancing for MCM by Spots distribution planning (changes after adding new fixture).
		23-04-16	Saturday	Weekly off
	19	24-04-16	Sunday	Weekly off
		25-04-16	Monday	Meeting with Rihan sir discussed about spots distribution for MCM. Trained New Trainees. Gave an overall idea about the project.
		26-04-16	Tuesday	Trained new trainees for •Daily Loss Report, •APS Software, •Line balancing methods/techniques, •Explained about ATT(Actual Tack time) and TT(Tack time) and its calculations, •Over speed Report and calculations, •STDS Software.
		27-04-16	Wednesday	Trained new trainees for •STDS Software along with practice on dummy station.
		28-04-16	Thursday	Trained new trainee STDS completion

				of BIW line.
		29-04-16	Friday	Leave taken for Award Function at the college
		30-04-16	Saturday	Weekly off
May. 2016	20	1/5/2016	Sunday	Weekly off
		2/5/2016	Monday	Trained new trainees for •Weekly Report, •Monthly Report & •4M Report.
		3/5/2016	Tuesday	Trained new trainees by STDS completion of BIW line.
		4/5/2016	Wednesday	Trained new trainees by STDS completion of BIW line.
		5/5/2016	Thursday	Trained new trainees for •APS Software including : Scroll dig, New Station creation etc. (Preparation for Shutdown)
		6/5/2016	Friday	Trained new trainees by STDS completion of BIW line with scroll dig
		7/5/2016	Saturday	Weekly off
	21	8/5/2016	Sunday	Weekly off
		9/5/2016	Monday	Training given to Team Leaders for APS software. APS Deployment for all the Line balancing done in the Body shop. Involving JES, Task sequence, Pictures, Symbols, Safety & Quality issues and Revision History Updation.
		10/5/2016	Tuesday	
		11/5/2016	Wednesday	
		12/5/2016	Thursday	
		13/5/2016	Friday	
		14/5/2016	Saturday	Weekly off
	22	15/5/2016	Sunday	Weekly off
		16/5/2016	Monday	Mentor Visit on Wednesday. Training given to Team Leaders for APS software. APS Deployment for all the Line balancing done in the Body shop. Involving JES, Task sequence,
		17/5/2016	Tuesday	
		18/5/2016	Wednesday	
		19/5/2016	Thursday	
		20/5/2016	Friday	

		21/5/2016	Saturday	Pictures, Symbols, Safety & Quality issues and Revision History Updation.
	23	22/5/2016	Sunday	Weekly off
		23/5/2016	Monday	APS Deployment for all the Line balancing done in the Body shop.
		24/5/2016	Tuesday	Shutdown Period for addition of Robots on MFL line and New Fixtures for MCM car.
		25/5/2016	Wednesday	
		26/5/2016	Thursday	
		27/5/2016	Friday	
		28/5/2016	Saturday	Weekly off
	24	29/5/2016	Sunday	Weekly off
		30/5/2016	Monday	Solved issues related to MFL, Side LH & RH and MRS lines. Print out taken for completed SOS & JES for time validation, conducted along with trials runs.
		31/5/2016	Tuesday	
June. 2016		1/6/2017	Wednesday	
		2/6/2017	Thursday	
		3/6/2017	Friday	
		4/6/2017	Saturday	Weekly off

Table 23 : Weekly Progress Report

SUMMARY AND FUTURE SCOPE

Production-line balancing study tends to employ thought and ingenuity to change conditions. Production-line design and operation is more art than science. Labor flexibility is the key to effective resource management. The idea of worker's checking and doing minor repair work on their own equipment possibly decreases the risk of equipment failure. Selecting an appropriate set of balancing mechanism is a part of work cell design and it must be linked with many other decisions for the system to function well.

RESULTS :

The duration of the project based on the Manpower Optimization target i.e. of 60 Manpower was for the entire year 2016, solely from Body shop. In which as per the planning we had to complete whole Time study for the entire Shop and based on which we had to do Line balancing. After the APS deployment the trial runs had to place and thus the production had to begun.

Fortunately we had successfully completed the whole project by May, 2016 itself along with the trial runs and Manpower was optimized beyond the target value. Which resulted into great appreciation for the work.

Following are the successful results during the Project Completion :

1. **Time Study Using STDS :**
   Nearly 120+ Operator's SOS Time Study have been completed. Namely of the following Lines :
   - ✓ Dash M300
   - ✓ Engine Room M300
   - ✓ Front Floor M300
   - ✓ Rear Floor M300
   - ✓ Underbody M300
   - ✓ Side LH and RH M300
   - ✓ Main Frame Line M300
   - ✓ Engine Room SGM
   - ✓ Rear Floor SGM
   - ✓ Front Floor SGM
   - ✓ Underbody SGM
   - ✓ BIW Line
   - ✓ Closure Line SGM

- ✓ Roof M300

Time Study involved the complete study of the respective station along with interaction with the Operators .

2. **Productivity Improvement through Line Balancing :**

Following are the proposals made on the basis of forecast study and high authority guidance to accomplish the target required for Manpower Optimization. All these Proposal's were accepted and successfully executed in the Body Shop.

AREA	PROPOSAL MADE
SGM M300	JPH Change from 6JPH/2Shifts to 2JPH/2Shifts JPH Change from 18JPH/2S to 22JPH/2S
CLOSURES	Closures M300 JPH change from 15JPH/3S to 18JPH/3S AND Closures SGM JPH change from 6JPH/2S to 6JPH/1S
ROBOTS	Proposal of transferring Robots from Australia

Based on these Proposal's Following Stations were Re-Balanced on the basis on the Time Study for Manpower Optimization:

1. Engine Room SGM
2. Front and Rear Floor SGM
3. Underbody SGM
4. Engine Room M300
5. Rear Floor M300
6. Front Floor M300
7. Underbody M300
8. Closure SGM

3. **Manpower Optimized :**

- Based on the Line balancing done an Overall Manpower Optimized was of **67 Manpower** from which 51 were from Line balancing and the rest was from 12% Absenteeism and TL to Workmen ratio. Among 51, I had alone optimized 43 Manpower :

11 Manpower were removed from SGM area and 6 From MFL M300 Line per shift, from which 8 Manpower were Re-deployed into M300 area for One Shift i.e. benefit of 18 Manpower in both shifts. Based on the Proposal of Work shift 25 manpower were removed from Closure Line.

Thus overall 25 + 18 = 43 manpower had been Optimized. These manpower will be utilized in the launch purpose of the New vehicle.

4. APS Deployment :

- Deployed APS for the entire Body Shop i.e. for all 6 Groups on line by generating SOS and JES for each and every operator, as per the new balanced line. Also generated Wall Charts and Scrolling of individual stations.
- Also Providing training to Team Leaders for APS deployment.

5. Study of Implementation of New Models

- **Proposal** made for an issue caused due to the changes done, at Main Respot Line (Common Line) was greatly appreciated for its cost free solution and has been approved for trial runs. This will reduce the work load at MRS line and the Line will thus get balanced.

6. Downtime Monitoring

- By analyzing downtime and acknowledging the respective departments about their problematic areas, in terms of number of vehicle lost per day, the downtime has reduced and losses are being rectified.
- The Plant HPU data shows improvement with the overview of the downtime losses over the entire project duration.
- Among the Two **proposed report** type for TIP board namely Station wise Report and 4M report , 4M report was approved and has been implemented on all Shop areas that are Body shop, Paint shop and General assembly shop along with Plant TIP board. The Report is currently in use and optimized efficiently.

7. **Ergonomics**

- Two High rated stations with Ergo issues were detected and solutions for them are being **proposed.**

  Which will improve the efficiency the operator and reduce the work load.

8. **Standardization**

- Based on the review, helped in making of the 9th version of the Standardization Guide along with its validation through proxy audits.

FUTURE SCOPE :

There are many changes taking place in the activities being performed at the Plant. Due to which Line balancing plays an important role in for smooth functioning along with efficiency at the shop floor. New Vehicles are about to launch in the market which are going to be produced at General Motors India, Talegaon plant. Thus there is a huge work about to take place in the near future.

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