MAT3010 (SLOT B2)
TOTAL QUALITY MANAGEMENT
J COMPONENT

REVIEW III
Final Report: Success Story of Ford Model T

Submitted to
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SUCCESS STORY OF FORD MODEL T
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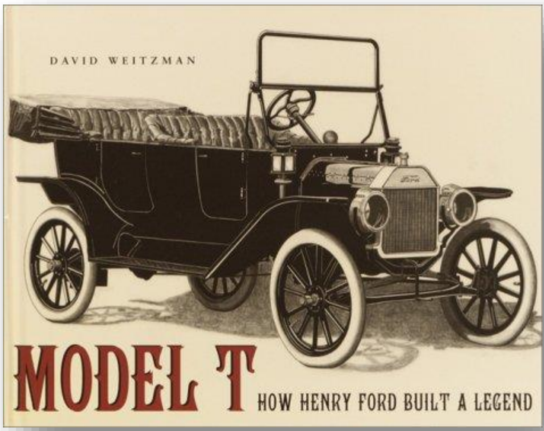

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Introduction

Henry Ford′s ideas and practices show many features seen in contemporary Japanese approaches. Ford, in the period from 1908 through the late 1920s, relied on a number of progressive and radical methods in manufacturing management; methods that were similar to the current Japanese methods. The system Ford used for the Model T is one radically different from that criticized by Schonberger, Ohno and Shingo. The main features of what can be called Ford’s model T production system (MTPS) to distinguish it from the modern one, and their similarities to those of Toyota’s JIT approach, will be described. In a foreword to a reprint of Ford’s Today and Tomorrow, Bodek remarks that Ohno suggested that people seeking the origins of his ideas should look to Ford since “...he learned it all from Ford’s book”. This article provides an overview of Ford’s policies and activities. It does not give a “snapshot” view of his policies at any one time, or of their implementation in any specific facility. A broader appreciation of Ford’s ideas is the objective, and a historical perspective covering the whole of its development is necessary. No one point would be adequate since Ford’s system evolved in a number of factories, and over a 30-year period before he fundamentally shifted to mixed model production and away from his basic manufacturing philosophy.

Ford recognized that quality was critical to increasing production and efficiency and much of his focus was on attaining the levels necessary to allow mass production. Quality was critical for manufacturing needs. The parts simply could not be put together if they did not fit properly. The assembly line was the capstone of this process – it could not exist without high quality parts, and it built on practices that took decades to develop. Consistency of performance was critical for interchangeability. Materials, men and machinery all had to operate within rigorously identified limits if the system and its products were to function properly. Ford played a key role in recognizing this and in identifying a suitable product for the market and developing a manufacturing system to deliver it.

Ford did not simply inspect work to remove quality problems. The system was designed so that operating staff would have relatively little and strictly limited influence on the quality and volume of work performed. Wherever possible Ford sought to mechanize the effort so that unskilled and very narrowly trained staff would be able to cope with the demands of the job. Ford comments that machinery would be used to do the hard work wherever possible, the system eliminated both the “heavy” and the “fine” work. Staff no longer had to slave at gruelling tasks, but skilful and time-consuming work was eliminated too. The assembly line gave Ford a mechanism for ensuring a very high level of control over the work that his employees performed – a mechanism that was designed considering the nature of the labour force. Ford employed people who were unskilled and poorly educated, few were high school graduates; and, in many cases the company had to teach immigrants English and other basics. The people were the weakest link in producing the quantities needed to the desired quality at the times required. The system was designed to minimize the potential for error and implicitly limited its requirements to the lowest common denominator. Ford often remarks that staff could and did rise above these levels through initiative; but he was generally very defensive about the control which the system had over the activities of the people in it.

The Model T is Ford's best known and most influential product. Ford succeeded because he recognized a need for an inexpensive, reliable automobile and exploited it. Ford's ideas reveal his approach to design as an engineer who differed from other automobile manufacturers. He did not regard big as synomous with strong, and sought to eliminate waste in unneeded weight. Large, heavy cars were undesirable: "I was working for lightness; the foreign makers have never seemed to appreciate what light weight means". A comment heavy with irony for those who remember the large "gas-guzzlers" of the 1950s and 1960s and their smaller, lighter European and Japanese competition. It is quite clear that Ford believed that the objective of manufacturing design was to deliver the best possible product to the customer as economically as possible. He believed in providing "service" to his customers and that a long-term perspective was required. The Model T was not only an integral part of the manufacturing system, it was the foundation on which the system was built.

One of the more interesting aspects of this review will be the relative ignorance of Western manufacturing managers about Ford's early approach to manufacturing, the period in which he had his greatest impact on automotive design and manufacturing development. As we know he had an integrated systems approach founded on a market strategy allied to a focused manufacturing system that emphasized quality, efficient production and an avoidance of waste; within a paternalistic framework intended to make the best use of a generally low grade but highly varied workforce.

Review of Literature (16 PAPERS)

Automating the Production Line

Summarizing: "One of the greatest challenges for any successful business is knowing when it's time to change. After all, conventional wisdom says "if it's not broke, don't fix it." But with technology changing at such a rapid pace, those who stand still will soon be left behind. The last time the world saw technological advancements at this pace, Henry Ford was just figuring out the assembly line. But it's quite possible that by looking back at Ford's adoption of the 'new' technology of his time we may be able to learn how to properly read the signs of today's technological trends so we can be ready to invest in AI and automation at the most advantageous time for our manufacturing, warehousing, and distribution systems.

Henry Ford was not a newcomer to the car business when he began producing the Model T in 1908. He had already been part of several automotive companies before the Ford Motor Company was founded, and built several other car models including his Quadricycle and the 999. But he dreamed of a vehicle for 'the great multitude,' and so the Model T was born. Unfortunately, the original Model T was still too expensive for most Americans. When Ford began churning the cars out via assembly line, however, their price dropped significantly. In 1909, when workers were still using traditional methods to piece the cars together, a Model T was priced at $825, and less than 11,000 were produced. But in 1916, three years after Ford started using assembly line production, the Ford Motor Company produced over half a million Model T(s) and sold each one for $345.

Automation can lead you to consider opportunities in ways you haven't before. A shift in production capabilities and costs allow you to reconsider your market from a new perspective. Higher productivity and efficiency equals a lower per unit cost that will change how competitive you can be within your market.

Help Your Workers: Henry Ford significantly altered the lives of his workers. At the beginning of assembly-line production within the Ford Motor Co, most workers managed 9-hour days for about $12 a week. But the shift was awkward, the work was hard, and turnover was high. So Ford changed the work periods to three 8-hour shifts and doubled the worker pay through a bonus structure. This, in turn, decreased his labour turnover and allowed for smooth, uninterrupted production of his cars.

Despite fears, current technology does not take away jobs. In fact, automation may help increase the number of skilled, high-paying jobs within the manufacturing sector, since an automated shop has need of better trained, higher skilled workers. This can be a win-win for an existing company as well as their current workforce if management offers educational reimbursement to employees who want to retrain to gain more skills: your employees gain 21st century skills that can allow them to remain with the company in a better-paid position, and you retain good employees who have a proven track record of reliability.

Decrease Waste, Increase Efficiency: One of the primary advantages to Henry Ford's assembly line was its increased efficiency. The Model T went through 84 individual assembly processes using interchangeable parts that were all mass-produced elsewhere and assembled into a single car by workers trained to do one particular job. While this seems like common sense today, it was a revolutionary idea in 1913, and one that increased worker productivity to such a level that the time to put a single Model T together dropped from over 12 hours in 1908 to 93 minutes in 1914."

Concluding: "Automation can make the same kinds of leaps in efficiency for your company. When Factory Five Racing, Include was looking to decrease the time it took to produce their hot rod trim kits, they turned to robotic automation. The change allowed them to produce a higher quality trim kit consisting of four sets of panels (four trunks, four hoods, and eight doors) in 24 minutes, down from 7.5 hours' time which restricts the sum of task processing times which can be completed at each workstation before the work-piece is moved to the next station by the conveyor belt. Major planning problems for operating assembly lines include supply chain integration, inventory control and production scheduling."

Beyond Fordism? : Strategic Choice & Labour Relations in Ford, UK

Summarizing: "The failure of the Western economies to reverse their deteriorating economic performance has called into question the organisational and technological basis of Fordism. Fordism is the progressive development of specialised machinery operated by closely supervised, deskilled labour to mass produces a standardised product for stable, homogeneous mass markets. The Ford Motor Company Intel has developed the quintessential form of Western management, namely a managerial structure based on strict functional responsibilities within a large-scale bureaucracy. Ford's management structure and culture have stressed continuity, caution and control, factors eminently suited to a slow-changing market environment and incremental innovation in product and process technologies. The appointment of Bob Ramsey as Director of Industrial Relations in 1973 symbolised the company's rejection of the Ford industrial creed of paternalism and direct control.
Ford's post-1980 approach to quality concentrates on translating customer expectations into production protocols. Unlike quality control a fundamental of a low-trust factory regime requires the active involvement of production workers.

Continuity and change in Ford's industrial relations: One of the major barriers to change in Fords has been the legacy of the company's chequered industrial relations history productivity. However, the coherence of Ford's national strategic initiatives stood in sharp contrast to plant management's insistence on unilateral managerial control. The resulting running battles at plant level seriously hampered production continuity and threatened to become a critical competitive handicap. This experience forced Ford executives to finally recognise that structural reforms of internal bargaining institutions alone were insufficient to sustain a profound process of organisational change. The task for Ford's senior management was to devise structures and processes which would not only involve shop floor representatives in maintaining collective agreements but also to qualitatively extend this principle to include informal responsibilities for productivity and innovation.

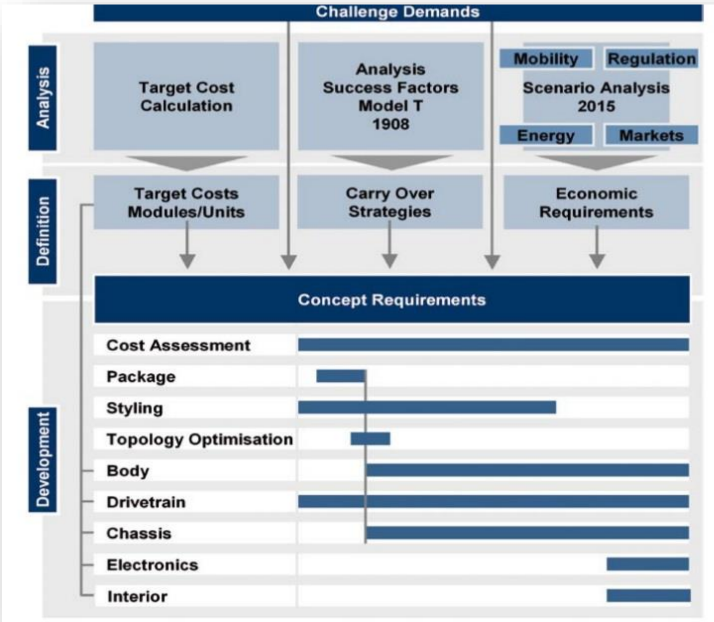
- Organisational change at Ford The primary impetus for change at Ford arose from the growing incursions of Japanese manufacturers into the corporation' score American and European markets.
- If Ford UK's first strategic goal was to reduce the company's breakeven point by rationalisation and increased efficiency then the second was to lay the organisational foundations necessary for competitive edge in the 'new industrial competition'.
- It is this double awareness, of the productive and innovative advantage enjoyed by Japanese car producers, which has determined the pattern of organisational change in Ford during the 1980s.

Ford's over-rigid hierarchical structure hindered the development of an integrated approach to organisational innovation. Ford wants to break down barriers between management groups. The success of Ford's strategic shift away from the mass production of utility vehicles hinges on the integration of design, manufacture and marketing. Ford of Europe introduced quality circles in 1979 with the threefold objective of improving manufacturing productivity, stimulating motivation and involvement on the shop floor and providing an informal forum for communication slowly building. The structures of EI have, as yet, been accepted only by salaried staff. Ford's 1985 Agreement aimed to close the gap between British and continental production practices. The key work organization elements were: versatility and flexibility, the acquisition of new skills and the elimination of inefficient demarcation lines. These principles were applied to both craft and production operatives."

Concluding: "The failure of AJ in the context of the British industrial relations system forced Ford UK to retrench, to introduce the long-term EIIPM strategy with the more realistic time horizons of five to ten years. Ford's abortive attempt to establish single unionism in its proposed Dundee plant is best understood as an extension of, rather than cavalier deviation from, established strategy. Ford's final withdrawal from Dundee may have had as much to do with financial, particularly exchange-rate, as industrial relations issues. The late 1988 decision to locate the new engine plant at Bridgend may have reversed the damage caused by the Dundee negotiations. Ford regards the process of changing work organisation as a vital arena."

Concept Car Development with the example of Ford Model T Successor

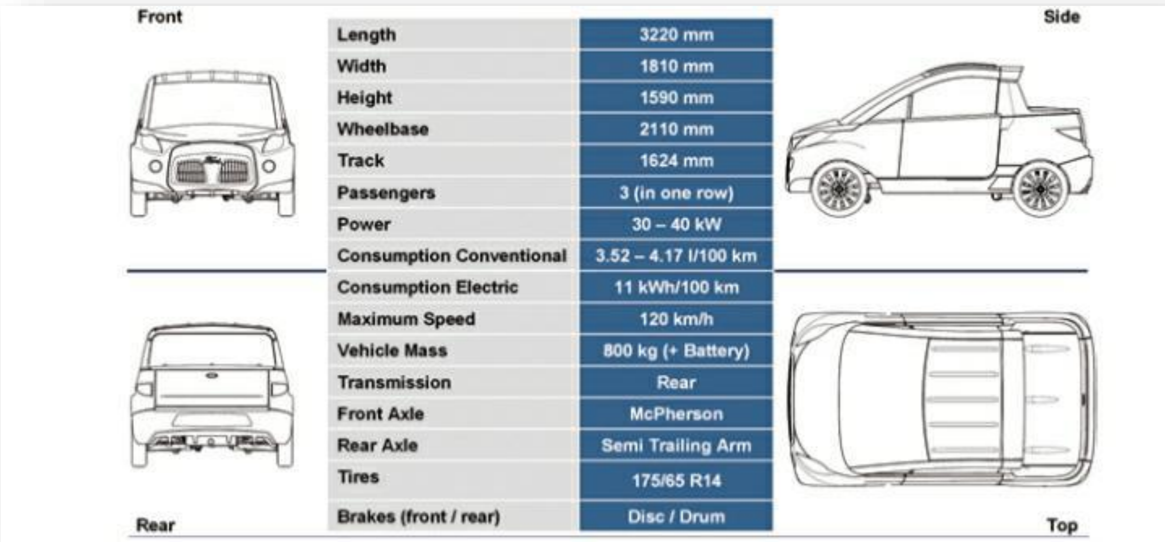
Summarizing and Concluding: "The legendary Ford Model T is still one of the most successful and sold models of vehicle history. A scientific approach, though inspired by the industrial development process, was chosen for the development of the concept vehicle, only five years after the foundation of the Ford Motor Company in 1903, the production of the Model T started. With the aim to meet the major demands that a world car has to accommodate in the 21st century, a scenario analysis for the target year 2015 was carried out. The low sales price was a key challenge during the development of the concept. Worldwide commonly used design concept is believed to foster the brand identity, an aspect that is gaining importance for success in the market due to an increasing technical unification. For



the body development the trade-off between low-cost and lightweight had to be put in focus, since both requirements were formal objectives of the challenge. A focus was therefore placed on a simple production and a robust design of chassis and body as well as possibilities for an individual styling by using change-able outer panel.

An efficient approach and an effective realisation of requirements allowed the concept to be simple, light and compel-ling – following the spirit of its predecessor. A focus was therefore placed on a simple production and a robust design of chassis and body as well as possibilities for an individual styling by using change-able outer panels. The modular drive-train allows to offer alternatives to the at least in the medium-term still dominant internal combustion engine such as hybrid or battery-electric traction.

Technical Specifications of New Model T”

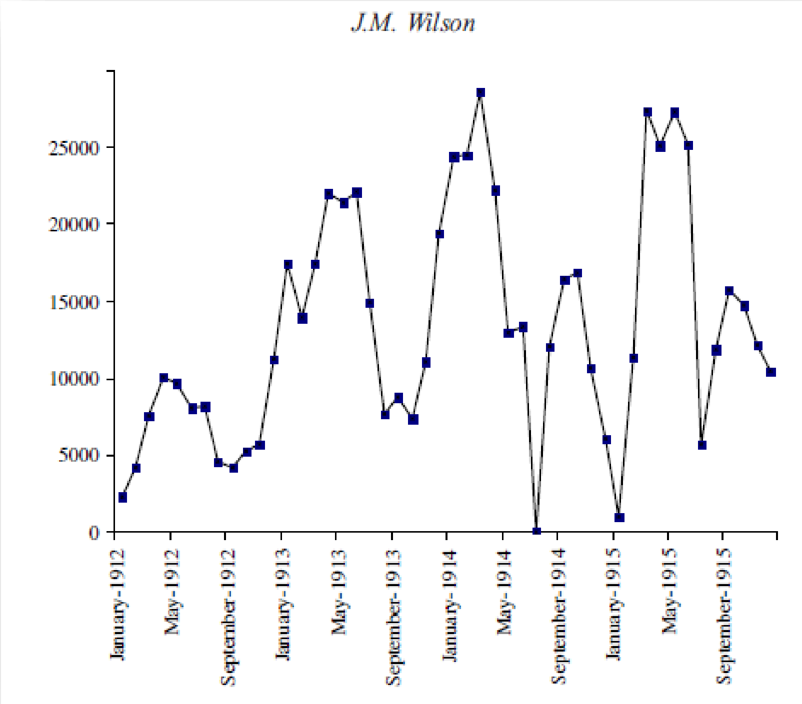


Henry Ford vs. Assembly Line Balancing

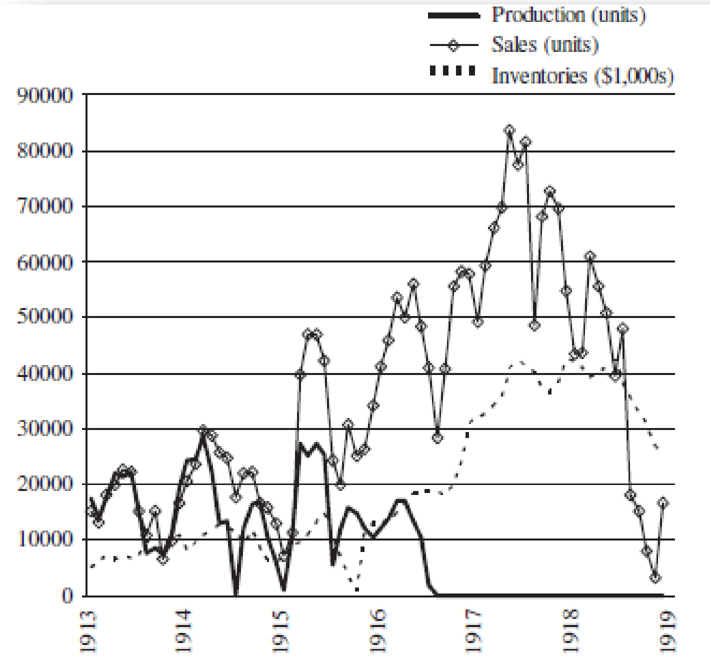
Summarizing:

- “Recognizing the variability of Ford's production and capacity changes introduces a new and important factor in system design and modelling: capacitychange costs. Such costs could be ignored in the case of stable operations, but Ford's starting and stopping lines entailed costs.
- From an organizational standpoint, Ford could promote preferred employeesto supervisory positions when demand increased and more line workers were required, and then return them to their normal line tasks when demand decreased.
- According to Gökçen, Kara, and Atasagun (2010), one of Toyota's system's principles was 'Shojinka,' or the ability to change a production line to suit changing demand by changing worker numbers and assignments. (2011) do so by assigning some personnel to tasks on adjacent lines; that example, a worker would work on an item on line 1, then situate themselves on line 2 and work there until the item on that line is completed, alternating back and forth betweenthe two lines.
- Ford’s multiple lines provided flexibility not recognised by either the general operations research literature (Erel and Sarin 1998; Boysen, Fliedner, and Scholl 2007) or historians (Hounshell 1984; Lewchuk 1987, Williams, Haslam,and Williams 1992; Williams et al.
- Future study should focus on flexibility, as the ability to adjust to demand fluctuations may be more essential than tiny gains in line 'efficiency' that reduce balancing delay Ford's production line was divided into four 'sides', with some employees working on the vehicles themselves, while others worked beneath the cars in pits or on trolleys attached to and hauled along with the automobiles (see Klann 1955 above).
- Salveson (1955) aimed to make it easier for systems to respond to demand orstaff fluctuations, but in practise, line rebalancing rarely occurs in reaction to short-term fluctuations. Gökçen, Kürad, and Benzer (2006) describe a model for lines with varying cycle periods, and this historical analysis demonstrates that their model, as well as the other PALBP analyses, may be of more than theoretical.

- Table 1 shows that the correlation statistics between sales and production, as well as those between stocks and production, are significant and positive. For e.g.; if April's sales statistics were not known until the end of the month, they would have had little impact on April's production.



- Ford implemented mass production systems despite highly variable demand,not under the conditions that: 'Gradually, as Model T sales increased and production schedules stabilised, Ford and his engineers and managers began to realise the profound impact of product design on their factory operations,' as is commonly believed. If Ford maintained a constant throughput consistent with an optimised line balance, hours and personnel would be stable, and finished product stocks would cushion sales volatility.



- According to O'Brien (1997), Ford was a pioneer in developing means of controlling inventory, receiving short-run feedback from dealers, and keeping production scheduling in line with sales: 'Ford pioneered in developing means of controlling inventory, receiving short-run feedback from dealers, and keepingproduction scheduling in line with sales' (O'Brien 1997, 200).

- Ford employed as many as six assembly lines with smaller capacities in combinations ideal for achieving its maximum production, and fewer as required to satisfy demand when it varied, rather than only one to manufactureup to the required maximum capacity, or at some theoretical maximum 'efficiency'."

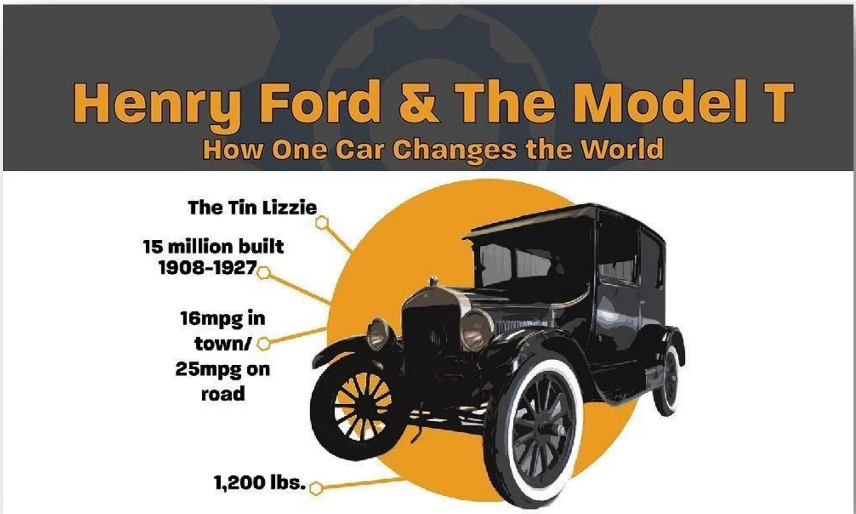
Concluding: "The implication of this historical case study, modern systems could be designedto be more adaptable. Because production lines are now more capital intensive than they were during Ford's time, the degree of flexibility available to Ford is unlikely to be replicated. Employment and labour practices are also more restrictive than they were during Ford's tenure, though the growing use of part-time and agency-suppliedtemporary workers may restore some staffing flexibility. Regardless of these potential constraints, system design should account for andaccommodate normal manufacturing variation. Multiple lines, as they did for ford, could provide flexibility. Line balancing in an increasingly competitive environment must also consider the line's role within the supply chain and howproduction must adapt to unexpected fluctuations."

Impact of the Model-T: Then and Now

Summarizing and Concluding:

- **"King of the assembly line**. The Model T brought mobility and prosperity on an undreamed of scale through manufacturing efficiencies at a price that anyone could afford. The moving assembly line created the mass-production process.
- **Friend of the factory worker**. The Model T was responsible for establishing a minimum wage and the eight-hour workday. The $5 a day minimum wage (created in early 1914 at Ford's Highland Park MI, factory) is often cited as having helped establish the middle-class. The factory work also gave jobs to people who usually could not find work, such as immigrants, women and minorities.
- **Personalized transport**. Thousands of different Model T accessories and add-on products were created and marketed by numerous suppliers, such as Peoria Accessory Co. (PACO, Peoria, IL). Because of this, the car spurred the aftermarket supplier industry, which is now a $38 billion industry.
- **A universal car**. The Model T was the auto industry's first global car. By 1921, it accounted for almost 57 percent of the world's automobile production. The Model T was manufactured in several countries and was sold by dealers on six continents.
- **Standardized steering**. Before the Model T, early American cars often had their steering wheel on the right-hand side of the dashboard. The Model T standardized the left-hand steering wheel.

- **Any colour - as long as it's black**. The myth that the Model T only came in black probably comes from the reality that almost 12 million of the 15 million vehicles built were black. But, in the early and late years of Model T production, the car was produced in many different colors, including blue, red, green and grey. Many of these hues were so dark, however, that they were hardly not so darken from black, which is another reason why the myth lives on.
- **Flexibility**. The Model T chassis was simple, strong and lightweight, with a unique three-point suspension that isolated the frame and powertrain from road shock that often caused many contemporary chassis designs to flex under heavy loads. By 1925, Ford was building its first factory-produced domestic pickup truck, the Ford Model T Runabout, with a pickup body. Ford also offered a heavier-duty, 1-ton-rated Model TT pickup.
- **Engine design**. The Tin Lizzie's original engine offered flexibility and boasted 20 hp, with a top speed of 40 to 45 mph. The front-mounted, 2.9-liter, four-cylinder, flex-fuel engine was the first single-block motor with a removable cylinder head. It was the basis for most modern engines. The engine could be matched to one of nine T body styles, all built on the same chassis. The Touring, Roadster, Ford, Coupe and Sedan were just some of the options available to consumers. The Model T established the concept of building multiple vehicle designs off the same platform.
- **Pop culture icon**. Soon after the Model T was unveiled, it started appearing in movies and songs, and became part of modern language and culture. The vehicle was featured in 1920s-era black-and-white comedies and became the subject of hundreds of jokes and cartoons that captured the experience about life with the Model T, the personality of the car and its creator, Henry Ford. Hundreds of songs were created as the Model T became part of pop culture, later generating dozens of nicknames for the car. The most common, "Tin Lizzie," was the moniker that had several possible origins, ranging from the popularity of the female name "Lizzie" during that time period to a famous Model T race car named "Old Liz."



- **Car of the century**. The Model T was the best-selling vehicle ever until 1972 when the Volkswagen bug surpassed it. During 19 years of production, more than 15 million Model T's were sold. On May 26, 1927, a ceremony marked the formal end of

Model T production. More than 70 years later, a panel of 126 automotive experts from 32 countries chose the Model T as the most influential car of the 20th century.”

Improving the Performance of Six Sigma; A case study of the Six Sigma process at Ford Motor Company

Summarizing: “In 2003, Ford Motor Company was ranked number four in the Fortune 500 (Hoovers.com, 2003) and was acknowledged as being the world number two producer of cars (Hoovers.com, 2003). Hoovers.com (2003) reported that in 2002 Ford Motor Company employed some 350,321 people worldwide with an annual sales figure of $163,420m. When an organisation decides to change the way it operates, then a coordinated approach is required. Six Sigma is one means of producing such change and in 1999; Ford adopted Six Sigma as a means of bringing about large-scale organisational change with a view to improving organisational efficiency.

Part of the Six Sigma process is to understand the financial implications of any changes made to an operation. Six Sigma uses a value known as the "Cost Of Poor Quality” (COPQ) to drive improvements made to a process. The COPQ consists of all the costs over the life of a product or service that can be attributed to a defective part (Harry and Schroeder, 2000). This cost is the value used to record all Six Sigma savings. The fact that the Six Sigma technique insists on an accurate calculation of the money saved by each project allows the impact of Six Sigma on profitability to be known. The development of Six Sigma and the mathematical concepts surrounding the sigma value are well documented and therefore, these topics are not covered. Instead, this section will explain what Six Sigma is, how the process has changed and how it works.

The Six Sigma breakthrough strategy is described as being a means of improving a process using a series of core process steps, namely Measure, Analyse, Improve and Control (MAIC) (Harry, 1998; Henderson and Evans, 2000). It would appear that different forms of the Six Sigma breakthrough strategy have materialised (Goh and Xie, 2004) and in 1999, Breyfogle (1999) wrote that Six Sigma consists of Deployment, Measurement, Analyse, Improvement and Control, of which the Measurement, Analyse, Improvement and Control phases are part of the project implementation phase.”

Concluding: “Some of the changes that have occurred include the addition of a Recognise (R) and Define (D) phase before the MAIC steps and Standardise (S) and Integrate (I) steps after the Control phase (Harry and Schroeder, 2000 [130]). Henderson and Evans (2000) observed that at GE, a Define phase had been added before the MAIC phases, and at Ford Motor Company, a Replicate phase has been added to create Define, Measure, Analyse, Improve, Control and Replicate (DMAICR). A further development of Six Sigma is proposed by Basu and Wright (2003 [82]) who describe a version of Six Sigma called Fit Sigma that incorporates lean methodology and tools to ensure sustainability of the initiative. There are a number of different forms of the Six Sigma breakthrough strategy, but the most common form would appear to be Define, Measure, Analyse, Improve and Control (DMAIC) (Henderson and Evans, 2000; Eckes, 2001 [10]; Coronado and Anthony, 2002; Goh and Xie, 2004; Soderborg, 2005; Raisinghani, 2005). While DMAIC appears to be the standard process, the author will deem that the start of the Six Sigma problem solving process, at a project level, starts from the Recognise (R).”

Henry Ford and the Model-T: Lesson for Product Platforming and Mass Customization

Summarizing: “On 27 September 1908, the first Model T Ford was wheeled off the production line in Detroit, Michigan. Richard Dawkins argues that natural selection acts to ensure organisms' bodies have no weak links. Henry Ford commissioned a survey of the car scrap-yards of America to find out if there were parts of the Model T which never failed. We argue that when resources can be diverted to different body parts with constant failure rates, then the allocation strategy that maximizes whole-organism longevity does not involve equalizing failure rates among components.

The Model T was produced from October 1908 May 1927 for an all. Ford first launched the Model N a Rader built in 1905 and one of the find fuel cylinder cars at the time. During this time, the Find More Company produced more Model T than all other American carmakers combined. The Ford Model T was based on the already. Ford aided the upper crankcase with main boarding with a new able cylinder heal. Main deals were afraid. The Model T was the starting point for today's tractor product line at Fond. In parallel, Find built the Model T (1 to), a tractor and designed 3 mock.

Model T as a platform: The Model T’s were based on a common platform promoting sharing of modules, components, manufacturing processes, and/or services. The resemblance to today's automotive platforms is striking. Henry Ford could also be argued that he implemented a form of lean manufacturing as seen in the Model T owner manual. The first 2500 models were proposed with a centrifuge water pump, slightly shorter engine block, crankshaft and very small commutators. The Model T family was tailored via specific bodies and features, but interfaces with the platform were common. The variety of the Model T platform was managed through a module-based design. Today's automakers are trying to replicate this level of modularity in their vehicles. Modules are substituted, und or removed to fit specific needs. In scaled hunt design model-based design, modules are added. The Model T family was tailored via specific bodies and featuring interfaces with the platform. Each body can be adapted to this common underbody.
Another interesting fact is how Ford adapted the Model Tl locate the Model TT by searching (scaled-based) the Model T to obtain a 1-ton lite truck. This operation was done by using any components from the Model T and specific new components to adapt to this new weight constraint.

Model T mass communication: The Model T was designed to satisfy the need for variety. Henry Ford proposed more than 5000 gadgets to customize the Model T, although, many were decorative in nature. This action ensured that mass production and mass customization generated thousands of unique vehicles during the lifecycle of the vehicle.

Ford's Model T car was the longest and perhaps most successful car ever realized, represented a product line of vehicles characterized by variety. Henry Ford's company built the common platform and used specialized manufacturers to tailor the Model Ts' to the exact customers' needs. Future work will target the study of points highlighted in the discussion section, especially the detail of the platform specification and the resulting family of products. Current practices will benefit from the Model T on numerous aspects from lifecycle management to mass customization."

Concluding: "Most of today's industries want to offer a variety of products based on a well-designed product family. Ideally, families of products should have high commonality while tailoring products from sets of customers to each customer. Many questions remain unanswered, but we believe that past experience can help improve current thoughts and approaches. In this study, we focused on the origin of the automotive industry to learn about product platform and mass customization. We discussed Ford's work and the Model T. This very successful car was not only available in a black model, but represented a product line of vehicles characterized by significant variety. Variety within the product line variety also through 5000 gadgets offered by the Ford Company; and variety finally with thousands of specific Model T's tailored to final customers' needs. The Model T platform was significant, including the entire underbody, the engine, etc., and improved over time along with the car bodies. The platform was independent from the bodies used to customize it. Interfaces were common for the entire product family, permitting easy manufacturing mixing and late differentiation. A version of mass customization was also implemented by Ford. In fact, Ford's company built the common platform and used specialized manufacturers to tailor the Model Ts to the exact customers' needs. Industries with manufactured products can learn from Henry Ford's success. Ford's experience was forgotten in the past industry designing non-platform product even when some product lines had sufficient homogeneity to be built on a product platform. Current practices will benefit from the Model T on numerous aspects from lifecycle management to mass customization via platform design and management. Future work will target the study of points highlighted in the discussion section, especially the detail of the platform specification and the resulting family of products."

Six Sigma case study: Ford Motors

Summarizing: "The Ford Motor Company is one of America's, and the world's largest and most successful automakers. Named after its founder Henry Ford, the company is known for its innovative and dynamic approach to manufacturing. Henry Ford pioneered and employed such manufacturing concepts as standardization, assembly lines, which came to be known as Fordism. He also paid his workers a living wage, allowing them to purchase the very products they made. Products like his famous Model T.

Ford was a visionary man. He saw the necessity of breaking down complex tasks into simpler procedures, using specialized tools, and interchangeable parts. While Ford's assembly line was a revolutionary achievement, his work grew from solidified ideas, with an eye for continuous improvement. Ford looked at established modes and broke them down into their core components, before building them back up again. He strove to take existing processes and always make them more functional, efficient, and effective. There were many advantages to Ford's ideas. Namely, the significant decrease in costs of production, radically simplifying the labour process and reducing required the workforce.

But how are Six Sigma and all its related approaches, like Lean and Kaizen, related to Ford? As you may know, Ford is a company known for its high quality. The company has pledged to utilize innovative products and use Total Quality Management to accomplish its goal of *Quality Is Job 1*. JD Power and Associates ranked Ford as one of the leading high-quality automakers, but Ford has come a long way in the last few decades. Today we examine just how the Ford Motor Company used Six Sigma to transform its processes and achieve its success."

Concluding: Why Was Six Sigma Necessary for Ford? There are four core factors behind Ford's Six Sigma initiative. These are:

- **Cost reduction.** Ford's old production process was surprisingly costly. By introducing Six Sigma, they were no longer using resources that were not necessary.
- **Improving quality.** Ford has always been known for their quality products, but event heir standards slip from time to time. While, for most companies, a mere 99% quality level is considered acceptable, this lets through a surprising amount of defect. As much as 20,000 instances of defect. Six Sigma espouses that only 99.99966% (and up) is ideal. This percentage limits the number of defects per million to just seven As such, Ford made some great astonishing strides in quality improvement using Six Sigma.
- **Poor customer satisfaction rates.** Satisfying customer demand is as critical to success as leveraging it. Many of these issues link to one another, as multiple instances of defect are likely to add up to a defective product. This will inevitably dissatisfy the customer which is why Ford chose to implement Six Sigma, to streamline their processes, and improve production issues. All of which adds up to a more productive company and happier customers.
- **Lowering environmental impact by reducing solvent consumption.** Six Sigma is an extremely green philosophy, and Ford uses it to make some great changes in their environmental awareness. Ford's consumption of vital resources proved very costly in the long-term. But by committing to a green work culture with Six Sigma, they reduced costs, increased quality, and improved customer satisfaction.

Technological Mutations and Henry Ford

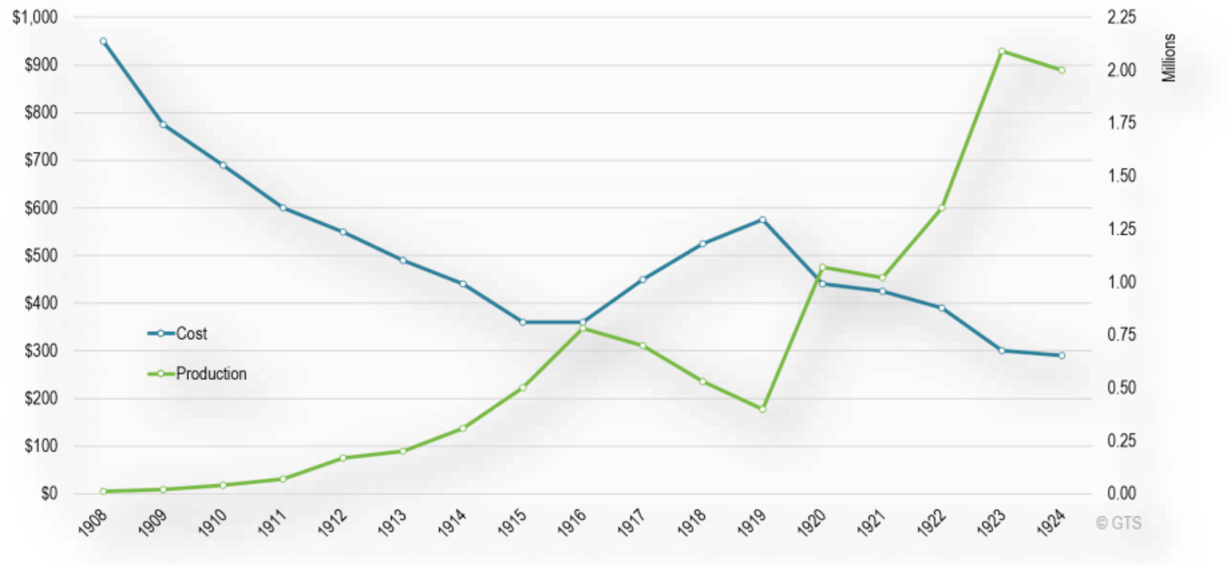
Summarizing: "Henry Ford did not invent the automobile or the assembly line. Instead, he was the most successful at marrying these two technologies together in ways that increased efficiency and reduced costs. Small household goods were manufactured on assembly lines and canned meats were made by stripping meat from carcasses on "disassembly" lines. Prior to the early 1900s, automobile chassis were placed on blocks, and workers brought the parts to the cars to be assembled one at a time. In 1901, Ransom E. Olds of Lansing had shown that the assembly line could be made to work for automotive production, despite the size and weight of the product. However, the Oldsmobile factory burned to the ground, and Henry Ford invested in a much larger factory that built upon Olds' methods. Ford's heavy steel rails and conveyer belts moved a car's chassis down a line. As a result, workers could stand in one place and complete one simple task, such as securing a specific bolt or adding a headlamp as cars moved along the line.

Ford's newest assembly line, complete with its massive moving belts, was up and running in 1913. Ford produced 250,000 Model T automobiles that year. This was thirty times as many cars as Ford had produced a few years prior; it was also more cars than Oldsmobile and over eighty other competing automakers based primarily out of Ohio, Michigan, and Illinois had ever made. A decade later, Ford was producing 2 million Model Ts, which were nearly identical to the earlier models except for the price. Ford was able to take advantage of economies of scale through mass production; consequently, the price of the Model T dropped from over $800 to under $300. Other automakers produced more diverse offerings, and many competing automakers produced better or cheaper cars. However, in 1913, no one could match the quality of the Model T for the price Ford was charging. As for the monotony of mass production, Ford quipped that his customers could have his vehicle in any colour they chose so long as that colour was black.

Henry Ford has mutated, primarily in Europe. The following section offers a few remarks about the idea of 'Fordism' and attempts to restrict its scope. Section 2 takes the central popular notion associated with Henry Ford in the 1920s, mass production, and distinguishes it from flow production, which is the more fundamental concept. Examples of British mass and flow production industries in the nineteenth century are considered. They show the importance of American machine tools from the 1890s for the development of flow production in the metal working trades, as well as the role of demand concentration for mass production. Developed especially to save labour in a skilled labour-scarce economy, US machinery proved as effective for the European motor industry context, described in section 3, as for that in North America. The following section (4) considers whether 'flexible specialisation' was an alternative or a precursor to mass production/Fordism. Section 5 examines the possibility that there was a technological discontinuity between Fordism and the Japanese approach to motor vehicle manufacture, whether for example Fordism was intrinsically rigid and Toyotism flexible. Finally section 6 discusses whether Fordism is dead and why national styles of production persist.

Concluding: Flexible Production: An Alternative to Mass Production and Fordism? The most commonly proposed alternative to 'Fordist' mass production is 'flexible specialisation'. Advocates emphasise the plasticity of technology, that there were viable alternatives historically to mass production (Sabel and Zeitlin 1985). Customers became habituated to mass produced solutions but such techniques were not necessary to arrive at an industrial society. High skill, universal machine economies towards the end of the eighteenth century 'in many ways anticipated contemporary developments'. Large-scale production repeatedly beat small on level playing fields over the centuries, but perhaps there were more opportunities for flexible production than there were for small scale production.

Much of the credibility of the 'flexible specialisation' counterfactual stems from an interpretation of current technological trends that identifies key features as increasing product differentiation, shortening production runs and more general purpose, rather than dedicated, machinery operated by a more skilled workforce. But as we will see the evidence for such a tendency is thin. One British motor production style was, in a sense, flexible. Whereas the



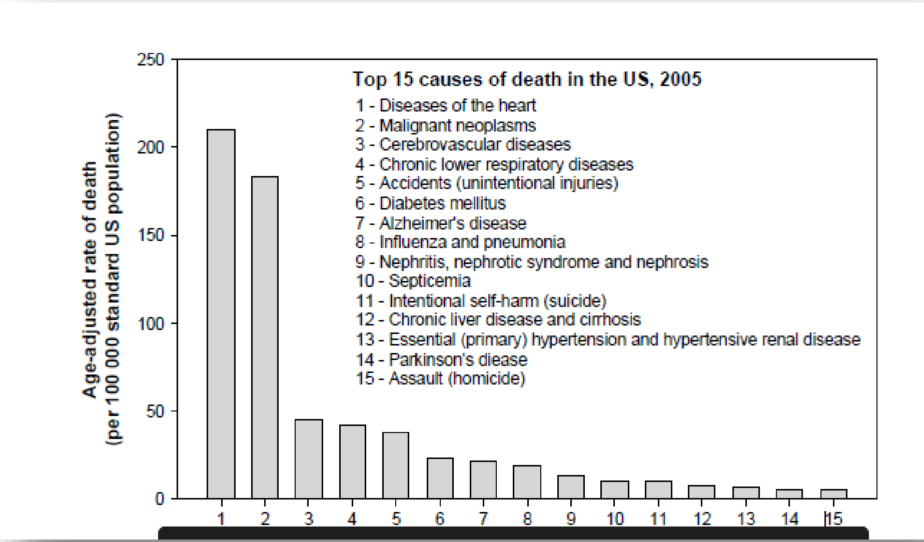
Ford approach was for machine pacing with high time rate wages, a British adaption entailed team bonuses and the continuation of a form of piece work on the production line (Lewchuk 1987, 1989). The role of shop stewards in this system was particularly striking. Shop stewards were neither union officials nor members of management but, elected by the workforce, they had a responsibility to keep going the production system that provided their electorates' earnings.

The Economics of Evolution: Henry Ford and the Model T

Summarizing: "On 27 September 1908, the first Model T Ford was wheeled off the production line in Detroit, Michigan. Henry Ford commissioned a survey of the car scrap-yards of America to find out if there were parts of the Model T which never failed. His inspectors came back with reports of almost every kind of failure: axles, brakes, pistons all were liable to go wrong. But Ford drew attention to one notable exception - the kingpins of the scrapped cars invariably had years of life left in them. Richard Dawkins argues that natural selection acts to ensure organisms' bodies have no weak links. Richard Dawkins: Why spend good money on something that will rarely if ever fail? Under these conditions the quality of the kingpins could be reduced, without drastically affecting the longevity of the car

Optimal allocation of elements favours the more damage-prone block (Block 1), but optimally allocating organisms still have Block 1s with much shorter expected fail-times. The relative contribution of extrinsic mortality to total mortality at first rises as organisms evolve ways to reduce their intrinsic mortality. One might wonder why it is so easy to fall into the Model T Ford fallacy, After 10000 generations, however, the probability of dying due to the failure of Block 1 still greatly exceeded t. Despite assertions to the contrary, evolution has not shaped different components of human bodies to 'fall apart' at the same time. In humans heart failure is far more likely to be the cause of death than liver failure, and some body parts may be more expensive to maintain than others. Natural selection will act to ameliorate the effects of damage, but the differing returns on investment means that organs are not likely to all be rendered equally likely to cause death.

One might wonder why it is so easy to fall into the Model T Ford fallacy,
Viewing an automobile or an organism as a linked chain of parts immediately leads to the conclusion that there should be no weakest links.
However, such a perspective implicitly assumes that the individual links in the chain are equal both in terms of the damage they receive, and in the costs of strengthening them.
Observational data



Despite occasional assertions to the contrary, evolution has not shaped different components of human bodies to 'fall apart' at the same time. We can see this most directly by noting that, for example, in humans heart failure is far more likely to be the cause of death than liver failure Likewise, Currey (1984) analysed records of accidents in horse racing and found that horses' distal leg bones were much more likely to suffer fatigue fractures than proximal ones.
We suggest that the very functions different body parts perform render some parts more likely to experience damage than others. Similarly, some body parts may be more expensive to maintain than others.

Concluding:

- “One might wonder why it is so easy to fall into the Model TFord fallacy, in spite of (1) the history of 'marginal value' arguments in ecology (Charnov 1976, Perrin 1992), (2) detailed discussions of the closely related question of why different body parts have greater capacity-to-load ratios ('safety factors') than others (Alexander 1981, 1997, Diamond 2002), and (3) the exposure of evolutionary biologists to other economic fallacies such as the 'Concorde fallacy', (Dawkins and Brockmann 1980).

- Viewing an automobile or an organism as a linked chain of parts immediately leads to the conclusion that there should be no weakest links.

- However, such a perspective implicitly assumes that the individual links in the chain are equal both in terms of the damage they receive, and in the costs of strengthening them.

- Moreover, it also implicitly assumes that if one link in the chain were weaker than the others, than this weak link, as opposed to its stronger brethren, would always be the source of chain failure."

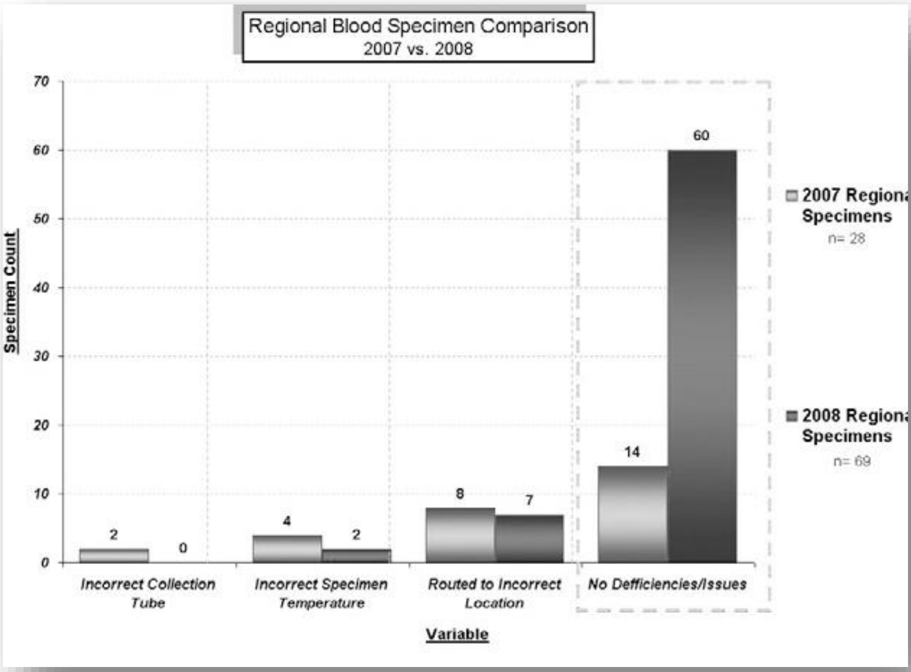
The Henry Ford Production System: Measures of Process Defects and Waste in Surgical Pathology as a Basis for Quality Improvement Initiatives

Summarizing: "This Henry Ford Production System has evolved as our business system that continually produces thousands of process improvements by an engaged, problem-solving laboratory workforce in our six acute care hospitals and 30 medical centres in southeast Michigan. This Lean cultural discipline and teamwork predicated on Deming management principles was the foundation on which these standardized laboratories achieved International Organization for Standardization (ISO) 15189 accreditation in 2013 as the largest ISO-accredited integrated laboratory system in the United States.

Numerous work and management systems have been created over the past decade to sustain our Lean culture, whose credo is "relentlessly pursuing perfection." These include subsystems for policy deployment, system-wide education and competency, plan-do-check-act (PDCA)–based continuous improvement, non-conformance (deviation) detection, classification and management, controlled electronic document taxonomy and management, functional horizontal management, service-line management review, audit systems and daily management.

Materials and methods: Before implementation of HFPS, different divisions and sections of pathology operated as independent units. No formal channels of communication were in place such as electronic test ordering or team meetings between departments. Any communication that did occur between groups tended to focus on fault finding, blame, and denial, rather than on using a team effort for reaching common goals successfully. Work performed in different sections lacked a method of standardization, which added to overall testing delays and waste. Our molecular laboratory is centrally located and is in close proximity to the histology laboratory. Despite being a part of the pathology department, the molecular laboratory remained isolated from the rest of the anatomical pathology laboratory because of its focus on nucleic acid-based testing rather than total tissue-based testing. Working in the molecular laboratory requires a highly specialized set of skills. Frequently, individuals who have mastered molecular biology techniques have little familiarity with important histology-based tissue processing techniques such as tissue fixation, paraffin embedding, sectioning on a microtome, and staining."

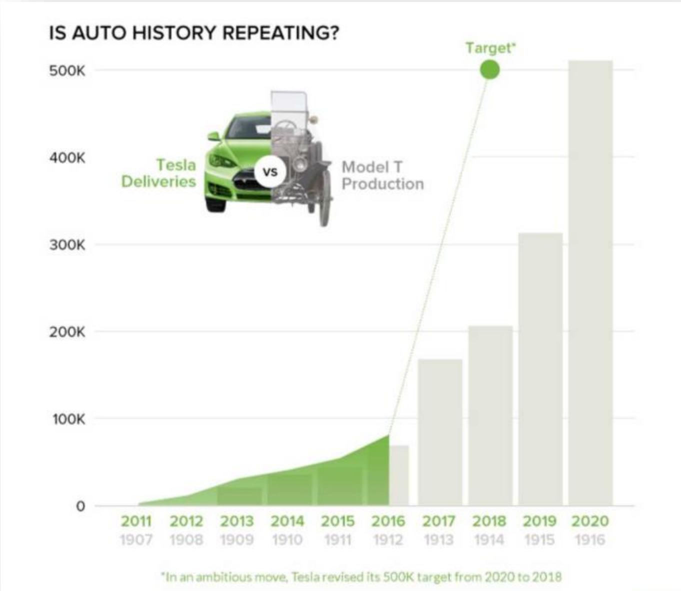
Concluding: “Customer-supplier meetings were introduced by HFPS team members as an effort to “hear the voice of the customer.” These meetings proved to be instrumental as collaborative intra- and interdepartmental efforts to assist in defining problems, increasing accountability, determining root causes, brainstorming solutions, and eventually implementing our efforts. Weekly customer-supplier meetings were undertaken with the mission of congregating workers to discuss their expectations and customer requirements as product was produced and passed from one work cell to another.[10] The goal was to create highly specified requirements to aid in direct handoffs between customers and suppliers so that the main types of waste in processes could be eliminated. Molecular pathology personnel were educated in HFPS principles in May 2006.”



Henry Ford and Innovation: The Model-T and the Assembly Line

Summarizing: “On October 1, 1908, the Ford Motor Company introduced one of the most famous and influential products in the history of American business—the Ford Model T. By the time the last the Model T rolled off the assembly line in 1927, it had made the company and its founder famous, wealthy and powerful—and altered American society forever The key to the Model T’s success was Henry Ford’s ability to recognize what Americans wanted in an automobile and then deliver such an automobile at a price most could afford.

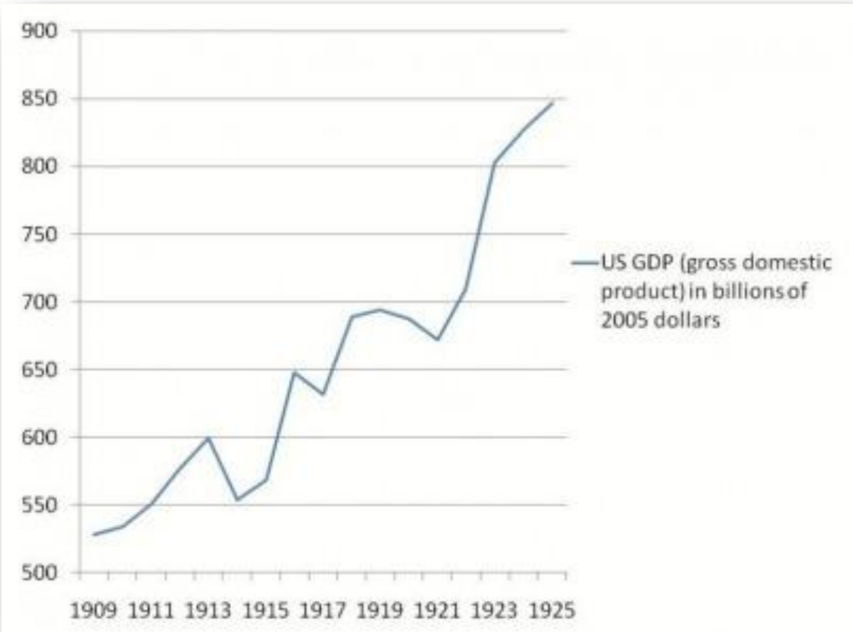
The Auto Industry Before the Model T: The Model T appeared when the American automobile industry was only a dozen years old. Charles and Frank Duryea of Springfield, Massachusetts, had become the first Americans to build a series of automobiles for sale in 1896, kick- starting a flourishing industry that by 1908 was selling some 63,500 cars a year.



Yet the automotive landscape remained a muddle: No particular size or price range clearly dominated. Not merely was there uncertainty about the right combination of size, power and features, but also a deep confusion about what automobiles were for, or as one historian later put it, “At stake were not only the forms motor vehicle technology would take, but also the social ends it would serve. How, where and with what effects should people use the new machines?”

Henry Ford, whose Ford Motor Company had been making cars since 1903, thought he knew what kind of cars Americans wanted. In 1906, Ford wrote to *The Automobile* magazine that the “greatest need today is a light, low-priced car with an up-to-date engine with ample horsepower, and built of the very best material. . . . It must be powerful enough for American roads and capable of carrying its passengers any- where that a horse-drawn vehicle will go without the driver being afraid of ruining his car.”

The same year Henry Ford made that statement, his company introduced a car that met many of those requirements, the Ford Model N. But it had several shortcomings and still seated only two or three people. Henry Ford thought he could do better. Early in 1907, he ordered construction of a room in the northeast corner of the third floor of the company’s plant on Piquette Avenue in Detroit. Behind the padlocked door of that room, Henry Ford and a small group of his closest associates created the Model T.

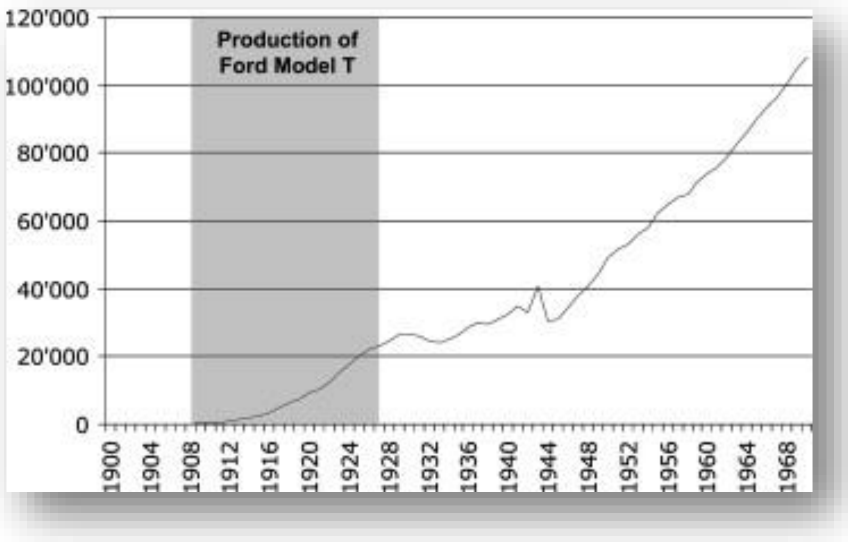


The Model T—An Advance in Car Design: The Model T’s engine met Ford’s requirements for being “up-to-date” by having a one-piece cylinder block and a detachable cylinder head. These are standard practice today, but in 1908 they represented the real advancements.”

Concluding: “The immediate impact of the assembly line was revolutionary. The use of interchangeable parts allowed for continuous workflow and more time on task by labourers. Worker specialization resulted in less waste and a higher quality of the end product. Sheer production of the Model T dramatically increased.”

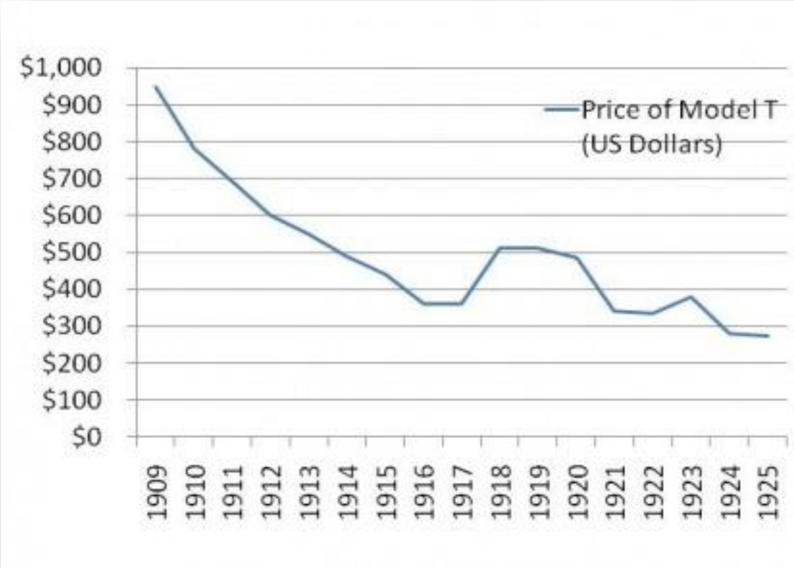
The Role of Process Simulation within Ford Six Sigma

Summarizing: “Ford employs a variation on these approaches DCOV (Define, Characterise, Optimise, Verify), to realise advantage in its products development. The latest vehicle line up proves this, including the Mondeo, Focus and Fiesta, all of which have benefited from the use of these tools. One of the crucial elements of a Six Sigma project, is the selection of project metrics. Project metrics should reflect the voice of the customer. Metrics should be measurable, meaningful and provide a common language among diverse team members.



WITNESS and Six Sigma: WITNESS can offer a number of benefits to a Six Sigma programme. If the organisation does not understand the "science" of their processes, they cannot control, modify or improve them. It is first necessary to study a process in order to know which variables affect it. Once this is understood, the variables affecting the process can be manipulated in a controlled fashion to optimize performance. In addition to studying the real process, building a simulation model can help with understanding. The model also provides a test-bed to measure the relative effects of improvement alternatives without undertaking expensive real time experimentation. The optimum alternative can be selected and implemented with confidence in the real world, minimizing the risks to the process and the customer.”

Concluding: “The model was constructed in this way to provide the Ford engineers with an easy to use tool for assessing Chiller capacity on future projects and to allow Ford engineers to evaluate and compare individual machine demand. With this model, engineers are able to quickly and accurately predict cooling capacity requirements. This analytical power will result in significant capital expenditure savings and provide valuable information during machine specification discussions and negotiations.”



Transforming to a Quality Culture: The Henry Ford Production System

Summarizing: “Henry Ford is credited with creating the first comprehensive lean manufacturing system and, more broadly, a lean enterprise encompassing not only his factories, but also their supply chains. Ford’s major insight was that increases in efficiency and productivity are derived readily from savings derived from waste in all its forms. The Toyota Production System (TPS) is based on the historic Ford System with a relentless goal of eliminating waste. Another popular manufacturing business–based quality improvement method developed by Motorola, effectively used by General Electric to achieve customer satisfaction, and now applied in health care, is known as Six Sigma. However, applications like the TPS, a refreshed and innovated version of Ford’s original production system, go even further to change the underlying management culture of the laboratory to create a continuously learning, empowered workforce, making scientifically based rapid process improvements as a means of continually striving toward higher performance. At Henry Ford Hospital, with the 15th largest hospital-based laboratory in the United States, we have proudly built on our founder’s approach to mass production to include the Toyota-derived concepts that go “beyond mass production and have melded this with currently available laboratory automation and new technology to create a culture continuously perfecting pathology laboratory processes and improving quality. We began by selecting team leaders who were competent, effective, and communicative subject matter experts in their field of expertise.

Concluding: This scientific method for continuous change and improvement is guided by 4 rules or principles that define how these “experiments” can be carried out by those doing the work at the lowest level without destabilizing the organi-zation.9 These rules, as deduced and described by Spear and Bowen,9 are: Rule 1: All work shall be highly specified as to content, sequence, timing, and outcome. Rule 2: Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses. Rule 3: The pathway for every product and service must be simple and direct. Rule 4: Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization.

These rules sound simple and define the functioning TPS culture, but their consistent adoption outside of Toyota is not. We believe that successful implementation of TPS style quality improvement goes far beyond lean manufacturing methods that focus on elimination of waste because TPS requires a major change in organizational culture .Other elements contribute to the success of the TPS. One important factor is the focus on a long-term philosophy rather than the short-term fix as in the common American business tactic for success. In effect, it’s all about creating trusted relationships and building long-term thinking into decision making. This, in turn, influences actions that enhance quality and thereby define long-term success, not necessarily the immediate financial bottom line.

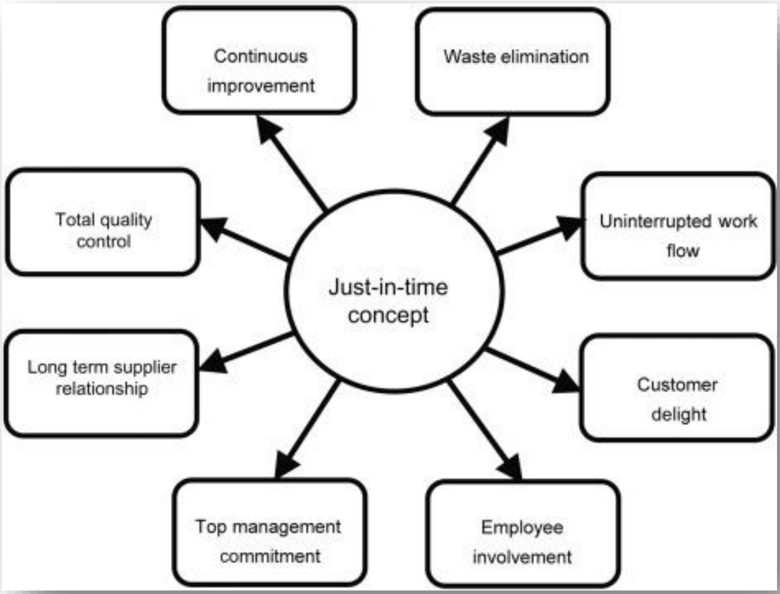
Henry Ford’s Just – In – Time System

Summarizing and Concluding: “The objective of Just-In-Time (JIT): Henry Ford who is said by many as the one whose first implement the Just-In-time System. Just-In-Time is the manufacturing production system and its main objectives are listed below:

- No inventories are stored: so one of the just-in-time objectives is to reduce or eliminate the storage of inventories. In the old manufacturing production system, the raw material is purchased, products or goods are produced, and stores. This concept costs a lot of money to store not only raw materials but also store finish goods. Also, the production process is quite slow as the company might not seeking a new way to improve the process. Therefore, JIT tries to overcome this problem. The productions are processed only if there are orders from customers.

- No material is purchase: In implementing the JIT, the material will not purchase if there are no productions. Unlike the old system, the raw material is purchased due to production forecasting demand and production. The old system normally has low networking with suppliers, and most of the raw materials required during the years are purchased in advance and spend a lot of money and space on storing the raw material and taking care of them.

- Just In Time System is trying to overcome this by ensuring that there is a good relationship with the supplier and the raw materials are purchased only if there is



production. However, this meets this objective. The company that implements Just In time needs to build a perfect relationship with its suppliers or, in order words, suppliers could access the company system to understand the demand. Otherwise, suppliers might not be able to supplies the raw material on time and as required. This is the warning point for the company that wishes to implement this system.

- Improve the Production System: Another main objective of Just-In-Time Production systems is to help the company improve the production process. We will look in detail at how Just-In-Time could help in the following.

Definition of Just In Time (JIT): Now let we go to the quick definition of Just-In-Time, Just-In-Time is part of the Lean Manufacturing System that tries to maximize the efficiency of the Manufacturing Process, Minimize the waste of Inventories, and reduce the Cost of Storing. Just-In-Time Manufacturing System required a deep understanding of the customer's demand, Perfect Purchasing and Procurement System, and Effective Production System. Just-In-Time is the concept, and it is not improving the company directly, yet, it influences another process to improve the company.

Just In Time Production: The concept of Just-In-Time Production is that there is no production if there is no purchase order. Just-In-Time Production requires the perfection of a customer's management system to lead the production department to get ordering data as quickly as possible. The customer order is the driver of production. Most of the companies fail to implement and miss understand this. Why? Because they understand that the Just-In-Time System is the method of forecasting how much product is required to produce due to current demand by using the Just-In-Time formula. This doesn't seem right. They first have to make sure that the production department could assess the customer's orders, and this data link to the purchasing department to make the quick order of material. We will talk later about the concept of Just-In-Time in Purchasing."

A Technical Examination of the Planetary Transmission of the Ford Model-T

Summarizing: “During the 19 year long production of Ford T-Model, its transmission remained unchanged. The transmission, designed by Joseph Galamb, and his team adopting Henry Ford’s ideas, was developed for slightly more than a year, in a secret office. What was this transmission like? This article brings it closer to current admirers through its history, and gives an analysis of it for those, with engineering aspect of view.

Principle of Working: The main section and the kinematical outline of the transmission. The element is the carrier of planetary gear, which is in the same time the flywheel mounted on the crank-shaft of the motor. On carrier there are three pins placed in 120 deg. On these pins are mounted the planet gears (Each planet gear consist of three, gears). The planet gears are coupled with others and with sun gears, which lie in the same axis as the crank-shaft. Sun gear, through friction clutch is directly connected to hollow shaft (the outgoing shaft which with two cone-gears connected to it, drives the wheels of the car). Sun gears it can be fixed by putting into use brake drums.

Handling of Transmission: For starting the motor the driver should put the handbrake off. This meant in the same time the release of the friction clutch. On start-up, while putting the handbrake off, the left pedal should be half way pressed. In this way the vehicle is put in idle speed. With continuing to press the pedal to the end, brake drum will be fixed, and the car starts up in low speed. For high speed, the pedal has to be simply released since with this the friction clutch is switched on. For reverse speed, first left pedal should be pressed halfway to switch the friction clutch off. Then the middle pedal must be pressed to the end, which will fix brake drum I. The third pedal is the brake. Thus with the transmission of Model T diverting was possible without taking hands off the steering wheel. *This was a remarkable transmission. I’m sure many old-timers remember the stunts they could perform with it. It was possible to teeter the car back and forth simply by stepping first on the low and then on the reverse pedals. By releasing the low and then reversing that motion a man could do almost anything he wanted to get the car out of difficulty when in danger of bogging down in a rough country road. No transmission in today’s cars could give that type of performance*.”

Concluding: “The final design proved to be very reliable and durable. It was used on all of the 16 million Model Ts’ produced worldwide from 1908 to 1927. The T Model was announced in March 1908, slightly more than a year after the beginning of development. As a result of hard teamwork during this period of time a car with a revolutionary transmission had been made, from which afterwards 16 million pieces were sold. The transmission is perhaps the only part which went unchanged throughout the 19 years of production. The design made by Galamb led design group, was patented by Henry Ford. The claim of patenting was handed in on 10th of August 1909, and it was accepted with patent number on 10th of October 1911. The simplicity, good efficiency, and load distributing of planetary transmission made it successful not just in automobile industry but in aviation too, during the First World War Galamb designed a planetary transmission for tanks as well.”

Methodology

At the start of the research, we had a preconception that the Ford Motor Co. has been maintaining its standard in the market starting from the model T to Ford Bronco Sport, Ford Ranger, Ford Mustang, Ford Escape, Ford Explorer, etc. As the research continued, these aspects were identified studied in detail we came to realise that it too had its highs and lows. And without a continuous improvement methodology and application of Lean Six Sigma and Total Quality Management tool no company would have the ability to stand out throughout the competition sphere today. The research identified that the processes for selection and scoping out Six Sigma projects are at the lowest level of process maturity in Ford Motor Company. The development of selection and scoping processes necessarily means that the solution is prescriptive so this requirement is fulfilled.

We also studied, compared and contrasted the company's core process regulations while it was in the hands of the father of mass production: Henry Ford himself to the present time CEO Jim Farley. Here we describe the abstract ideas we could pick up from the top 10 research papers we have studied:

- In *Automating the production line: Henry Ford began it all when he designed the first car assembly line in 1914* we get to know that the automatic production line is a production system that automatically completes all or part of the manufacturing process of the product by a work-piece transfer system and a control system, which is a combination of a set of automatic machine tools and auxiliary equipment in a process sequence, referred to as an automatic line. This thesis aims to achieve the concept of the same.
- *Beyond Fordism? Strategic choice and labor relations in Ford UK* conveys that new industrial competition has led major automobile manufacturers to re-analyze their approaches to business strategy and industrial relations. This article examines attempts at Ford Motor Co. to adopt its traditional approach to work organization to its changing business environment.
- *Concept car development with the example of a Ford model T successor* develops an innovative vehicle concept which is capable of carrying conventional as well as alternative drivetrain modules thanks to its scalable design — a modern "Tin Lizzy" with the basic sales price of less than 7000 US dollars.
- *Henry Ford vs. Assembly Line Balancing*. This analysis shows Ford's assembly line was used differently than modern ones and their production systems were more flexible than previously recognized. It will be shown that Ford used multiple lines flexibly to cope with large monthly variations in sales. Although a line may be optimized to yield the lowest cost production, systems composed of several parallel lines may yield low cost production along with output and product flexibility.
- *Improving the performance of Six Sigma: a case study of the Six Sigma process at Ford Motor Company*. This thesis concerns the question, "Why is the performance of

Six Sigma within The Ford Motor Company below that experienced in other companies, and what can be done to improve it?“ This thesis aims to make recommendations that would improve the performance of Six Sigma within the Ford Motor Company.

- In *Henry Ford and the Model T: Lessons for Product Platforming and Mass Customization*, they study Ford's Model T in depth and describe insights into Ford's vision and his car: how the platform was built, how it was leveraged, and how the platform was maintained dynamically and with continuous improvements to maximize learning and economies of scale. Finally, they compared Ford's approach to more current approaches to learn from his innovative product line.

- *Technological Mutations and Henry Ford*. Focussing primarily on Europe, this paper examines the evolution of the production technology associated with Henry Ford. Key elements identified are mass and flow production, the progress of which are traced from the early nineteenth century. The concentration of standardized demand, necessary for mechanization and therefore mass production, was in war-related production and often in state industry.

- *The economics of evolution: Henry Ford and the Model T* conveys that: For the past 30 years evolutionary biologists have used a fictional tale about engineer and businessman Henry Ford to help illustrate the undesirability of over-design. Thus, on discovering that kingpins were rarely damaged in scrapped Model T automobiles, Henry Ford is alleged to have concluded that the kingpins were unnecessarily durable and asked that they be built to a cheaper specification. The general lesson that has been drawn from this tale is that natural selection will act to equalize the mortality risks accruing from damage to each part of the organism's body. This paper argues the validity of the tale.

- *The Henry Ford Production System: measures of process defects and waste in surgical pathology as a basis for quality improvement initiatives.* In this research they implemented a continuous quality improvement initiative in pursuit of a "zero-defects" performance goal in surgical pathology that required design of novel data collection tools to assess their current condition and sources of defects and waste. They found that through deep and honest exposure and the concerted effort of all workers, they could identify numerous sources of waste in their processes.

- *The Role of Process Simulation within Ford Six Sigma.* Ford was one of the first companies to adopt and witness simulation to help develop effective manufacturing facilities, and they have also invested significantly in the Six Sigma Breakthrough Methodology. Hence its roles and impacts were presented.

- In *Transforming to a Quality Culture: The Henry Ford Production* they describe the cultural transformation of the surgical pathology laboratory at Henry Ford Hospital, Detroit, MI, to one that has adopted an expectation for empowered workers to see their daily work in the context of continually learning and making effective process improvements that are designed and tested by the scientific method. This transformation has been achieved by creating an organizational and educational framework for implementing guiding principles originally systematized as the basis of lean manufacturing by our founder, Henry Ford, at the turn of the century, and incorporating the innovations of the Toyota Production System.

- *Henry Ford's just-in-time system*. This thesis states that Henry Ford′s ideas and practices show many features seen in contemporary Japanese approaches. Ford, in the period from 1908 through the late 1920s, relied on a number of progressive and radical methods in manufacturing management; methods that were similar to the current Japanese methods.
- In *A Technical Examination of the Planetary Transmission of the Ford Model T* we get to know that during the 19 year long production of Ford T-Model, its transmission remained unchanged. The transmission, designed by Joseph Galamb, and his team adopting Henry Ford's ideas, was developed for slightly more than a year, in a secret office. What was this transmission like? This article brings it closer to current admirers through its history, and gives an analysis of it for those, with engineering aspect of view.

After spending time with every research paper we had the task of integrating all the concepts of these papers to a jot down from the perspective of total quality management. Because no other thesis had exactly been stating all the points together. We had the desired outcomes of our project planned as to answer the question "Was Henry Ford unknowingly following the current TQM methodology to achieve grand success with the Model T?" In addition to answering this question, in the process we also got answers to the following questions about the current system of Ford Motor Company:

- Why Ford Motor Company is not achieving performance seen in other companies with Six Sigma?
- How the implementation of Six Sigma within Ford could be improved?
- What is the root cause of poor performance?
- How to solve the issue of poor performance?

Why Ford Motor Company is not achieving performance seen in other companies with Six Sigma?

There are two aspects to this question, the first being what is best in class performance and the second being why is Ford Motor Company not achieving this level of performance. Best in class performance is a relative measure, is dependent upon the scope of who is included within the comparator group and their objectives. What makes it difficult is that ultimately, the desired performance will depend upon the goal of the process and how it is aligned to the strategy of the organisation. In this respect, the author would advocate a different goal, using absolute targets. This would reduce the level of confusion surrounding what is meant by the phrase Best in Class and can therefore inspire greater levels of performance. As to why Ford Motor Company is not achieving greater levels of performance, this is due to the low level of process maturity that is existent within the phases of the Six Sigma process. Improving the maturity of the Six Sigma process is the responsibility of the Six Sigma deployment office. Once the process maturity is grown, then there is no reason why Six Sigma cannot achieve much higher levels of performance.

How the implementation of Six Sigma within Ford could be improved?

The answer here lies in growing the performance of the Six Sigma process to ensure that it is aligned with the goals of the organisation. The proposals given tackle the immediate issue, namely that there are not accepted processes for selecting and scoping projects. To improve the performance of Six Sigma within Ford Motor Company, the author has challenged the current thinking regarding Six Sigma project selection. In section 7.5.1, the thoughts regarding project selection and scoping were discussed, namely that Pyzdek (2003 [190]) maintains that project selection is an art as well as a science, and Rath and Strong (2003 [351]) write that the initial project selection will never be perfect. This is strong evidence that Six Sigma project selection is an ad hoc process which suggests that it is a level 1 process according to Gardner's process maturity continuum. What makes this interesting is the same resistance observed in organisations resisting change are observed within the Six Sigma literature. The key contribution is to use the Six Sigma methodology combined with an understanding of the concept of process maturity and develop tools that actually increase the process maturity of the project selection and scoping process of Six Sigma. This is exactly in line with what process improvement methodologies are trying to achieve. The tools then developed take Six Sigma to a level 2 process and this allows the process to be managed and improved further. Improving the maturity of Six Sigma has required a number of different factors to come together.

What is the root cause of poor performance?

To make it possible to solve the issue of poor performance, it is necessary to understand what the issue is at a root cause level. This means that while inappropriate metrics, leadership support and resource availability are often cited as reasons for the poor performance of Six Sigma, these are symptomatic of the underlying cause, namely that the issue of selecting appropriate projects that are of a suitable scope is not done well, which in turn is caused by inadequacies in the process. To determine the root cause, it is necessary to adopt a structure within which to analyse the information, namely the EFQM and the process maturity model. Using this approach with interviews made it possible to create distance between the researcher and the problem. This in turn dispelled many preconceived ideas and allowed a more objective investigation of the issue.

How to solve the issue of poor performance?

Having identified the cause of poor performance, it was necessary to then analyse what would be required to raise the process performance from level 1 to level 2 and develop the appropriate process steps. To achieve this, it was necessary to decompose the idea behind what Six Sigma could achieve to provide a procedure for analysing projects using existing process performance data. The use of these tools allows the objective identification of the highest priority issue. In addition to identifying processes to select and scope projects, it is desirable to provide other tools that allow a further growth in maturity of the process. Here the control plan, FMEA and reaction plan are created specifically for the Six Sigma process. This is new and while the application of an FMEA to manage risk is not a new concept, the concept of using an FMEA on a Six Sigma project is new. Furthermore, while the last part of the Six Sigma training is the Control phase, there is nothing in the literature that facilitates the management of Six Sigma using cycle time and yield, since these metrics are only used on processes and up until now, the work conducted using Six Sigma are viewed as projects which are seen as unique and individual pieces of work as is described in chapter 7.2.1. Through increasing the process maturity of Six Sigma, it is now possible to view Six Sigma as the application of a process and therefore the idea of yield and cycle time can now be applied. One further question that should be considered is whether any of the outcomes of this research would benefit other companies or users of Six Sigma. It appears from the literature that project selection and scoping remain the largest undefined areas within Six Sigma and therefore the application of the process maturity model to assess the performance and drive improvement are relevant. It is believed that unless other companies have developed systematic and rigorous processes for selecting projects, then the approach here will produce dramatic improvements to their project yield performance. Even where companies have rigorous processes for selecting and scoping projects, the approach taken here of identifying the process maturity of different steps through the use of the techniques here will allow the performance of Six Sigma to be improved. Henderson and Evans (2000) note that Six Sigma has been described as the "Rolls Royce" of quality improvement systems. However, in line with Six Sigma principles, even Six Sigma can be improved. Following this philosophy, adaptations to the system are not indicative of a system failure, but instead demonstrate that the methodology is improving and therefore working.

Apart from these, our other results we obtained by brainstorming each and every decision of Henry Ford, why he might have taken those decisions, and how did that contribute to the success of the Ford Model T. Those results have been presented in the later sections.

Result and Discussion

Henry Ford did not invent the automobile or the assembly line. Instead, he was the most successful at marrying these two technologies together in ways that increased efficiency and reduced costs. Let’s see his ideas and decisions that can be related to the currently practiced TQM principles:

PAPER CONCEPT	ITS LINK TO TQM
Automating the Production Line	One of the main principles of TQM is making a tightly knit integrated system of processes. Automating the Production Line for the first time systematized the working span of every staff. This could be called the first step towards achieving integrity.
New Industrial Competition that made Ford re-analyse their Work Environment	As work environment directly impacts employee performance, and employee involvement is a critical tool to achieve continuous improvement in companies, this major change in Ford Motor Co. can be credited to be one of the basic steps towards the bigger goal.
Assembly line: used differently, more flexible, multiple parallel lines	Ford used multiple lines flexibly to cope with large monthly variations in sales. Although a line may be optimized to yield the lowest cost production, systems composed of several parallel lines may yield low cost production along with output and product flexibility. A flexible product design will reduce redesign costs and allow quicker response to customers with increased performance. So satisfying customers was one of his priorities. Which in turn is also a TQM goal.
Innovative Product Line and Platform	Product innovation is important because it can help one create new spaces in a seemingly crowded market. By identifying the gaps and imposing oneself into a new space, one can find an audience and satisfy consumer needs in a way that is new and refreshing. Ford Model T was the first of its kind that gave Ford its name and customer base.
Evolution of Production Technology in Mass and Flow	Henry Ford’s contributions offer valuable lessons for Product Platforming and Mass Customization. Product platforming is a specific approach to new product development utilizing common technology components or subsystems deployed across multiple products or product lines which has been argued to bring numerous valuable organizational outcomes and cost reduction. Both these factors being a concern in TQM, we can credit his decisions to have been following a similar path.

Undesirability of over-design => Kipkings were rarely damaged in scrapped Model Ts'	To reduce the cost of his vehicle, Ford drew attention to the fact that Kipkings (a part of the Model T) were more durable than required and ordered them to be made of cheaper specifications that would allow all the parts of the vehicle to wear out at a similar rate. He did not want to spend on something that would not be optimally used off by his customers. This proves that he had foreseen the undesirability of over design that early in time. This decision definitely contributed to the success of the Model T.
Experiment in the pursuit of "Zero Defect" system => numerous sources of wastes could be identified with the collective effort of all the workforce	Through the collective effort of the workforce, a zero defect system could be achieved in Ford Motor Company. This resonates to the TQM practice of Employee Involvement in every stage of processes and projects. It is only through transparency and a rapid flow of open communication and ideas between employees and executives, that wastes can be identified and reduced.
Comparison with Japanese Practices and Ideology	He had an integrated systems approach founded on a market strategy allied to a focused manufacturing system that emphasized quality, efficient production and an avoidance of waste; within a paternalistic framework intended to make the best use of a generally low grade but highly varied workforce. These on being compared to Japanese practices did align together even though they were introduced independently. Just like many TQM practices align with Japanese ideology.

Now let's see why Ford Model-T was a big success:

Its SPECIFICATIONS
• Inline 4 cylinder engine with 20 horsepower.
• 10 gallon fuel tank (you need to guess how far you've gone assuming 20 miles are covered per gallon).
• Maximum speed was 45 miles/ hour which might sound so slow but it was a lot faster than a horse and buggy (with average speed of 5 to 8 miles/ hour) which was the common mode of transport back then.
• Made for rough terrain.

All these specifications might sound to be a joke today as we have vehicles which run at 180 kmph. But at that time people could never even think of travelling at that speed and more over even owning a car! It didn't bother then if they had to carry an extra set of blankets for the comfort they were getting was unimaginable. Ford could produce it at such a mass scale and in such a low cost only because of his techniques and choices of production.

WHAT WAS EXCLUDED?	WHAT WAS INCLUDED?
• No heating	• A car! And not a horse and buggy!
• No air conditioning	• All terrain capability
• No gas gauge, and other luxuries.	• At a great price.

Now, let's see the current time situation of Ford Motor Co. Here is the comparison of performance of Six Sigma at Ford Motor Company and GE:

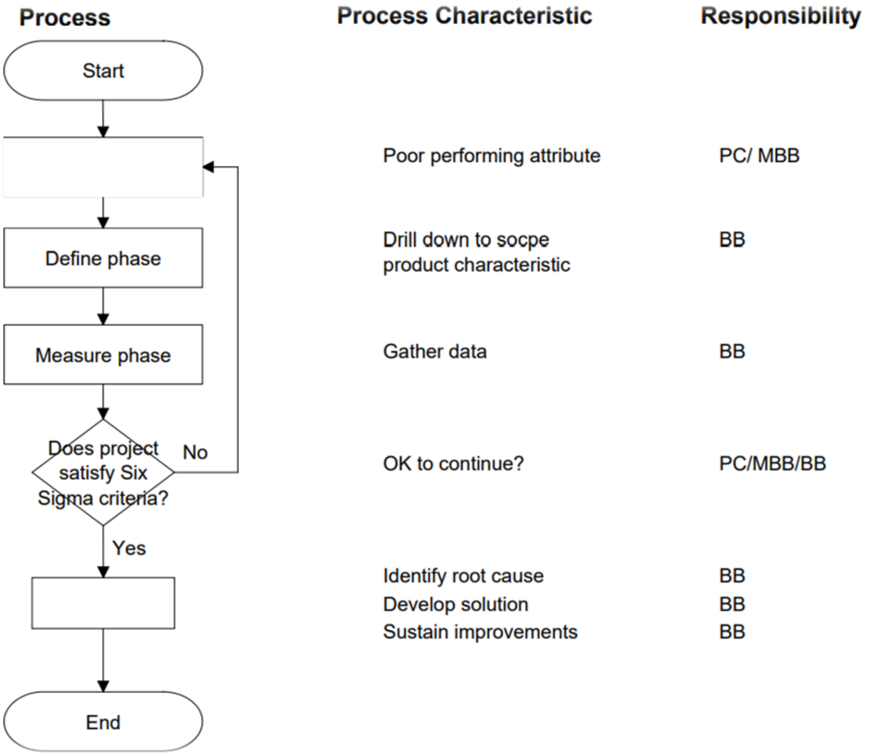
Six Sigma Metrics (At two year launch milestone)	Ford Motor Company (2000-2001)	GE (1996-1997)
Global revenues	$162 billion (2001 CY)	$91 billion (1997 CY)
Number of Black Belts	2,476	~2,600
Average time to implement projects	~240 days	120-180 days
Number of concurrent projects per year/Black Belt	1.3 per year	3 – 4 per year
Cumulative year 2 financial impact per Black Belt	~$263,000	~ $ 538,000
Number of completed projects	~2,500	~8,200
Cumulative Corporate financial impact	$326 million	$700 million
~$370 M	Difference	

*Adapted from A.T. Kearney analysis. Sources: (1) Ford Motor Company Six Sigma database (2) GE Annual reports (3) Public domain data

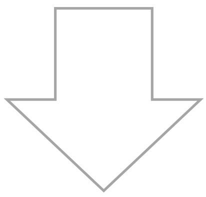
GE	$M waste elimination	Ford	$M waste elimination
1996	125	2000	52
1997	700	2001	326
1998	1275	2002	564

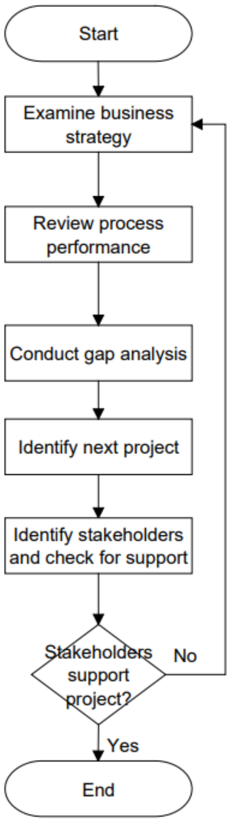
*Adapted from A.T. Kearney analysis. Sources: (1) Ford Six Sigma benefits cannot be directly tied to Profit & Loss (P&L) results for individual actions. (2) GE Annual Reports – Benefits impact bottom line directly and are documented in annual reports.

Some further recommendations to Ford Motor Co. to improve its current Performance and Six Sigma:



Current process map of the Six Sigma process in Ford Motor Co.





Process	Purpose of step	Process characteristics	Frequency
Start			
Examine business strategy	Determine required performance level	Key business metrics and objectives available	Once per annum
Review process performance	Determine current performance level	Key process performance parameters available	As data is available (Once per quarter / once per month
Conduct gap analysis	Identify biggest performance shortfalls	Worst performing process identified Performance gap described with data	Each time process performance is reviewed
Identify next project	Identify highest priority project	Highest priority project identified Project aligned with business	As projects are required
Identify stakeholders and check for support	Assess stakeholder support	Project charter complete demonstrating stakeholder support	Once per project
Stakeholders support project?	Ensure stakeholder support project	OK to continue?	Once per project
End			

Revised and Improved process map for selecting and scoping a Six Sigma project

Conclusion

We discussed Ford's work and the Model T. This very successful car (the longest and perhaps most successful car ever realized), was not only available in a black model, but represented a product line of vehicles characterized by significant variety. Variety within the product line (average of five different products each year), variety also through 5000 gadgets offered by the Ford Company; and variety finally with thousands of specific Model Ts tailored to final customers' needs.

The Model T platform was significant, including the entire underbody, the engine, etc., and improved over time along with the car bodies. The platform was independent from the bodies used to customize it. Interfaces were common for the entire product family, permitting easy manufacturing mixing and late differentiation. A version of mass customization was also implemented by Ford. In fact, Ford's company built the common platform and used specialized manufacturers to tailor the Model Ts to the exact customers' needs.

Industries with manufactured products can learn from Henry Ford's success. Ford's experience was forgotten in the past industry designing non-platform product even when some product lines had sufficient homogeneity to be build on a product platform. Current practices will benefit from the Model T on numerous aspects from lifecycle management to mass customization via platform design and management. Future work will target the study of points highlighted in the discussion section, especially the detail of the platform specification and the resulting family of products.

In the process we also discovered and discussed Ford Motor Company's current backlogs in management and presented a revised process map that can be used to improve the production capability in the company.

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