# RECENT TREND TOWARDS USE OF MANUFACTURING AUTOMATION IN THE AUTOMOBILE INDUSTRY

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# RECENT TREND TOWARDS USE OF MANUFACTURING AUTOMATION IN THE AUTOMOBILE INDUSTRY


**ABSTRACT:**

**O**ver the past 25 years, even while coping with an unprecedented pace of change, worldwide manufacturers have managed to maintain at least one constant*: a solid, unbroken track record of productivity improvement*. Vertically integrated enterprises have given way to virtual networks capable of taking advantage of trends such as cheap offshore production. Long, steady production runs have changed to short, demand-driven production bursts. Manageable bills of materials and product catalogues have exploded as the number of products and features has skyrocketed. Yet, through it all, U.S. manufacturers have remained at or near the top in enhancing productivity, at least as measured in the traditional terms of output per worker hour.

**D**ue to **global competitiveness** in the market, manufacturing automations are found to be only solutions to achieve substantial gains in productivity for years. But getting to the next level will require the ability to recognize and quickly respond to demand shifts, operate at maximum efficiency, and generate the greatest possible return on assets.

***This paper covers*** Process Prototyping and Design for Manufacturing & Process Prototyping Service for Rapid Product and Process Development and Design for Manufacturing by using NC, CNC, Unconventional Manufacturing Process Devices, Use of CAD, CAM CAE & CATIA for designing & using ROBOTICS for eliminating human errors & working under unhygienic environments. It also leads expediting quality & expeditious manufacturing processes in general and automobile industry in particular. Automobile manufacturer are dramatically redesigning new models of automotive vehicles every four to five years.



**Keywords**: Productivity, Process prototyping, Process development, NC, CNC, Robotic, Automobile industry.

## 1.0 INTRODUCTION

It is on record that Automobile innovation started as early as in the year 1335, when several Italians developed a wind powered geared moving wheels. Thereafter until 1712, since Thomas Newcomen didn't build his first steam engine we can guess that this was possibly a model vehicle powered by a mechanism like Hero's steam engine, a spinning wheel with jets on the periphery. In 1765 James Watt developed the first pressurized steam engine which proved to be much more efficient and compact that the Newcomen steam powered engine and in 1862, Alphonse Bear de Rochas figured out how to compress the gas in the same cylinder in which it was to burn, which is the way we still do it. This process of bringing the gas into the cylinder, compressing it, combusting the compressed mixture, then exhausting it is known as the Otto cycle, or four cycle engine. In 1876, Nokolaus Otto patented the Otto cycle engine, de Rochas had neglected to do so, and this later became the basis for Daimler and Benz breaking the Otto patent by claiming prior art from de Rochas.

Up to 1891 no mass production took place & the first closed circuit automobile race held at Narragansett Park, Rhode Island, in September 1896. All four cars to the left are Duryeas; on the right is a Morris & Salom Electrobat. Thirteen Duryeas of the same design were produced in 1896, making it the first production car. Henry Ford had an engine running by 1893 but it was 1896 before he built his first car. By the end of the year Ford had sold his first car, which he called a Quadra cycle, for $200 and used the money to build another one. Ford could not offer a car for sale until 1903.

The Curved Dash Oldsmobile had a single cylinder engine, tiller steering and chain drive. It sold for $650. In 1901 600 were sold and the next years were 1902 - 2,500, 1903 - 4,000, and 1904 - 5,000. In August 1904 Ransom Olds left the company to form Reo (for Ransom Eli Olds). **Ransom E. Olds was the first mass producer of gasoline powered automobiles in the United States**, even though Duryea was the first auto manufacturer with their 13 cars.

The Rolls Royce Silver Ghost of 1906 was a six cylinder car that stayed in production until 1925. It represented the best engineering and technology available at the time and these cars still run smoothly and silently today. **This period marked the end of the beginning of the automobile.**

Over 75 years mainly the innovations were concentrating towards the developments of fuel efficient engines, comfortable interior and manufacture of aerodynamic shape. Due to growing demand of automobile vehicles, it causing serious problem of **depletion** of **fossil fuel** [8.1] as predicted by Hubbert [8.2] through bell shaped

Curve & releasing **high emission** which has gone beyond the limits prescribed under US Pollution Protection Act-1995(i.e. HC- 0.24 gpm, NOx-0.4 gpm & CO-3.4 gpm)[8.5] and also causing reduction in Ozone layer ultimately making global heating. This necessitates to go far manufacturing of fuel efficient & low pollution vehicles. Now for the last ***two decades***, manufacturers are investing heavily on research & development on Process Prototyping and Design for Manufacturing & Process Prototyping Service for Rapid Product and Process Development and Design for Manufacturing by using NC, CNC, Unconventional Manufacturing Process Devices, Use of CAD, CAM CAE & CATIA for designing & using ROBOTICS for eliminating human errors & working under unhygienic environments.

Automation also leads expediting quality & expeditious manufacturing processes in general and automobile industry in particular. Automobile manufacturer are dramatically redesigning new models of automotive vehicles every four to five years.

## 2.0 WHAT IS AUTOMATION?

To improve product quality and efficiency in production, automakers invest a large amount of time and money into developing and improving the manufacturing process, and rely heavily on research and technological innovation.

**Thus** Automation is modern technologies used in advancing manufacturing for the automotive industry which include:

- **Programmable machines and tools-**Robotics
- **High speed data communication and data management-**NC & CNC machines
- **Supercomputing-**Product & Process developments
- **Virtual manufacturing and complex visualization techniques-**Modeling & evaluating by CAD, CAM,CAE, CATIA & Pro- Engineers
- **Advanced techniques –**Unconventional machining, forming, forging & magnetic particle welding.
- **Manufacturing Automation Laboratories-** for developing tools

## 3.0 USE OF ROBOTICS IN AUTOMOTIVE MANUFACTURING INDUSTRY:

The word robot comes from the Czech word "robota", meaning "forced labor." The stuff of science fiction robotics in the 21st century is different than your parents or your grandparents? ideas of robotics. What used to be thought of as futuristic improbability is now becoming a reality. There are, theoretically**, *three Laws of Robotics***.

- The Laws of Robotics were developed by a small group of scientists who believe that robotics is the wave of the future. The first law, referred to as law zero, is that a robot may not injure humanity, or, though inaction, allow humanity to come to harm.
- The second law states that a robot may not injure a human being, or, through inaction, allow a human being to come to harm, unless this would violate a higher order law.

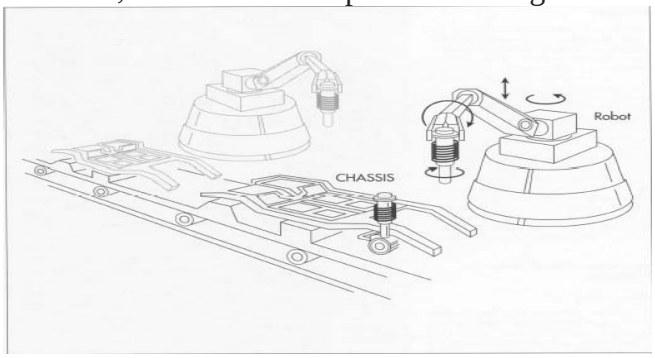
This law was created so that mankind would seek not to create robots that would harm people.

- The third law is that a robot must obey orders given it by human beings, except where such orders would conflict with a higher order law.

And finally the final law is that a robot must protect its own existence as long as such protection does not conflict with a higher order law. These were used in a recent Hollywood movie however many people don't know that the Laws of Robotics actually exists.

A robot is an electro-mechanical device that can perform autonomous or preprogrammed tasks. A robot may act under the direct control of a human (e.g. the robotic arm of the space shuttle) or autonomously under the control of a programmed computer. Robots may be used to perform tasks that are too dangerous or difficult for humans to implement directly (e.g. nuclear waste clean up) or may be used to automate repetitive tasks that can be performed more cheaply by a robot than by the employment of a human (e.g. automobile production.)

According to the Wiktionary, robotics is the science and technology of robots, their design, manufacture, and application. ROBOTICS requires a working knowledge of electronics, mechanics, and software. A person working in the field has become known as a roboticist.




Over the last 25 years, automation technology has become an essential part of automobile assembly plants. A typical assembly plant uses several hundred robots to build and paint the vehicle frame. While robotic technology continues to grow in assembly plants, the technology does have limitations, especially in performing more delicate tasks. The advent of Intelligent Assist Devices, in particular Cobots (Collaborative robots), aided in reducing ergonomic concerns, while also improving safety, quality and productivity. Cobots, developed by Northwestern University and General Motors Corporation, are designed to work in collaboration with human operators to move objects and perform physically demanding tasks on vehicle assembly lines [8.7].

## 4.0 USE OF NC & CNC MACHINES IN AUTOMOTIVE MANUFACTURING INDUSTRY:

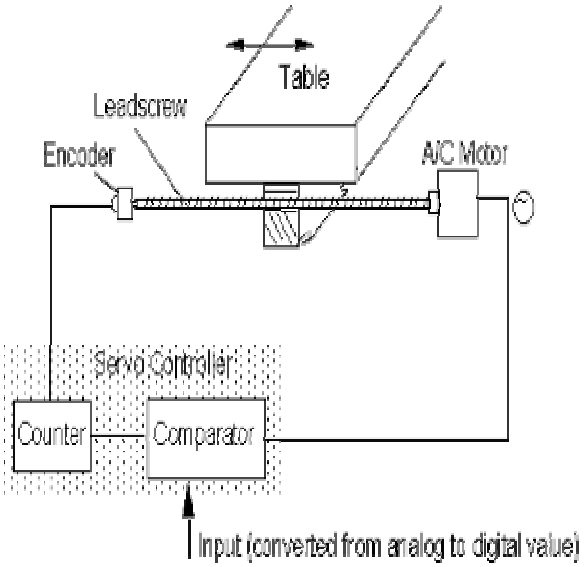
**4.1 History:** US Air Force commissioned MIT to develop the first "numerically controlled" machine in 1949. It was demonstrated in 1952.

**4.2 Motivation:** To manufacture complex curved geometries in 2D or 3D was extremely expensive by mechanical means (which usually would require complex jigs to control the cutter motions).

Most modern machine tool companies manufacture only NC or CNC [8.3] machine tools. The dominant advantages of NC machines are:

- Easier to program; easy storage of existing programs;
- Easy to change a program
- Avoids human errors
- NC machines are safer to operate
- Complex geometry is produced as cheaply as simple ones
- Usually generates closer tolerances than manually operated machines

**4.3 Control of NC Machines:** The most common motor types for larger machines are servo-controlled motors. Depending upon the hardware the smallest distance unit that the machine tool can be moved by is referred to as a BLU (Basic Length Unit). In practice, the BLU is equivalent to the accuracy of the machine tool.




(A schematic of the servo control hardware)

Every NC machine tool structurally has two components:-:

- The conventional machine tool, with servo motors to drive the lead-screws
- A Machine Control Unit (MCU) or the **controller**.

The MCU is made up of a Data Processing Unit (DPU) and a Control-Loops Unit (CLU).

❖ **Data Processing Unit:**
- Input device [RS-232 port/ Tape Reader/ Punched Tape Reader]
- Data Reading Circuits and Parity Checking Circuits
- Decoders to distribute data to the axes controllers.

❖ **Control` Loops Unit:**
- Interpolator to supply machine-motion commands between data points
- Position control loop hardware for each axis of motion

### 4.4 Classifications of NC Machine Tools:

☞ **Based on Motion Type:**
Point-to-Point
Continuous path

☞ **Based on Control Loops:**
Open loop
Closed loop

☞ **Based on Power Supply:**
- Electric
- Hydraulic
- Pneumatic

☞ **Based on Positioning System**
Incremental
Absolute

It is known fact that competition in Automobile Industry will remain challenging & relentless in future. Cost effective production is solid success of car manufacturers.

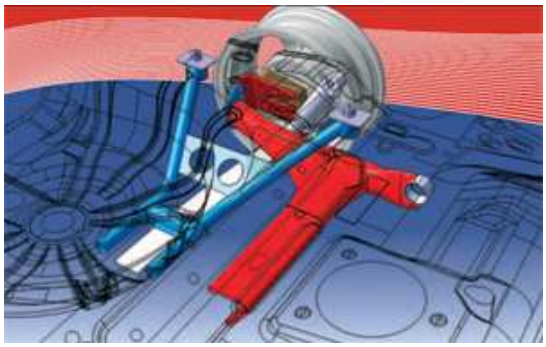
## 5.0 DESIGN, MODELING & EVALUATING THE NEW CAR IN AUTOMOTIVE INDUSTRY:

Yet meeting customer preference in time, thus bringing adopted or new car models in the market within shorter span will impact manufacturer's bottom line significantly. One important step to drive down the required time to market of new car model is to shorten the period needed for making respective design studies & mock-ups (up to 1:1 scale). Today's world is moving forward to design most sophisticated components of vehicles in very short time. The use of Computer Aided Design, Computer Aided Manufacturing, Computer Aided Engineering and CATIA [8.4] to prepare drawing as well as working models to evaluate its functional working is found effective solution. The use of CATIA is very rapidly taking its pace world wide for ***aerodynamic body*** as well as parts where ***indigenous shapes*** are required to be given.

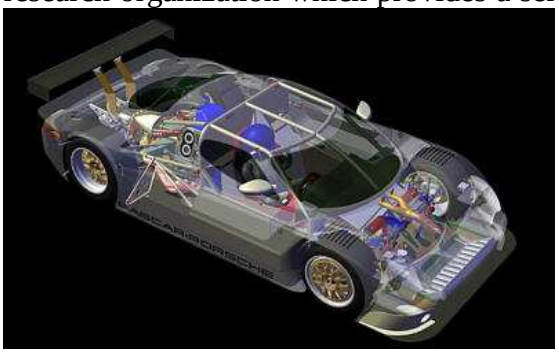
### 5.1 CAD, CAM, CAE & CATIA V5 for Automotive Design:

CATIA [8.4] is the world's leading CAD/CAM/CAE software. This software gives you a broad range of integrated solutions that cover all aspects of:

- Product design & manufacture.
- Driving enterprise competitiveness
- Task productivity Process improvement



CATIA (Computer-Assisted Three-Dimensional Interactive Application) is acclaimed throughout the world as the leading program for use in design. CATIA offers unequalled scope of functionality, together with total integration of all its functions, thereby ensuring that its users are able to address the most challenging design tasks, and then translate those into realistic, manufacturable products. It also opens up new frontiers in Concurrent Engineering, leading to better designs, at lower cost, in significantly shorter time. With a development history stretching over more than 15 years, CATIA has proven itself in every imaginable industry, and with the availability of Release 5, which operates on a PC platform, is accessible by even the smallest of manufacturers. Use of CATIA V5 is being done very rapidly by MIRA, a leading independent design, development, testing and research organization which provides a service to the worldwide automotive industry[8.4].



### 5.2 CAD, CAM CAE –Daytona Prototype Racing Car

The Daytona Prototype is a new class of Grand Am racing car scheduled to debut in the 2003.It has flawless performance of race car designed in Solid Edge wows Grand Am Racing fans [8.5].

## 6.0 PRODUCT & PROCESS FOR LEAN [8.10] / FLEXIBLE MANUFACTURING IN AUTOMOTIVE INDUSTRY:

**Where Automation and Information Meet?**

Keeping competitiveness in this fast-paced industry means reacting quickly to changes in the marketplace and on the plant floor. IBM and Rockwell Automation have leveraged their combined capabilities to create an integrated automation and information solution that goes beyond traditional manufacturing execution systems (MES) to overcome corporate data organization boundaries.

By providing a unified view of processes and data, as well as providing data integrity, Rockwell Automation [8.15] and IBM Performance Solution delivers real-time connectivity, marrying MES and production systems to enable actionable response to a variety of automotive challenges, including:

- Assessing current and future plant capability and capacity.
- Identifying weak links in the supply chain.
- Determining in advance the vehicles affected by component
- Deficiencies, which help reduce costly and often unnecessary recalls.
- Deciding when to implement new technology or applications.

Creating effective strategies can reduce time-to-market, lower costs, and improve quality control and business systems for increased visibility and decision support. The application of automotive business processes and data models includes scenarios that address the major critical issues facing today's automotive industry, enabling you as to how quickly implementing this solution will make business and manufacturing processes more efficient. These scenarios include:

- Just-in-Sequence Scheduling
- Locate Vehicle Status Determination
- Daily Production Schedule and Calendar
- Deficiencies, which help reduce costly and often unnecessary
- Actual Production Determination
- Overall Equipment Effectiveness
- Warranty Search on Tracing Information
- Manufacturing Constraint Checks
- Vendor Managed Inventory

To day Design Science uses Design Research and [8.9] Trend—Design Research cuts product development costs, while gathering vitally needed design data.

**7.0 CONCLUSIONS:**

Keeping in view of global competitive market pressure, the manufacturing automation processes in automotive industry, controls following major elements:-

- Fuel efficient, Low emission & Cost effectiveness of vehicles
- Improves Durability & Longevity of vehicle
- Improves Process & Product developments with ergonomics
- Provides Flexibility to change the new models by using CAD, CAM, CAE and CATIA [8.4] & PRO-Engineer.
- Improves towards reduction in weight by using facilities of advanced tools & equipments( e.g. Electro-magnetic particle Welding, Unconventional Forging & Machining) [8.13]
- Improves Technological & Process balancing by using ROBOTIC [8.6] & COBOTIC.
- Motivation to workforce and to have adequate organizational setup

- Line balancing – improves flow of raw material and inventory control.
- Requires investment towards Researches and Engineering.
- Implementation programmes to match with global developments and new area to be looked into for further scope.

The use of automation worldwide improves the productivity in automobile industry without adding manpower. While looking trends in global automobile manufacturing, *Japanese automakers have been leaders in stream-lined manufacturing process systems*. These methods have been adopted by manufacturing plants worldwide.

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