

# **Effectiveness of increasing span of control on operational performance variables: A case study**

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## **Abstract**

The following paper investigates the impact of increasing the span of control post 2009 at the Big Three (GM, Ford, and Chrysler LLC) facilities in North America on selected operational performance variables. Utilizing Design of Experiment (DOE), this research addressed the significance of the three independent variables on the three outputs and the optimal level of span of control based on the best achieved outputs. The inputs for this study are the average span of control at the Engine, Transmission, and Assembly facilities, and the outputs are: Jobs per Hour Lost (JPHL), Quality rejects (Direct Run First Time capability), and employee morale (Absenteeism). The analysis shows that the variables are significant for all outputs. While the absenteeism variable improved the other two deteriorate. The paper clearly indicates that the lower the span of control the better the operational outputs.

**Keywords:** span of control efficiency, direct run loss, jobs per hour lost

## **Introduction**

The 2009 economic crises caused a significant decline in automotive market shares. According to the Research and Statistics Branch at the United Nations Industrial Development Organization (2010), this reduction in market share and market demand, forced the Big Three to shut down plants, lay off employees, cut production and make organizational changes such as increasing the span of control. Post 2009 the Big Three started looking at different organizational strategies in order to reduce cost. A particular attention was given to the span of control and its efficiency and effectiveness within those companies (Wunker 2012). According to Wunker (2012), the new trends within the Big Three are based on downsizing and flattening the organizations. Flattening the organization will eliminate certain managerial roles and will increase the number of team leaders. Driven by macro-environmental (i.e. demand declines, competition) and organizational factors (i.e. stagnant sales associated with low profitability, poor international competitiveness improvement, growth of stable management) firms continue to flatten their organization (Toyota Motor Company 2010). Researchers have discovered that downsizing is not necessarily advantageous, is not an entire beneficial technique to enterprises, and it generally has a negative effect on employees.

The following study investigated impact of increasing the span of control at different Big Three facilities in North America and their impact on operational performance. The three output variables that this study considered, namely jobs per hour lost, quality rejects and absenteeism were selected based on recommendations from the managers at the facilities studied. The facilities visited are divided into three categories: engine, transmission and assembly facilities. The engine and transmission facilities provide parts for the assembly facility. This study grouped the three facilities based on parts supply dependence. All facilities studied operate under United Auto Workers and management contract or agreement. The main objectives of this paper are to study the significance of the interactions between the variables and the overall impact of increasing the span of control on output variables. In addition, the paper determines the optimal level of span based on the data obtained.

## Background

All three types of facilities studied produce different components but from an operational perspective they are identical. The engine and transmission facilities at the Big Three are considered PowerTrain facilities. The Powertrain facilities provide components to the assembly plant that is responsible for producing the final product. For example an engine or a transmission facility could provide parts to more than one assembly facility. This study grouped the facilities by the relationship between them. Therefore, the engine and transmission facility that provide parts to an assembly facility is placed in the same group.

The assembly process within the automotive facilities: Engine, Transmission and Assembly are designed in a sequential pattern. This process is known as continuous flow or referred to as line flow. For example, the automotive assembly facility is comprised of three main departments (Figure 1) and each department is divided into several sections or zones.

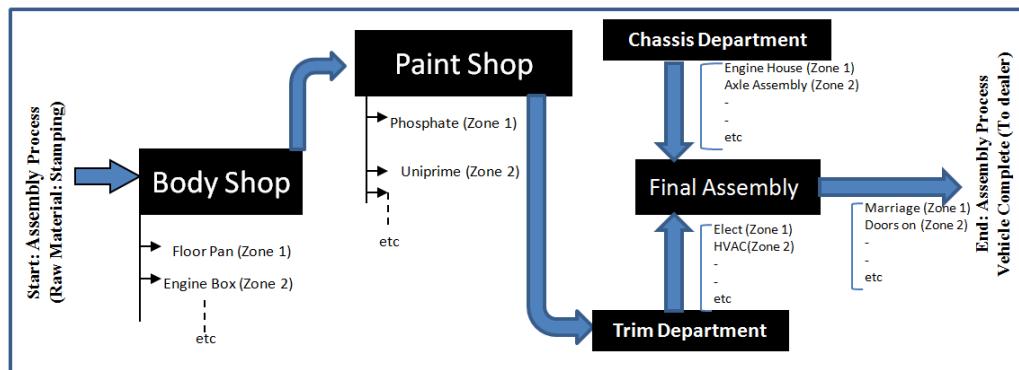


Figure 1: Automotive Assembly process layout

The design of the process layout in the manufacturing facility directly affects the efficiency and utilization of a company (El-Khalil and Halawi 2012). The objective of any process layout is to organize the company's physical facility in a manner that promotes an efficient use of people, equipment, material, and energy (Dolgui and Proth 2010).

## Organizational Structure: Span of Control and Responsibilities

The standard organizational structure at all of the automotive facilities is comprised of several levels, as illustrated in Figure 2. Each type of employee has a different title and responsibilities. Table 1 presents the bottom two levels.

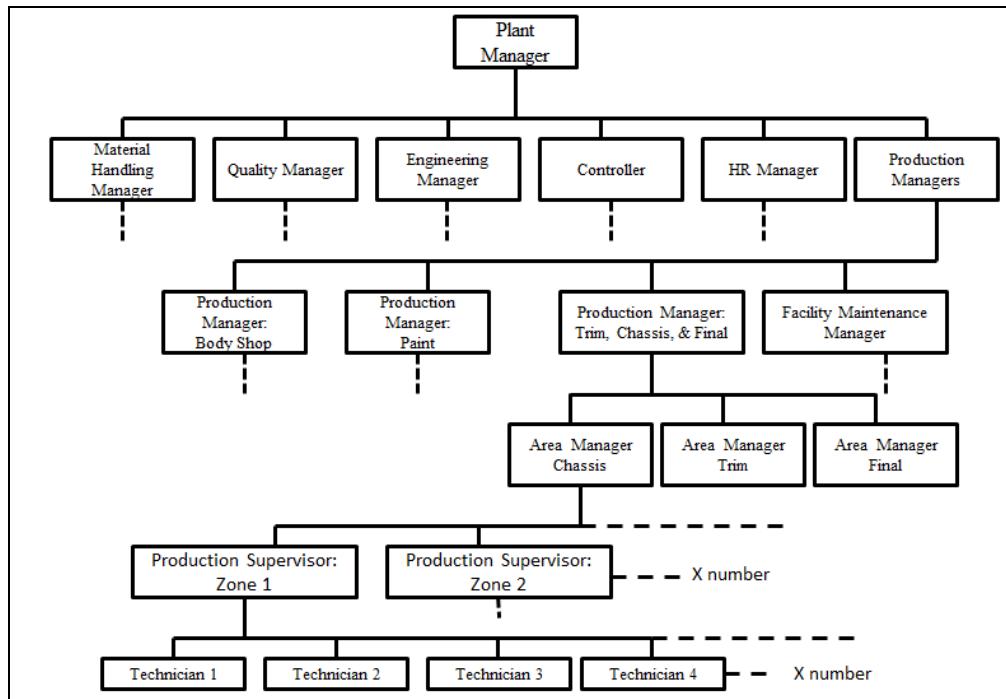


Figure 2: Manufacturing Facility Organizational Chart sample

Table 1: Organizational levels and description

Level	Title	Requirements and Description
1	Technicians	<ul style="list-style-type: none"> <li>• Paid Hourly</li> <li>• Responsible for a defined work area</li> <li>• Given a specific work load to be performed within takt time</li> <li>• Notify production supervisor in case issues arise that prevent operation completion</li> </ul>
2	Production supervisors	<ul style="list-style-type: none"> <li>• Ensure their zone/department employees deliver production requirements within takt time, at the required quality, and at a given cost</li> <li>• Train employees and plan for production</li> <li>• Assign technicians to work station</li> <li>• Appraise employee performance, reward, and discipline employees</li> <li>• Address complaints and resolves problems</li> <li>• Adjust tools and machines</li> <li>• Conduct Scorecard review</li> <li>• Orders and obtain material required for technicians</li> <li>• Assist and support technicians in solving work problems</li> <li>• Translate targets and plans (given by upper management) to their subordinates</li> </ul>

Authors such as Wall et al (1986), and Gittell (2001) indicate that neither team voice nor the representative voice shows a significant relationship towards labor productivity when solely

observed. However, team voice, considered in concurrence with representative voice, significantly enhances worker efficiency.

### *Business Plan and Scorecard*

The automotive assembly facilities (Engine, Transmission and Assembly) operate based on a business plan that is created by the all employees within the facility. The business plan is updated annually and includes scorecard targets for safety, quality, delivery, cost, moral, and environment (SQDCME). These targets are detailed and tracked on daily bases by facility managers and employees. The purpose of establishing a business plan system is to deliver business success that is driven by discipline in development and execution. Based on the facilities visited, this process is:

- 1- Developed with all levels of the organization.
- 2- Establishes one common goal and alignment to focus on established objectives. These objectives support the score card process: Safety, Quality, Delivery, and Cost, Moral, and Environment (SQDCME) goals and objectives.
- 3- Provides plan that gives focus and direction.
- 4- Drives continuous improvement process.

Based on the recommendations given by managers and engineers at the engine, transmission and assembly facilities visited, the top three variables that directly impact cost that were studies are: (a) quality rejects, (b) jobs per hour lost (JPHL), and (c) moral. The latter issues are measures that the business plan tracks/includes on a daily basis. Those issues are part of a process that identify problems and implement solutions to improve facility overall performance. The numbers for the three variables will represent the average for the three facilities.

### *Quality rejects: Direct Run First Time Capability (DRFTC)*

The automotive companies (i.e. Big Three) utilize Direct Run First Time Capability (DRFTC) in order to evaluate the capability of building quality in the process and to clarify the problems to be resolved. The DRLFTC is a standardized method of measurement that is common through all facilities at the Big Three. DRLFTC, also known as FTC is measured by multiplying throughputs from the stages/stations in the inspection zone at the end of the process. Figure 4 illustrates how the process is conducted at the Assembly facilities.

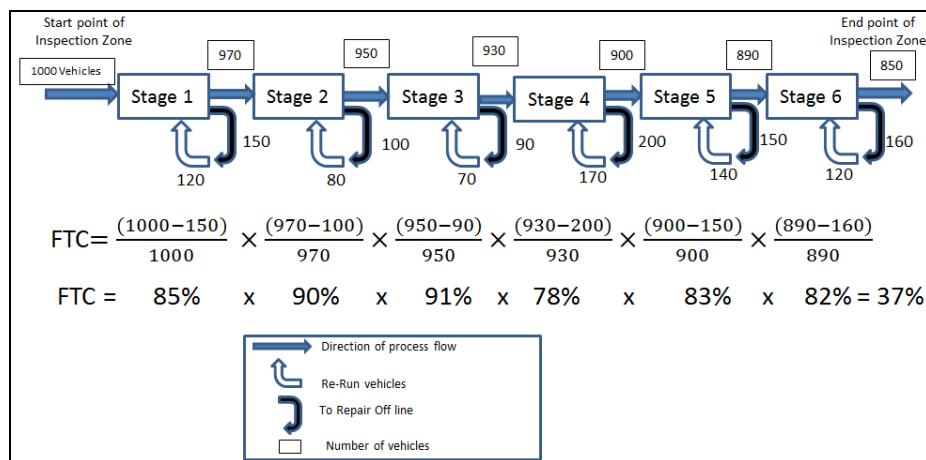


Figure 3: Inspection and Road Test Zone (Final Department): Calculating DRLFTC by stage

### *Jobs per Hour (Lost)*

The Jobs per Hour (JPH) lost is a number calculated at the facilities to reflect lost production volume caused by operator related issues. These issues include items found during production that cause line stoppage. Examples of such issues are: misassembled parts, missing parts, and wrong parts installed. This number is determined prior to the Inspection Zone stage.

$$JPH(Lost) = JPH - \text{down time (unpredicted down time)} \quad (1)$$

Where:

$$JPH = \frac{\text{Time available per hour for production}}{\text{Time it takes to produce a vehicle}} \quad (2)$$

- Time available per hour for production = 1 hour – forecasted down time (i.e. breaks, lunch, team meetings, and or maintenance).
- Time it takes to produce a vehicle typically is determined by Takt time. The latter is determined annually by the forecasted sales (the Takt time is calculated by dividing available annual working days by the annual forecasted volume of production).

The production supervisor is required to review each Job per hour lost with in his or her department and zone (with the production employee) and report each job lost and reasons.

### *Moral*

Moral will be determined through data obtained from each facility on the overall absenteeism. The numbers utilized in this study perfects the assembly facility manpower only. The reason for selecting the assembly facilities was based on the fact that the assembly facility manpower ratio in comparison with the Powertrain facilities is 1 to 10.

### **The Experiment: Effect of increasing Span of Control**

Design of experiment was utilized in this paper to design, conduct, and analyzes the experiment in order to effectively draw an objective decision and or conclusion.

The experiment was designed to determine the significance of variables on outputs and the optimal level of span of control based on the best achieved outputs (pre 2009).

*Hypothesis:* the independent variables (i.e. Assembly =  $x_1$ , Engine =  $x_2$ , and Transmission =  $x_3$ ) are insignificant for the three outputs determined (i.e. DRFTC, JPHL, and Absenteeism). The acceptance of the hypothesis requires the P-values based on the analysis of variance be greater than 0.05.

### *Method*

This research, which focuses on the impact of increasing the span of control on automotive facility outputs, is an extension of an earlier study on the Big Three automotive flexibility (El-Khalil 2009). The Big Three companies were contacted and asked for permission in order to visit facilities and interview personnel for this research. The companies provided a list of facilities with specific dates for visits and recommended certain experts from those facilities for interviews. Interviews and visits were conducted between August 2011 and August 2012.

## Design

The experiment was a full factorial design (3 factors at levels 3)  $3^3 = 27$ . Independent variable code are: -1 “Low”, 0 “Average”, and 1 “High” (were Low = 45 to 60, Average = 61-80, and High = above 80). The factors are: A = Assembly ( $x_1$ ), E = Engine ( $x_2$ ), and T = Transmission ( $x_3$ ).

The hypothesis states that the three independent variables have no significant impact on the outputs determined (i.e. DRLFTC, Jobs per Hour Lost (JPHL), and Absenteeism). The aim is also to identify the ranking of significant factors.

The data utilized was obtained from 67 different automotive facilities at the Big Three in North America. The data presented in the study was based on average number for two years post 2009 (2010 and 2011). The outputs utilized based on recommendations by the facilities are:

Output 1: Direct Run Lose First Time Capability (DR-FTC)

Output 2: Jobs per Hour Lost (JPHL)

Output 3: Absenteeism (ABS)

Therefore, three designs of experiments combinations were performed:

$$DR = a_1 \times C^{k_1} \times T^{L_1} \times A^{m_1}$$

$$JH = a_2 \times C^{k_2} \times T^{L_2} \times A^{m_2}$$

$$INJ = a_3 \times C^{k_3} \times T^{L_3} \times A^{m_3}$$

Take the natural log of the above three equations

$$Ln DR = Ln a_1 + K_1 Ln C + L_1 Ln T + m_1 Ln A$$

$$Ln JH = Ln a_2 + K_2 Ln C + L_2 Ln T + m_2 Ln A$$

$$Ln INJ = Ln a_3 + K_3 Ln C + L_3 Ln T + m_3 Ln A$$

The quadratic models for the outputs are as follows:

For DR:

$$y_1 = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_{11} x_1^2 + b_{22} x_2^2 + b_{33} x_3^2 + b_{12} x_1 x_2 + b_{13} x_1 x_3 + b_{23} x_2 x_3$$

For JN:

$$y_2 = c_0 + c_1 x_1 + c_2 x_2 + c_3 x_3 + c_{11} x_1^2 + c_{22} x_2^2 + c_{33} x_3^2 + c_{12} x_1 x_2 + c_{13} x_1 x_3 + c_{23} x_2 x_3$$

For INJ:

$$y_3 = d_0 + d_1 x_1 + d_2 x_2 + d_3 x_3 + d_{11} x_1^2 + d_{22} x_2^2 + d_{33} x_3^2 + d_{12} x_1 x_2 + d_{13} x_1 x_3 + d_{23} x_2 x_3$$

## Analysis of results

The outputs obtained from the Minitab software show the following:

- 1- All P-values based on analysis of variance are less than 0.05, which is a clear indication to reject the hypothesis. In other words, it means that there is a 5% probability (maximum) that the results are randomly distributed. The result indicates that the term X1 (Engine), X2 (Transmission) and X3 (Assembly) are significant for all responses of output.
- 2- Based on the main effects plot we conclude that DRFTC, JPHL, and Absenteeism deteriorate as the span of control increase, with one exception for Transmission facilities at high span ABS was lower than span at average span (but higher than at lower). This deterioration is more significant in Assembly facilities than Engine and Transmission.
- 3- Interaction plots indicate that there are interactions for ABC: Engine and Transmission at average level, Engine and Assembly at high, and Transmission and Assembly at High level. DRFTC there are interactions between Engine and Transmission at average level,

interaction between Engine and assembly at high level, and interaction between all three at average level. For JPHL: Interaction between Engine and Transmission at High level, interaction between Engine and Assembly at high level. The interaction plots indicate that as span of control increase interaction tends to increase.

- 4- The plots generated in the analysis phase, clearly indicate that the lower the span of control the better is the three outputs.

Overall the span of control has a direct impact on the three variables. This impact increases as the span of control increase.

#### *Increasing span of control Post 2009*

The span of control was increased in all facilities after 2009. The level of changes (i.e. increase, decrease) in outputs and inputs varied significantly. The span of control increase at its lowest level was 71% and at its highest level the increase went up as high as 214% with an average increase of 139%.

In comparison with data from pre 2009, the post 2009 numbers indicate the following:

- 1- Increase in Span of Control by an average of 139%
- 2- Deterioration in DRFTC by an average of 2%.
- 3- Deterioration in JPHL by an average of 90%.
- 4- Improvement in absenteeism by an average of 4%.
- 5- The increase in span of control from pre 2009 to post 2009 was not a standard increase. Based on the data collected some facilities within the same companies increased by different ratios.
- 6- The facilities which had the lowest number of increase in span of control in most case showed an improvement in all three outputs (9 to 1 ratio).

*Table 2: Percentage increase and decrease in inputs and outputs from Pre 2009 to Post 2009*

Pre 2009 vs. Post 2009				
	Span of Control	*JPHL	**DRFTC	***ABS
Min	71%	-10%	-9%	-31%
Max	214%	200%	12%	8%
Average	139%	90%	-2%	-4%
Std	47%	51%	6%	8%

Calculated % = (Post 09 – Pre 09)/09 x 100

\* +ve JPHL = deterioration and – ve = Improvement

\*\* – ve DRFTC = deterioration and + ve = Improvement

\*\*\*+ve ABS = deterioration and – ve = Improvement

In its attempt to support the supervisor's new task the automotive companies (Big Three) adopted the Toyota production system of span of control. This new adopted concept introduced an additional level to the management process which is a technician team leader, as illustrated in Figure 8. The technician team leader is an employee selected from the same zone or department and his or her task is to insure support team members in conducting their task. Part of the team leader task is to:

- 1- Insure that all technicians' machine and or equipment are available and running to specification,
- 2- Support technician in case problems occur,

- 3- Randomly inspect conducted job in the zone,
- 4- Monitor and control technician training and rotation on jobs in the zone,
- 5- Update the metrics board,
- 6- Conduct safety talks,
- 7- Conduct team meetings and resolve issues arise,
- 8- Communicate with supervisor for the required support.

The following are some of the concerns and issues noted during the conducted facility visits:

- 1- The Toyota team leader system is implemented in a non-union environment,
- 2- Union employees cannot supervise other union employees (by UAW contract Article VI, Section 1). Therefore, the team leader can give direction and it's up to the technician to follow or not,
- 3- Managers interviewed indicated that most of the team leaders are given position by seniority. Capability was not the criterion for selection in most cases,
- 4- Managers indicated that the new system was decided on by upper management and implemented within two month period.

In theory, since the supervisor in the new system (Post 2009) adopted at the Big Three will only deal with the team leaders his or her span of control will increase but without increasing work load. In practice the supervisors interviewed at the Big Three indicated the following:

- 1- The changes in span of control was done within one month and issues such as team leaders and responsibility was determined after,
- 2- They are in daily contact with technicians, in most case resolving and directing technicians to perform certain tasks, due to the conflicts and UAW supervision agreement mentioned above,
- 3- Most of team leaders lack the skills in certain area which require the supervisor to perform their jobs. For example some team leaders do not know how to get information and update board charts in Microsoft Excel or PowerPoint,
- 4- Most of team leaders lack technical skills.

The comments and the result achieved indicate that the upper management “need” to look decisive undermines the value of giving the process its necessary time in order to assess, evaluate people, and adjust strategies before implementing the new span or control structure.

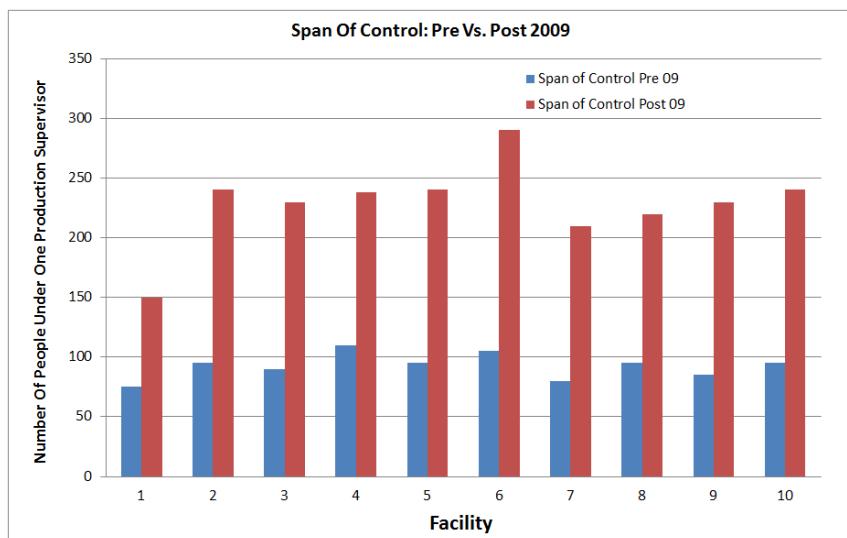


Figure 4: Span of control increase from Pre 2009 to Post 2009

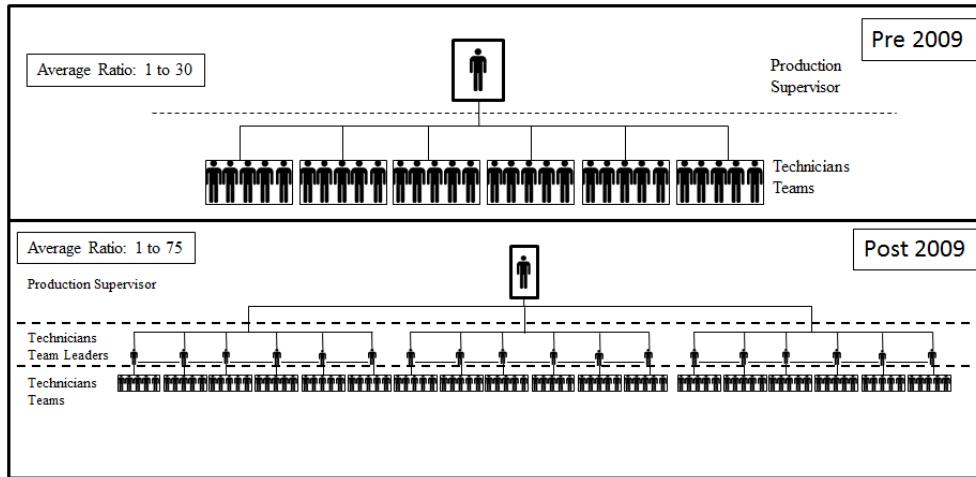


Figure 5: Span of control increase from Pre 2009 to Post 2009

#### *Efficiency Comparisons Pre 2009 and Post 2009*

Improving labor efficiency directly reduces cost of manufacturing and assembly. The objective of each facility is to increase efficiency to optimal level. According to the Harbour Report automotive companies such as Toyota operates at 96 to 126% utilization. Advantages of improving efficiency and utilization (Wilson 2010):

- 1- Reduce labor cost,
- 2- Reduce tool and machinery usage,
- 3- Reduce work in process,
- 4- Improve quality control,
- 5- Others.

Authors, such as Morgan (2006), indicate that increasing efficiency without providing proper training, equipment, tools, proper work zone area, and team support will lead to deterioration in SQDCME. According to the managers at the facilities visited there has been a drastic reduction in manpower in the past four years. That reduction average in the past 6 years was as follows:

- 1- For Engine facilities around 25%.
- 2- For Transmission facilities around 31%.
- 3- For Assembly facilities around 35%.

Based on the above information, a question was presented to the facilities personnel about the discrepancy between improvements in efficiency and deterioration in facility output variables. The managers indicated that the top three reasons that the improvement in output variables was not the same as improvements achieved in labor efficiency due to the following:

- 1- 98% of managers indicated that the number one issue is increasing supervisor subordinate technicians. Lack of supervisors' time to respond to issues and concern during production shift.
- 2- 95% of managers indicated that the number two issue is lack of proper training. Increasing technicians responsibility with minor or no training given.
- 3- 60% of managers indicated that the number three issue is employee classification. For example if technicians find a problem they will not fix it due to classification restrictions and they need to call an inspector or a team leader to fix problem. This issue can be resolved by eliminating the different employee classification, which is the case at Toyota, Honda, and Nissan (Toyota Motors Company 2010).

## Concluding Remarks

Achieving an efficient and practical direct reports number or span of control number in automotive industry is a challenging task which requires time and support of every discipline within the organization. Increasing the span of control without improving the skills of employees and or technicians will lead to deterioration in operation performance metrics. The task of increasing the levels for span of control will provide improvements required only if the new level has the capability to perform its task. The data indicates that the lower the span of control is the better the business metrics are.

It is clear that the upper management must adapt their methods to suit their needs. For example, in an area that requires higher skilled employees the span of control must be lower than the area that does not require as much skills. In addition, issues such as: the ability of team leaders directing technicians must be addressed (i.e. resolve issue with the support of UAW), providing proper and frequent training to employees, and team leader position should be based only on capabilities and skills. Addressing such issues will surely improve the business metrics such that the span of control can be increased without deteriorating, safety, quality, and cost.

Future work conducted in this area should focus on issue such as: standardization of team leader assignment, limitations and responsibilities of supervisor, span of control in other industries in comparison to automotive utilizing similar metrics, and the impact of span of control on other metrics such as material handling, labor relation, and in station quality.

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