Application of Toyota's Production System to Reduce Traffic Accidents in Abha's Region - Case Study

Abdelhakim Naif Abdelhadi
Industrial Engineering Department
King Khalid University
Abha, KSA

Abstract

Traffic accidents are an enormous problem facing the country of Saudi Arabia and the countries in the developing world. We can take advantages and benefited from applying the lean manufacturing concept which was created by Toyota's company to minimize the number of car accidents and contribute in minimizing the number of traffic fatality and help saving lives. Using lean manufacturing to minimize the number of traffic accidents is a new approach and it will help reducing the human being losses and minimize the financial cost occurs as a result of these accidents. To use this concept, we shall present our system and mimic it to a factory due to the fact that lean manufacturing was used in manufacturing processes.

Need for Study of Traffic Accidents in Abha, KSA

The Kingdom of Saudi Arabia (KSA) has experienced a rapid economic growth since the oil boom in 1973 resulting in an enormous increase in the number of vehicles associated with rapidly expanding road construction. In Saudi Arabia the motor vehicle is the main means of transportation, there has been a large percentage of deaths reported by traffic accidents. According to a survey []conducted a figure equivalent to 3.5% of the total population in Saudi Arabia have died due to road accidents, amounting to one person killed and four injured every hour. Over 65% of accidents occur because of vehicles travelling at excess speed and/or drivers disobeying traffic rules. The number of registered vehicles has increased enormously due to the dramatic increase in the oil prices after 1973. This growth in motorization has accompanied with a drastic increase in the size of the road network in the country. The length of paved roads has increased dramatically. As a result of this remarkable growth in motorization and the road-network size, traffic accidents have become a serious problem facing this country. A report by the kingdom's General Directorate of Traffic has revealed that Saudi Arabia is one of the highest Road Accident Death Toll in the world per capita and averages of 18 persons are died on the country's roads each day. Table 1, shows statistics from the General Directorate of Traffic accidents recorded in the Kingdom of Saudi Arabia during the years 2000-2012.

Table 1: Number of accidents, deaths and injuries per year

Year	No. of Accidents	No. of Deaths	No. of Injuries
2000	280401	4419	28998
2001	305649	3913	28379
2002	223816	4161	28372
2003	261872	4293	30439
2004	293281	5168	34811
2005	296051	5982	34441
2006	283648	5883	35884
2007	435264	6358	36025
2008	485931	6458	36489
2009	493151	6634	37341
2010	537624	6904	38824
2011	544179	7153	39160
2012	589258	7638	41086

During a lecture at Madinah Islamic University as part of the 29th GCC Traffic Week events, Zuhair Sharaf, director of the Madinah Traffic Department said: Saudi Arabia tops the world in the number of traffic accidents, with more than 86,000 lives lost in the last two decades. "This exceeds the number of lives claimed by several international conflicts," and "Financial losses resulting from accidents are estimated at more than SR 13 billion a year," he pointed out. http://www.arabnews.com/more-killed-saudi-roads-iraqi-violence-2011

Data Forecasting

In this section the trend analysis method has been used to forecast the number of accidents and the number of injuries/deaths to show the severity of the current situation and its toll on the society and the country.
Minitab software was used to come up with the following required forecast:

1. **Trend Analysis for No. of Accidents**

Data No. of Accidents
Length 13

Fitted Trend Equation

Yt = 213300 * (1.08079**t)

Accuracy Measures

MAPE 12
MAD 38184
MSD 1912597062

Forecasts

Period	Forecast
2013	632929
2014	**684062**
2015	**739326**
2016	**799054**
2017	863607
2018	933376
2019	1008781
2020	1090278

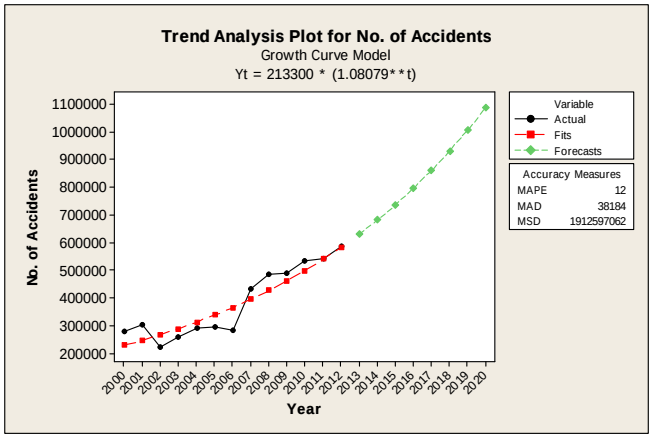

Figure 1: Trend Analysis for No. of Accidents

2. **Trend Analysis for No. of Deaths**

Data No. of Deaths
Length 13

Fitted Trend Equation

Yt = 3815.43 * (1.05728**t)

Accuracy Measures

MAPE 6
MAD 295
MSD 112816

Forecasts

Period	Forecast
2013	8321
2014	8798
2015	9302
2016	9834

2017	10398
2018	10993
2019	11623
2020	12289

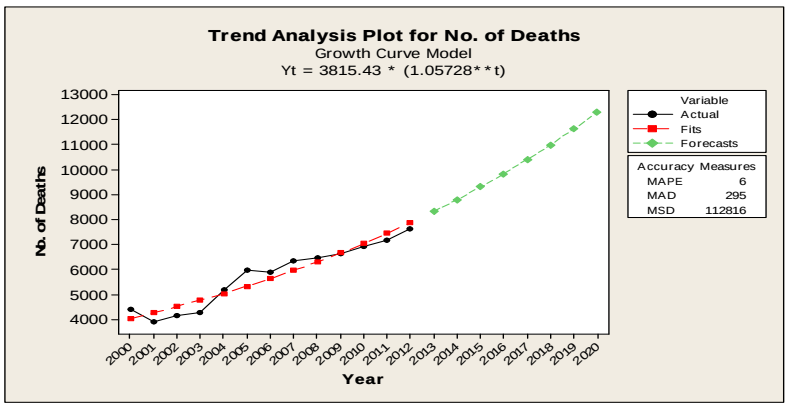

Figure 2: Trend Analysis for No. of Deaths

3. Trend Analysis for No. of Injuries

Data No. of Injuries
Length 13

Fitted Trend Equation

Yt = 27603.9 * (1.03186**t)

Accuracy Measures

MAPE	3
MAD	938
MSD	1348162

Forecasts

Period	Forecast
2013	42819
2014	44183
2015	45591
2016	47043
2017	48542
2018	50088
2019	51684
2020	53330

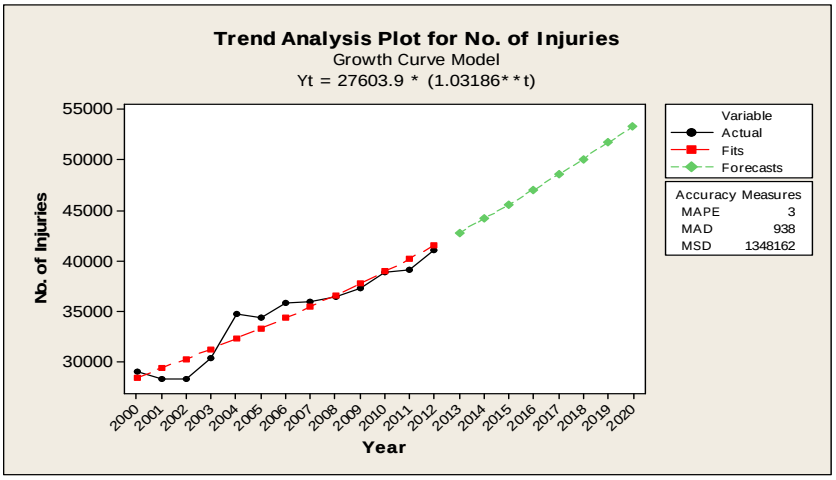

Figure 3: Trend Analysis for No. of Injuries

The trend analysis is used to make the forecast for each of the previous case. The accuracy of the forecast is quit very well due to the values of the accuracy measures provided by the results output. The values of MAPE, MAD MSD are very low. Table 2 shows the current and the predicted forecasted data. The forecasted data shows the severity of the situation and the urgent need to study the situation and trying to minimize the number of the occurrence of the accidents in the Kingdom of Saudi Arabia and hence the number of the accidents in Asir's region.

Table 2: Current and predicted forecasted data

Year	No. of Accidents	No. of Deaths	No. of Injuries
2001	305649	3913	28379
2002	223816	4161	28372
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2009	493151	6634	37341
2010	537624	6904	38824
2011	544179	7153	39160
2012	589258	7638	41086
2013	632929	8321	42819
2014	684062	8798	44183
2015	739326	9302	45591
2016	799054	9834	47043
2017	863607	10398	48542
2018	933376	10993	50088
2019	1008781	11623	51684
2020	1090278	12289	53330

Some facts about road accidents in KSA

- The main source of road accident data in KSA is the police.
- About 8 persons per 10,000 vehicles are killed in traffic accidents in KSA.
- Of deaths in Ministry of Health hospitals, 81% are due to road traffic accidents and 20% of their beds are occupied by traffic accidents victims. Also, 79.2% of patients admitted with spinal injuries have sustained their injuries as a result of a motor vehicle accident.
- Motor vehicle accidents have social, medical and economic effects on an individual. The average estimated cost of accidents in Saudi Arabia every year is $ 5.56 billion.[source]
- 101 people injured and 18 people killed everyday (Ministry of Interior, 2008) due to traffic accidents.
- Traffic accidents are the first cause of death in Saudi Arabia**.**
- In a study showed that youth's had the wrong knowledge of driving practices, also lacked in traffic regulations and signs.

Factors that contribute for enforcing the safety to avoid traffic accidents

1. **Limitations in enforcing drivers to adhere to the traffic rules:** Traffic departments use many traditional methods to enforce drivers to adhere to speed limits. Examples of these methods are using humps, radar, secret traffic, and deploying speed cameras with penalties, i.e. Saher system, in areas that have more speeding and accidents problem. However these traditional methods do not provide satisfactory solution because: their effect is limited in space and time. Moreover, traditional ways are not flexible in terms of taking into account time of day, day of week etc.
2. **Limited number of traffic department staff:** With the rapid increase in number of vehicles in Saudi Arabia (7 million vehicles), the traffic department managed to cover this number by only 14 thousand traffic policemen including those who work within offices . This means a ratio of 1 traffic policeman for every 500 vehicles. It was supposed to serve the capital city of KSA 'Riyadh' alone over nine thousand policemen, while the actual number is over a thousand. This shortage of staff led to limited observation of drivers' behavior in the road network.
3. **Absence of Speed limit signs:** From the survey we have conducted among 50 car drivers, it has shown that only 33% of them s know exactly the maximum speed limit in all different types of roads. About 90% of them have the willing to adhere to speed traffic rules if they know them. This suggests that about 60% of drivers are ignorant regarding speed limits but are willing to adhere.

4. **Lack of traffic situation data:** the statistics about the total number of traffic mortality in Saudi Arabia is less than the reality. This is concluded from the difference between Saudi Arabia's definition of traffic mortality, which is dying in crash location or during transition to a hospital, and the World Health Organization's definition which is dying immediately or within 30 days as a result of the crash. Furthermore, most of the countries that have succeeded in reducing the percentage of deaths resulting from traffic accidents have been provided with a comprehensive and accurate data on the percentage of traffic violations and accidents so that the researchers and traffic engineers can solve this problem. So far, In Saudi Arabia, there is no central database for violations and accidents statistics for the whole country. Moreover, most of the studies were based on incomplete or outdated data.

Lean production means doing more work with fewer resources by adapting of mass production concept in which work is accomplished in less time, smaller space, with fewer workers and less equipment
In general there are several activities in manufacturing which can be divided into:

- Actual work - activities that add value to the product
- Auxiliary work - activities that support the value-adding activities
- Muda (waste) - activities that neither add value nor support the value-adding activities

Muda (Waste) is considered the main evil in the production system and one should try to eliminate or minimize its presence. According to Taiichi Ohno there are seven forms of waste:

1. Production of defective parts
2. Production of more parts than needed (overproduction)
3. Excessive inventories
4. Unnecessary processing steps
5. Unnecessary movement of people
6. Unnecessary handling of materials
7. Workers waiting

Keys to Eliminating Waste can be achieved by using the following lean production:

1. Just-in-time production
2. Autonomation (automation with a human touch)
3. Worker involvement

Just-In-Time Production: Production and delivery of exactly the required number of each component to the downstream operation in the manufacturing sequence just at the moment when the component is needed. This approach in general will minimizes:

- Work-in-process
- Manufacturing lead time

Requisites for JIT

1. A pull system of production control
2. Setup time reduction for smaller batch sizes
3. Stable and reliable production operations

Pull System of Production Control: A system in which the order to make and deliver parts at each workstation in the production sequence comes from the downstream station that uses those parts
Alternative is a push system in which parts are produced at each station irrespective of the immediate need for those parts at the downstream station

Kanban System:

- Toyota’s way of implementing a pull system of production control
- Kanban means “card” in Japanese
- Two types of kanbans:
    1. Production kanban – authorizes upstream station to produce a batch of parts.
    2. Transport kanban – authorizes transport of the parts to the downstream station.

Production Operations

- Production leveling - distribute changes in product mix and quantity as evenly as possible over time
- On-time delivery of components
- Defect-free components and materials
- Reliable production equipment
- Workforce that is cooperative, committed, and cross-trained

- Dependable supplier base
- Autonomation
  Production machines operate autonomously as long as they are functioning properly, when they do not function properly (e.g., they produce a defect), they are designed to stop
- Autonomation topics:
  1. Stop the process
  2. Error prevention

When an error or other exception is identified, the poka-yoke responses are either or both of the following:

1. Stops the process when an error or problem is detected
2. Provides an audible or visible warning to alert operator and other workers

Total Productive Maintenance, TPM,

- Goal: zero breakdowns
- TPM = integration of preventive and predictive maintenance to avoid emergency maintenance
  1. Emergency maintenance = repair equipment that breaks down
  2. Preventive maintenance = routine repairs to avoid breakdowns
  3. Predictive maintenance = anticipating malfunctions before they occur

Worker Involvement Components:

- Continuous improvement
- Visual workplace
- Standard work procedures
- Total productive maintenance

- Continuous Improvement, "Kaizen": Japanese word meaning continuous improvement of production operations. Usually implemented by worker teams:
  - Encourages worker sense of responsibility
  - Allows workers to gain recognition among colleagues
  - Improves worker's technical skills

Visual Management and 5S:

- Principle: the status of the work situation should be evident just by looking at it
  - Objects that obstruct the view are not allowed
  - Build-up of WIP is limited to a specific height
  - Andon boards located above the assembly line indicate the status of the workstations
  - Worker training includes use of photos and diagrams to document work instructions
- Worker Involvement through 5S, this is one major principle in the application of lean manufacturing. The following Table 3, shows those 5 words in Japanese and what they mean in English.

Table 3: Words in Japanese and what they mean in English

Japanese word	**English equivalent**
1. Seiri	1. Sort
2. Seiton	2. Set in order, simplify access
3. Seiso	3. Shine, sweep, scrub
4. Seiketsu	4. Standardize
5. Shitsuke	5. Self-discipline, sustain

Standardized Work Procedures:

Three components:

1. Cycle time – actual time required: "Takt time" – reciprocal of demand rate adjusted for available shift time.
2. Work sequence: Basically the same as a standard method.
3. Standard work-in-process: Minimum number of parts to avoid waiting of workers.

The Toyota Way in Service: The Case of Lean Product Development

Jeffery K. Liker and James M. Morgan the authors of an article which outlines and illustrates the management principles of the Toyota's product development system, that can be applied to any technical or service process. The article provides a different look at how the basic principles of the Toyota Production System, TPS (which is based on lean principles including a focus on the customer, continued improvement and quality through waste reduction, and tightly integrated upstream and downstream processes as part of a lean value chain) can be applied to service operations.

The authors argue that the Toyota Way is a true system approach that effectively integrates people, process and technology. Toyota's approach to product development has evolved as a living system with its own trials and tribulations, but a consistent trend upward through ongoing learning and continuous improvement supports the value in its approach.

Review of TPS Principles

The authors represented the TPS as a house which become a cultural icon in the manufacturing world. It is been illustrated in Fig. 4, which indicates that the house is as strong as any weakest part of that system and should be considered as a whole. With a weak foundation or a weak pillar, the house is not stable, even if other parts are very strong.

Figure 4: Toyota Production System House

The parts should work together to create the whole. The parts are as follows:

1. **Just in Time:** it relates to making material flow throughout the process very fast, getting the right part to the right place at the right time.
2. **Jidoka**: it represents the machine with human intelligence. The intelligence is to do simple thing-detect any deviation from the standard and stop itself while waiting for help by using *andon*, which is a sound or light, to signal for help.
3. **Heijonka and "Stable and Standardized Processes"**: Heijonka means leveling. The goal is to create a leveled stream of orders and level work load. Through the leveling of the work load, the chance will be created to standardization and an indication for inventory to compensate for instability.
4. **People Engaged in *Kaizen:*** Kaizen is a continuous improvement that spread throughout the organization.
5. **Jidoka:** means machine and people are shutting when there is a problem. If the people are skilled through training and motivated, they will solve the problem as soon as it surface.

Toyota's Management Principles in Lean Product-Process development

The authors identified 13 management principles that can be considered the **foundation for the lean product development. They organized these into a** framework of process, people and tool technology, which can be applied to service industries and service operations.

A. Process, when thinking of a process improvement, we often think of simple repetitive process, which is not the case in the product development. Yet, Toyota views product development as a less precise process than any short cycle manufacturing jobs. They were able to standardize the process, refine it, eliminate waste, and continually reduce time and cost from program to another.

A summary of the process principles are:

1. Establish customer defined value to separate value added from waste; Lean is a never ending journey of waste elimination.
2. Front load the product development process to thoroughly explore alternative solutions while there is Maximum design Space; defining the wrong problem or converges to a wrong solution will have costs throughout the product life cycle. Exploring alternatives and anticipate future problem at the root cause has exponential benefits.

3. Create a leveled product development process flow; leveling the flow starts with stabilizing the process so it can be predicted and appropriately planned. This allows product planning to reduce wild swings in work load.
4. Utilize rigorous standardization to reduce variations, and create flexibility and predictable outcome.

B. People principles of lean product development, people provide the intelligence and energy to any lean system. People systems include recruitment and selection of engineers, training, leadership, etc. **The people principles are:**

1. Develop a Chief Engineer System, to integrate development from start to finish**.**
2. Organize to balance functional expertise and cross functional integration, everybody understand that they are there to serve the customer and the chief engineer represent the customer, so in a sense everybody work for the chief engineer.
3. Develop towering technical competence in all engineers; engineers must have deep specialized knowledge of the product and process that come from a direct experience through the *genchi genbutusu* principle which pushes engineers to get their hands dirty and go directly to see for themselves how is the work is getting done and what he problems are. In fact their first year engineers spend moths on the production line building cars.
4. Build in learning of continuous improvement; organizational learning is a necessary condition for continuous improvement and builds on all of the other principles.
5. Build a culture to support excellence and relentless improvement; excellence and kaizen in the final analysis reflect the organizational culture.

C. Tool and technology, the third subsystem involves the tools and technologies employed to develop and build the product. This subsystem not only include CAD systems, machine technology, and digital manufacturing and testing technology, but all of the soft tools that support the effort of the people involved in the development project whether it be for problem solving, learning, or standardizing best practice, which can be summarized by:

1. Adopt technology to fit your people and process: technology must be customized and always subordinate to the people and process.
2. Align your organization through simple, visual communication; the specific objectives must be cascaded down and joint problems solving is enabled by simple, visual communication such as A3 paper size type.
3. Use powerful tools for standardization and organizational learning; powerful tools can be simple. Their power comes from enabling standardization which is necessary for organizational learning.

Learning from the Toyota Way

Many companies throughout the world are seeking to learn from Toyota's system. Typically they limit their exploration to a few superficial lean tools. Companies that have seen success with lean tools in manufacturing plants want to apply them on their product development process. What they are looking for is a quick fix to reduce the lead time and cost and improve quality. But they never tried to create a culture of lean manufacturing, while they believe that they gone lean in the shop floor. Its more complex than a quick fix, it is a culture transformation, it is a PDCA (Plan, Do, Check, Act) learning process they need to start on learning and never look back, just keep going continuously in the improvement process. Toyota has developed a true learning organization focused on adding value to its associates, the community, and society and in such model other companies can look to for inspiration, ideas, and methodology. The case of product development should give new insight into how Toyota's management principles can be applied outside the production floor, Toyota has developed a true learning organization focused on adding value to its associate, the community, and the society in large and as such; is a model other companies can look to for inspiration, ideas, and methodologies. The authors found that as a starting point to implement the Toyotas' lean approach to product development, one should follow the following steps;

1. Identify the repetitive process to improve.
2. Apply a value stream mapping to identify waste and then a future state map with waste removed (a method to map the process and show the value added from non-value added steps).
3. Implement the changes.
4. Celebrate the success.

Once the organization has gone through the implementation of the previous steps a number of times, they should clarify and find if:

1. The changes lead to new standardized processes that are basis for future waste reduction.

2. The people throughout the organization engaged in a continuous improvement and aligned around a common objective.
4. All the soft tools and harder technologies being used to support improving the delivery of product and service to the customer.

Ultimately, any company seeks the adoption of Toyotas' Way; they should envision what they want to become and not to be a Toyota itself. It is a culture change, and not necessarily looks like Toyota. The spirit of challenge and always trying to get better is the central theme of the Toyota Way. Finally using lean product development put pressure and accountability on the project owners. It also breaks down the walls in the internal department issues related to multiple managers with many projects who focus on departmental issues rather than product success or failure.

Applying Lean Manufacturing Concept to Minimize the Number of Traffic Accidents at Abha city:

Using lean manufacturing to minimize the number of traffic accidents is a new approach and it will help reducing the human being losses and minimize the financial cost occurs as a result of these accidents. To use this concept, we shall present our system and mimic it to a factory due to the fact that lean manufacturing was used in manufacturing processes. Once the comparison is made it will be easy to apply the principals of lean manufacturing and benefited from its outcomes. It should be pointed out that it is not possible to instruct and forced the public directly on how to apply the findings of the lean manufacturing; rather, we will use some of the lean concepts such as visual concept to educate the public as they use their vehicles while they are unaware that they are applying the concepts of lean manufacturing. Any manufacturing system is composed of inputs and outputs, and the goal of lean manufacturing is to maximize the output with fewer resources by adapting the mass production philosophy in which the work is accomplished in less time, smaller spaces, with fewer workers and less equipment. In any manufacturing processes system there are three activities:

- Actual work, this type of work adds value to the product
- Auxiliary work, this type of work support the value adding activities
- Muda (waste), this kind of activities neither add a value nor support the value adding activities.

Muda is considered the ghost in the production system and one should try to get rid of this type of activities or at least minimize its presence and effects. As mentioned before, according to Taiichi Ohno there are seven types of waste: Production of defective parts, Production of more parts than needed (overproduction), Excessive inventories, Unnecessary processing steps, Unnecessary movement of people, Unnecessary handling of materials and Workers waiting.We will consider the city of Abha (or for that matter any city) as our factory plant and the parts moving in this manufacturing system are the moving vehicles. The goal is to have a smooth and safe trip for each vehicle from its origin point to its final destination safely and within a reasonable time.

1. **Mapping the current situation:**

The main source of the traffic accidents data is the police department. The following are some statistical data collected in 2012 showing the severity of the current situation.

Table 4: Number of accidents in Asir as distributed by severity for the year 2012

Number of Accidents	Severity of accident		
	Damages accident	Injury accident	Fatal accident
17698	16798	486	414

Table 5: Number of accidents in Asir as distributed by location for the year 2012

Distribution of Accidents by Location		Total
Urban area	Rural area	
11723	5975	17698

An initial study of Tables 3 and 4 show the following observations:

- More than 50% of the accidents occurred in 2012 resulted in an injury.
- About 25% of the accidents are fatal accidents.
- More than 2/3rd of the accidents locations are in an urban area.

Accordingly, we are going to study the situation in the city of Abha and the reasons behind the volume of such accidents in relation to the concepts of lean manufacturing. According to Paleti et al [Accident Analysis and Prevention 42 (2010) 1839–1854, Examining the influence of aggressive driving behavior on driver injury

severity in traffic crashes Rajesh Paleti 1, Naveen Eluru2, Chandra R. Bhat∗] The main causes of traffic accidents are:

1. Driver
2. Vehicle
3. Roadway
4. Environmental

We will map and investigate each cause in relation to current situation in the contest of lean manufacturing.

1.1- Drivers

1.2-

Table 6 shows the number of accidents based on their causes in Abha's region and it indicates that high percentage of car accidents are due to human factors. While Table 7 present the traffic accidents based on the age of the driver involved in the accidents.

Table 6: Causes of car accidents for the year 2012

Sudden stop	Improper Turns	Improper Passing	Disregard of Traffic Control signs	Speeding	Intoxicated drivers	Tire blowouts	Distractions	others
1209	819	1921	243	6887	68	4	3784	2763

Table 7: Distribution of vehicle drivers involved by age group for the year 2012

Age group					Total
Less than 18	18-29	30-39	40-49	More than 50	
1882	13626	9134	3678	2070	30390

A survey conducted in the region about the driver's education regarding the traffic issues indicated that 72% does not understand the meaning of the traffic rules. While less that 1% of the drivers put the seat belt on.

1.2 Vehicles

Table 8 illustrates the conditions of the vehicles involved in the accidents as reported by the traffic accidents investigators, it indicates that only 0.0033 of the traffic accidents occurred in 2012 were caused by a defect in the vehicle itself.

Table 8: Conditions of the vehicles involved in the accidents for the year 2012

Driving lamps failure	Brake Failures	steering or suspension system failure	Sudden mechanical failure	Good conditions
34	29	5	31	30291

If you ride or drive a vehicle in the Abha city you will notice that the percentage of vehicles which has defects is very high. We conducted a random survey in different parking lots to visually inspect the conditions of the vehicles. The recorded defects are: rear (tail) lights, tiers defects, head lights, scratched or broken vehicle glass and vehicle side mirrors defects. Table 9 present our findings; it shows that high percentage of vehicles has some sort of defects which does not coincides with the data collected by accidents report shown in Table 7, even though, the mechanical issue which could affect the safety of the vehicle was not considered in this survey.

Table 9: Percentage of visual defected vehicles in different locations

Location	Total number of Vehicle involved	Number of defects*	Percentage, %
Asir Mall	576	93	16
Asir Hospital	612	122	20
Abha Airport	484	28	6
Downtown	688	49	7
Alwaha Center	320	20	6
Private Abha Hospital	410	49	12
Total	3090	361	12

*Rear (tail) lights, tiers defects, head lights, scratched or broken vehicle glass and vehicle side mirrors defects.

1.3 Roadway

The third major contributor to traffic accidents is the roadway designs; it should conform to the international standards. Some of the factors contribute to the road designs is the traffic signs and signals. It is noted that the traffic sign are not enough and the sizes of these signs does not get close to match the international standards. The following photos are taken from different places with the vicinity of Abha city. The first photo is a snap shot showing the line markings in a construction zone while the second photo shows high volume traffic road without line markings. Most of the roads are lacking traffic signs to inform the public about the status of the roads.

Picture 1: Snap shot showing the line markings in a construction zone

Picture 2: High volume traffic road without line markings

Picture 3: High volume traffic road with bad line markings.

Picture 4, High volume traffic road with bad line markings.

Picture 5: High volume traffic road with bad line markings.

Picture 6: Major intersection without traffic signal

Picture 7: Major intersection without traffic signal

Picture 8: Major intersection without traffic signal

2.1.4 Environment: In a random survey, it was found that more than 40% of the drivers are not Saudi national and came from different cultures, 60% of them do not have the ability to read the written the traffic signs.

2.2 Identifying the non-value adding: Lean production is derived from the product flow velocity through the elimination of all non-added activities, (Arnheiter and Maleyeff, 2005, pp. 10-11). Just in time, Heijonka and Kaizen will be our criteria for identifying the waste and implement Lean Manufacturing concept. Since vehicles in our plant are considered to be the production items; the goal is to have smooth and safe trip from any station (point) to another station. Several elements had been identified which makes it difficult to reach the intended destination in the planned time:

- The roads markings are not obvious and clear (refer to Picture 1 through 8) and some roads lacks markings at all which makes it difficult for drivers to drive safely in their lanes; this leads to use more time and work as distraction for the drivers. This situation can be solved by applying the Hijonka principle which uses visual concept as a mean to reduce the waste; by applying the suitable international standards for the road markings.
- Several roads intersections lack the existence of traffic signals to control the traffic flow. Pictures (6), (7) and (8) show a sample of traffic jam at two different intersections which makes it difficult for drivers to get to their destination on time due to this traffic jam. This situation can be solved by using a visual aid (traffic signals) to guide and control the vehicles flow.
- We conducted a random survey at different parts of the city asking the drivers about the permitted speed limits at their location; 92% of the answers were negative due to the lack of enough signs showing the permitted speed limit. Using visual aid by adding more speed limit signs to clarify the required speed limit will help inform the drivers about the required speed limit, hence helps in reducing the over speeding.
- It has been noted that there is no standardization for the design of the traffic signs. For example; some signs were written in both Arabic language (local language) and English language, while some other sign were written in Arabic language. This situation makes it difficult for the driver to interpret the signs in the intended time to response to it. When the signs are standardized, this will help creating a smooth and efficient traffic flow.
- One of major wastes identified by Womack et al. (2003) is Production of defective parts; since we are considering the vehicles in the system as our production parts, there should be a minimum number of defects in the system. Table (9), showing the percentage of defected vehicles in different locations selected randomly. The defected items will hinder the movement of the traffic and could lead to accidents. By applying the lean concept, one should eliminate the presence of the defected vehicles from the system by adopting laws toward this purpose and enforce it using the traffic police.
- It has been noticed that high number of vehicles at some intersections makes U-turn. This situation leads to conclusion that the intended destination of those cars is at some point before reaching the intersection were the U-turn is made. This creates an unnecessary movement of people and unnecessary handling of materials; this is a type of Muda. Table (10), shows statistical data collected

Conclusion

Lean manufacturing can improve the traffic flow inside or outside the city limits. The following principals can be used in that regard:

- **Visual Management and 5S**
  - Objects that obstruct the view are not allowed, such as some advertisement adds.

- Worker training includes use of photos and diagrams to document work instructions, in our case, we have to increase the number of visual signs that teaches the drivers about the driving laws and the danger of irresponsible driving
- Increase the number of traffic signals to enforce the drivers to slow down.

- **Standardization:** All signs used in the system should have the same standard, for example; all of the traffic signs should be in the same language.
- **Seiso (Shine, sweep, scrub):** The roads should be clean from dirt and cars should be clean.
- **Shitsuke (Self-discipline):** More driving strict rules to enforce the driver to have more disciplines in driving since most accidents occurred as a result of driver errors.
- One major principal of lean manufacturing is the elimination of the production of the defective parts, in our system we have to eliminate the presence of any defect in the vehicles in the system since road safety and vehicle condition contribute to accidents.
- Finally, continuous improvement to the system is needed because lean manufacturing is never ending journey.

Table 10: Number of cars makes U turns at an intersection

Time		Number of cars on the traffic light	Turn on the traffic light	Drivers using seat belts
FROM (AM)	TO(AM)			
6:30	6:32	126	22	2
6:33	6:35	132	21	0
6:36	6:38	129	26	1
6:39	6:41	137	32	1
6:42	6:44	151	29	0
6:45	6:47	142	20	0
6:48	6:50	137	22	1
6:51	6:53	139	22	0
6:54	6:56	128	19	0
6:57	6:59	123	22	1
7:00	7:02	129	23	2
7:03	7:05	132	25	2

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