Visvesvaraya Technological University
Belagavi, Karnataka-590 028

"FABRICATION AND ASSEMBLING OF QUAD LEANING SUSPENSION VEHICLE"

A Project Report Submitted in partial fulfillment for the award

Bachelor of Engineering

in

Mechanical Engineering

Submitted by

MOHAMMED ABU HUZEFA	**(4AD13ME046)**
MOHAMMED SALMAN	**(4AD13ME051)**
MOHAMMED SUFIANULLA SHARIFF	**(4AD13ME052)**
MUQHTHADIR RAIHAN	**(4AD13ME056)**

Under the guidance of

Sri SURESH KUMAR S
Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING

ATME College of Engineering, Mysuru

2016- 2017

ATME COLLEGE OF ENGINEERING, MYSURU-28

(Affiliated to Visvesvaraya Technological University, Belagavi)

DEPARTMENT OF MECHANICAL ENGINEERING

Certificate

This is to certify that the project work entitled **"FABRICATION AND ASSEMBLING OF QUAD LEANING SUSPENSION VEHICLE"** is a bona-fide work carried out by **Mohammed Abu Huzefa (4AD13ME046), Mohammed Salman (4AD13ME051), Mohammed Sufianulla Shariff (4AD13ME052), Muqhthadir Raihan (4AD13ME056)** in partial fulfillment for the award of Bachelor of Engineering in **Mechanical Engineering** of the **Visvesvaraya Technological University, Belagavi** during the academic year 2016 - 2017. It is certified that all the corrections / suggestions indicated for internal assessment have been incorporated. The project report has been approved as it satisfies the academic requirements in the respect of project work prescribed for mentioned degree.

Signature of the Guide	Signature of the HOD	Signature of the Principal
Sri Suresh Kumar S	**Sri Dr. Rathnakar G**	**Dr. L. Basavaraj**
Assistant Professor,	Professor and Head	ATMECE, Mysuru
Dept. of Mech. Engg.,	Dept. of Mech. Engg.,	
ATMECE, Mysuru	ATMECE, Mysuru	

External Viva

Name of Examiners	Signature with Date
1.	
2.	

ACKNOWLEDGEMENT

We express our sincere gratitude to our guide **Sri. SURESH KUMAR S,** Assistant Professor, Dept of Mechanical Engineering, ATMECE, for his valuable suggestions and continued encouragement, timely comments and immense help throughout the project work.

We are highly indebted to **Sri. Dr. Rathnakar G**, Professor and Head, Dept. of Mechanical Engineering, ATMECE, Mysuru and **Dr. L. Basavaraj**, Principal, ATMECE, Mysuru for providing me a congenial environment for the project work.

Last but not the least I sincerely thank **My Parents** and other **family members** who have been my strength in every instance of my life and all my friends who have directly or indirectly helped me in the completion of my project work.

Project group

MOHAMMED ABU HUZEFA

MOHAMMED SALMAN

MOHAMMED SUFIANULLA SHARIFF

MUQHTHADIR RAIHAN

ABSTRACT

India is the nation where agriculture is the main source of income. Being mechanical engineers it's our duty to supply proper machines to the farmers and make their work easy. Quad leaning suspension vehicle helps while handling, braking and also isolates bumps from the road, vibrations etc. Most of today's vehicles have a non-tilting suspension system, which have been doing a good job for a very long time. However, as time progressed and technology advanced, changes are bound to happen. QUAD LEANING SUSPENSION VEHICLE (QLSV) is designed to lean over any kind of surface as the land on which they cultivate does not have a proper surface so thinking of an idea that strikes into the mind, why don't we solve the problem by providing suitable machine which makes man's work easy. It is not only limited for agriculture but it can be used in various fields like mining, construction, sports etc. A tilting mechanism is carried out for a normal fuel run bike to give it the flexibility of a car. The prototype which is made shows us a new kind of suspension that is gaining popularity each and every day. Tilting suspension system that drastically improves the safety, performance and efficiency of the vehicle Even though, this mechanism is not entirely new.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.INTRODUCTION

1.1 INTRODUCTION OF ATV'S

An all-terrain vehicle (ATV), also known as a quad, quad bike, three-wheeler, four-wheeler, or quadricycle as defined by the American National Standards Institute (ANSI) is a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. Although it is a street-legal vehicle in some countries, it is not street-legal within most states and provinces of Australia, the United States or Canada.

By the current ANSI definition, ATVs are intended for use by a single operator, although some companies have developed ATVs intended for use by the operator and one passenger. These ATVs are referred to as tandem ATVs

Three-wheeler era (1967–1987):The first three-wheeled ATV was the Sperry-Rand Tricart. It was designed in 1967 as a graduate project of John Plessinger at the Cranbrook Academy of Arts near Detroit. The Tricart was straddle-ridden with a sit-in rather than sit-on style (similar to the contemporaneous Big Wheel toy). In 1968 Plessinger sold the Tricart patents and design rights to Sperry-Rand New Holland who manufactured them commercially. Numerous small American manufacturers of 3-wheelers followed. These small manufacturers were unable to compete when larger motorcycle companies like Honda Entered the market in 1969. Honda introduced their first sit-on straddle-ridden three-wheeled ATVs in 1969, which were famously portrayed in the James Bond movie, Diamonds Are Forever and other TV shows such as Magnum, P.I. and Hart to Hart. Dubbed the US90 and later—when Honda acquired the trademark on the term—the ATC90 (All Terrain Cycle), it was designed purely for recreational use. Clearly influenced by earlier ATVs, it featured large balloon tires instead of a mechanical suspension.

By the early 1980s, suspension and lower-profile tires were introduced. The 1982 Honda ATC200E Big Red was a landmark model. It featured both suspension and racks, making it the first utility three-wheeled ATV. The ability to go anywhere on terrain that most other vehicles could not cross soon made them popular with US and Canadian hunters, and those just looking for a good trail ride. Soon other manufacturers introduced their own models. Sales of utility machines skyrocketed.

Sport models were also developed by Honda, which had a virtual monopoly in the market due to effective patents on design and engine placement. The 1981 ATC250R was the first high-performance three-wheeler, featuring full suspension, a 248 cc air cooled two-stroke engine, a five-speed transmission with manual clutch, and a front disc brake. For the sporting trail rider, the 1983 ATC200X was another landmark machine. It used an easy-to-handle 192 cc four-stroke that was ideal for new participants in the sport. The ATC200X was the first high-performance four-stroke ATV that featured full suspension, front and rear disc brakes with single piston calipers, an 18-horsepower engine, sporty looks and is widely considered one of the best ATV's ever produced.

Four-wheelers (1985-today)

Suzuki was a leader in the development of four-wheeled ATVs. It sold the first model, the 1982 QuadRunner LT125, which was a recreational machine for beginners. Suzuki sold the first four-wheeled mini ATV, the LT50, from 1984 to 1987. After the LT50, Suzuki sold the first ATV with a CVT transmission, the LT80, from 1987 to 2006.

In 1985 Suzuki introduced to the industry the first high-performance four-wheel ATV, the Suzuki LT250R QuadRacer. This machine was in production for the 1985–1992 model years. During its production run it underwent three major engineering makeovers. However, the core features were retained. These were: a sophisticated long-travel suspension, a liquid-cooled two-stroke motor and a fully manual five-speed transmission for 1985–1986 models and a six-speed transmission for the 87–92 models. It was a machine exclusively designed for racing by highly skilled riders.

Honda responded a year later with the FourTrax TRX250R—a machine that has not been replicated until recently. It currently remains a trophy winner and competitor to big-bore ATVs. Kawasaki responded with its Tecate-4 250. The TRX250R was very similar to the ATC250R it eventually replaced, and is often considered one of the greatest sport ATVs ever built.

In 1987, Yamaha Motor Company introduced a different type of high-performance machine, the Banshee 350, which featured a twin-cylinder liquid-cooled two-stroke motor from the RD350LC street motorcycle.

Heavier and more difficult to ride in the dirt than the 250s, the Banshee became a popular machine with sand dune riders thanks to its unique power delivery. The Banshee remains popular, but 2006 is the last year it was available in the U.S. (due to EPA emissions regulations); it remained available in Canada until 2008 and in Australia until 2012.

Shortly after the introduction of the Banshee in 1987, Suzuki released the LT500R QuadRacer. This unique quad was powered by a 500cc liquid-cooled two-stroke engine with a five-speed transmission. This ATV earned the nickname "Quadzilla" with its remarkable amount of speed and size. While there are claims of 100+ mph stock Quadzillas, it was officially recorded by 3&4 Wheel Action magazine as reaching a top speed of over 79 mph (127 km/h) in a high-speed shootout in its 1988 June issue, making it the fastest production four-wheeled ATV ever produced. Suzuki discontinued the production of the LT500R in 1990 after just four years.

At the same time, development of utility ATVs was rapidly escalating. The 1986 Honda FourTrax TRX350 4x4 ushered in the era of four-wheel drive ATVs. Other manufacturers quickly followed suit, and 4x4s have remained the most popular type of ATV ever since. These machines are popular with hunters, farmers, ranchers and workers at construction sites.

Models continue, today, to be divided into the sport and utility markets. Sport models are generally small, light, two-wheel drive vehicles that accelerate quickly, have a manual transmission and run at speeds up to approximately 80 mph (130 km/h). Utility models are generally bigger four-wheel drive vehicles with a maximum speed of up to approximately 70 mph (110 km/h). They have the ability to haul small loads on attached racks or small dump beds. They may also tow small trailers. Due to the different weights, each has advantages on different types of terrain. A popular model is Yamaha's Raptor 700, which features a nearly 700 cc four-stroke engine.

Six-wheel models often have a small dump bed, with an extra set of wheels at the back to increase the payload capacity. They can be either four-wheel drive (back wheels driving only), or six-wheel drive.

In 2011 LandFighter was founded, "the first Dutch/European ATV brand". The largest part of production takes site in Taiwan, to European standards; the ATVs are finally assembled in the Netherlands.

1.2 INTRODUCTION ON LEANING SUSPENSION

The Quad Leaning Vehicle is a state of an art technology in the field of automobiles. It provides the advantages of increased passenger comfort and handling.

This odd-looking creation could be the start of something massive it is the first prototype of an entirely new design of leaning four wheeled bike which not only offers a massive increase in safety, but should it reach production, will be legal for everyone holding any license.

Suspension is of extreme importance in any road vehicle. It consists mainly of the spring and damper that perform the function of shock absorption and the linkages that connect the vehicle and the shock absorbers to the wheels. When the wheel of a vehicle goes over an obstruction, the movement is termed as a ‘bump’ and the suspension system, through the motion of the linkages and the spring-damper arrangement absorbs the forces created by this motion. The force depends on the un-sprung mass at each wheel; greater sprung to un-sprung mass ratio implies the occupants will be less affected by road imperfections. The main role of suspension system is to support weight of the vehicle and to provide comfort to the passenger.

Vehicle performance during cornering has been improved by most of the car manufacturers by using electronic stability control (ESC). Car manufacturers use different brand names for ESC, such as, Volvo named it DSTC (Dynamic Stability and Traction Control); Mercedes and Holden called it ESP (Electronic Stability Program); DSC (Dynamic Stability Control) is the term used by BMW and Jaguar but despite the term used the processes are almost the same. To avoid over steering and under steering during cornering, ESC extends the brake and different torque on each wheel of the vehicle.

But ESC reduces the longevity of the tire as the tire skids while random braking. To overcome this problem a vehicle can be tilted inwards via an active or semi-active suspension system.

The development of narrow vehicles is a promising alternative that is being proposed to address increasing traffic congestion and limited highway capacity in metropolitan areas. In order to provide an acceptable replacement for today's average passenger car, these vehicles should retain the perceived safety and the ease and comfort of driving a regular four-wheeled vehicle. Narrow vehicles currently used in urban transportation (e.g. motorcycles) require the driver to balance the vehicle while it is turning, meaning that the vehicle must be tilted into the curve to compensate for the tilting moment of the centripetal force generated by the tires. These vehicles also lack the level of safety that the majority of commuters would prefer. This could be addressed by increasing the dimensions of such a vehicle, preferably in terms of height, not to compromise the benefits gained from the narrower lane track. Building narrow vehicles taller tends to increase their tilt and the chances of a rollover during tight cornering.

A four-wheel vehicle, with two steerable front wheels and 2 driven rear wheels which may be either rider- or motor-powdered, includes steering/coupling linkage disposed adjacent to the lower end of a steering column having a handle bar attached to its upper end. The steering/coupling linkage pivotally couples a forward frame to a rear frame which supports the rider and includes the rear wheel and its means for propulsion. The steering/coupling linkage includes a pivot shaft, a bearing housing and a mechanical connection for leaning the frame in the direction of a turn so as to compensate for centrifugal force encountered in turning the vehicle.

The mechanical connection causes the frame to lean in a controlled relationship to the amount of rotation of the steering shaft, within rotational limits, to emulate the leaning action of a conventional bike when making a turn.

1.3 INTRODUCTION OF QLSV IN AGRICULTURE

Quad leaning suspension vehicle (QLSVs, also known as quad bikes) are one piece of farm equipment that most farmers can't do without. Although they are not designed to be a ATV, on most small farms they can reduce the need for one.

QLSV is capable of doing variety of farming tasks, including transporting people and equipment from A to B, towing a trailer, spraying, spreading and much more. For those that don't know anything about motorbikes, selecting a hobby farm QLSV can be a daunting task.

Quad leaning suspension vehicle(QLSV) can be used either by civilian or military. In some cases, there are QLSV that has been used in agriculture field. This type of vehicle is designed to operate in difficult and complex terrains. Generally, QLSV consists of three main parts. These parts are chassis, drive train and suspension. The main objective of this project is to develop a complete unit of QLSVs chassis frame, which is then used as the main part of an QLSV. A proper design methodology is undertaken. Before the chassis frame is fabricated, basic Finite Element Analysis (FEA) were performed to determine the chassis frame feasibility. By participating in the project, students are able to have practical and hands-on experience particularly in automotive engineering field. Furthermore, students can also develop their much-needed soft skills since they are working in a team to build the vehicle

There is a variety of adventure sports, nowadays available in the market. Quad bike comes under the category. Designing an off-road vehicle intended for the non-professional weekend off-road enthusiast is the general mission of our project. The overall objective is to have a vehicle that will trek through outdoor terrain with ease. The team focused on increasing the quality and optimizing the vehicle weight. We also focused on maximizing strength and optimizing effectiveness under limited resources. Creating an off-road vehicle that is faster, more manoeuvrable, and easier to manufacture required improvements in every aspect of the bike. Quad bike provides a cheaper option for human transport into the mines and often used by armed forces. The ATV provides individual, all-terrain mobility to deployed Special Operations Forces in austere locations and across a myriad of special operations missions. The vehicles are extremely flexible and internally transportable within rotary wing assets, and they allow fully combat-equipped SOF operators to move around the battlefield rapidly in terrain not easily navigated by larger, heavier vehicles.

2.LITERATURE SURVEY

1) Tilting independent suspension system for motorcycle trike: The concept of tilting suspension came into existence during the 21^{st} century. On 18^{th} Mar 2008, Lawayne Matthias implemented it in three wheeled vehicles and filed a patent on same (US 7,343,997). He had used active tilting (i.e. it has computer-controlled power mechanism). He had implemented his mechanism on rear wheel. We got our basic design about the leaning mechanism from his patent.

Generally, vehicles are rear wheel drive so according to Davis steering mechanism they have to implement differential on rear wheel so that outer wheel travel with higher speed than the inner wheel. By implementing it the design become very complex and also the control system on frame can be complex. So, the main drawback was that he implemented the mechanism on rear wheel.

2) Leaning Vehicle with tilting front wheels: On 19^{th} JAN 2010, Daniel Mercier implemented the leaning mechanism on vehicle. According to his design, vehicle has a frame pivotally connected to the lower end of a shock tower, the pivotal connection defining a frame leaning axis wherein the frame is adapted to lean to a right side and to a left side relative to the shock tower about the frame leaning axis. The leaning vehicle includes an actuator operatively connected to the frame and to the shock tower which is adapted to impart a leaning motion to the frame relative to the shock tower about the frame leaning axis.

Another aspect of his present invention is to provide a leaning vehicle comprising an electronic control unit ECU electrically connected to at least one sensor adapted to detect a direction and magnitude of a torque applied to the steering column and the ECU being operatively connected to the actuator; Yet another aspect is to provide a vehicle speed sensor electrically connected to the ECU and adapted to send signals to the ECU.From his patent we came to know that 0^{o} to 50^{o} is the optimal range of tilting.

Toyota I road: On 19th july 2012, Robert B. Hill; Fred Lux, Aloha; Timothy Michael Miller; Edmund Jerome Stilwell filed a patent (US2012/01817656). In contrast to their patent, the free-to-lean design described herein enables the vehicle to lean smoothly and naturally, like a motorcycle, always on the correct lean angle, using no energy, and it then gently holds the vehicle upright at stops and low speeds, using almost no energy. (Generally, when the vehicle is driven to a stop, the vehicle is already upright, such that the system only uses energy to close a hydraulic valve and hold the vehicle in the existing position (or applies very little pressure to adjust the lean angle a few degrees); this analogous to the very limited energy a motorcycle rider uses when putting their toe on the ground at a stop to hold their vehicle in an upright posture.) the limitation was the design was complex and costly arrangement.

3.PROBLEM STATEMENT

Three-wheel vehicle having a frame pivotally connected to a two-wheel rear suspension assembly, and drive train structured in such a way that, the frame and the front wheel can lean into a corner while the two rear wheels remain substantially vertical. In addition to having the frame lean into a corner while turning a leaning vehicle, the two front or rear wheels of the leaning vehicle may also tilt in the same direction as the frame to reflect the general behaviour of a motorcycle. In order to allow the two front or rear wheels to lean to side or the other, the suspension assembly must be connected to the wheels in such a manner that the suspension components do not interfere with the leaning wheels.

An improvement of the vehicle disclosed in U.S. Pat. No. 7,343,997 in which the two rear wheels can lean into a corner is disclosed in U.S. Pat. No. 7,591,337 also to Van Den Brink et al. US Pat Application No. 2005/0167174 A1 discloses a relatively complex front suspension and steering system for a leaning vehicle equipped with a pair of independent front upright suspensions mounted on an „articulated quadrilateral structure‟ adapted to tilt the front wheels with the frame when negotiating a curve. The disclosed suspension is adapted to allow the front wheels to independently move up and down while simultaneously remaining parallel to each other and to the frame when the vehicle is leaning into a corner like a motorcycle. This suspension system is bulky and complex and it is specifically designed for two front wheels that are relatively close to one another. This type of suspension would be difficult to employ on a larger vehicle. Another well-known type of front suspension assembly used in leaning vehicles in which the front wheels tilt into the corner is the double A-arm type front suspension. The double A-arm type suspension is adapted to transmit the leaning motion of the vehicle frame to the wheels by virtue of its substantially parallel upper and lower A-arms connected to upper and lower points of the wheels respectively. When the vehicle leans into a right corner for instance, the right upper A-arm pushes on the upper point of the right wheel while the right lower A-arm pulls on the lower point of the right wheel thereby tilting the right wheel towards the corner. At the same time, the left upper A-arm pulls on the upper point of the left wheel while the left lower A-arm pushes on the lower point of the left wheel thereby tilting the left wheel towards the right corner as well. One such vehicle is the Mercedes F300 Life Jet which was first unveiled at the1997 Frankfurt Motor Show (Germany) but never reached production.

This type of front suspension with the appropriate tilting connections allows the wheels and frame to lean, however the angle to which the wheels can lean and thus the angle to which the vehicle frame can lean is limited. Furthermore, the left and right spring and shock absorber assemblies are directly involved in the leaning of the vehicle such that the suspension becomes less effective when the vehicle is leaning. Also, the displacements of multiple A-arms implies that the front of the vehicle must remain substantially free of other components to avoid interferences. Thus, there exists a need for a leaning vehicle having a two-wheel front suspension assembly that permits tilting of the wheels to a greater degree than that of the prior art leaning vehicles and that remains effective when the vehicle is leaning into a corner.

4.MODERNIZATION OF ATV'S

ATVs - those 4-wheeled behemoths of the track or back trials - loved by the off-road enthusiast and treasured by farmers.

The All-Terrain Vehicle cannot claim a history as deep or as long as the motorcycle but it certainly rouses the passion of owners and riders everywhere. The "ATV" first emerged in the 1960s and referred to amphibious 6-wheelers like the Jiger in 1961, the Amphicat manufactured in the late 1960s and the Terra Tiger.

These original vehicles were "non-straddle" and once straddle ridden ATVs came to market, the term AATV or amphibious all-terrain vehicle was attached to the 6-wheelers.

The first ATV as we know it emerged as a 3-wheeler. The Sperry-Rand Tricart was designed in 1967 and manufactured in 1968. However, it was the Honda ATC that made 3-wheelers a household name and set the path for today's ATV. In 1970, Honda introduced their US90 or

ATC90 (All Terrain Cycle). The movie *Diamonds Are Forever* and the TV shows *Magnum, P.I.* and *Hart to Hart* helped spur on its popularity. It was 100 percent recreational use only and incorporated large balloon tires instead of a suspension. The ATC70 provided fun for kids and in 1979 the ATC110 opened up the throttle.

FIG.4.1 HONDA ATC90

During this time, farmers realized the value of using an ATC for work and the 3-wheel market tapped into a new demographic. Honda and other manufacturers began addressing the popularity of 3-wheelers by cranking out new models.

FIG.4.2 HONDA ATC 70

Honda released the ATC 70 a smaller version of the ATC 90 intended for youngsters.

Though ATVs were originally targeted towards sportsmen until the 70's gas crunch when customers began purchasing them as utility vehicles for agriculture and farming purposes. This was because ATVs cost exponentially less than a ATV, and guzzled only 8 percent of the fuel needed to feed a ATV.

By the 1980s ATV demand was at an all-time high and they became multi-purpose machines serving both recreational and utility purposes.

Honda's ATC250R, sold in 1981, is considered the first high-performance three-wheeler with full suspension and a five-speed transmission. In 1982 Honda unveiled the ATC200E Big Red, a landscape changing model featuring suspension and racks giving it the distinction as the first utility three-wheeled ATV. The next year, Honda marketed the handling-friendly ATC200X to beginners.

FIG.4.3 HONDA ATC250R

Kawasaki first introduced the KLT200 - a three-wheeled ATV - into the market in 1981. The company's first four-wheeler debuted in 1985 and was called the Bayou 185. The Bayou 300 4x4, Kawasaki's first ATV 4-wheel drive, found traction in 1989.

Polaris welcomed the Trailboss into the family in 1985 which is considered to be the first American-made all-terrain vehicle.

In 1980, Yamaha introduced the Tri-Moto (YT125) their first three-wheeled ATV sold in the United States. In 1984, Yamaha debuted their first four-wheeled ATV, the YFM200, in the United States. Other contributions include the Grizzly 600, a 4x4 ATV with automatic transmission in 1998 and in 2000 the Buckmaster Edition Big Bear 400 4x4, the first ATV with camouflage bodywork.

In 1982, Suzuki introduced the first 4-wheeled ATV called the QuadRunner 125 (pictured below). It came equipped with an odometer, five forward speeds and reverse! This quad paved the way for the 4-wheel ATV revolution.

FIG.4.4 SUZUKI QUAD RUNNER

In 1985, Suzuki took the ATV world by storm when it introduced the first high-performance 4-wheel ATV, the Suzuki LT250R QuadRace (below).

FIG.4.5 SUZUKI LT 250R

Meanwhile, Honda was working on its own 4-wheeled concept. After scrutinizing research, testing the prototypes with riders wearing 50-pound instrument packs that recorded information on every aspect of the machine's operation, they unleashed their beast in 1984 known as the FourTrax TRX250R (below).

FIG.4.6 HONDA FOUR TRAX 300

Honda introduced its first 4-wheeler in 1984, the TRX200, and dominated the market owning 69 percent of all ATV sales in the United States. The new 4-wheel concept helped bring an end to the 3-wheeler which officially came to an end in 1987 when safety concerns resulted in a ban that lasted 10 years.

In the 1990s, farms everywhere had an ATV and the leading manufacturer was once again Honda with their FourTrax 300.

FIG.4.7 HONDA FOUR TRAX 250

To this day, the FourTrax 250R continues to win awards for its performance.1984 was Honda's biggest sales year for ATVs. 370,000 units were delivered making up 69 percent of total ATV sales in the U.S. that year.

In 1986, Honda unveiled the first four-wheel-drive ATV, the FourTrax[a] 350 4x4. For its grand unveiling it was lowered from a helicopter to show all four wheels moving under their own power.

This model would ultimately become the most versatile and popular ATV in history.

ATVs Now

FIG.4.8 MODERN ATV

ATVs have become more than recreational vehicles and have stood the test of time as vital tools in a wide range of industries from farming, agriculture, hunting, industry, ranching but also an important means of mobility for people with disabilities.

Interestingly, many of the uses and application for ATVs have sprung from their owners, who have helped shape their growth and design along the way.

FIG.4.9 ATV WITH TILLER

Today, the term "ATV" primarily defines 4-wheel recreational or racing models and "UTV" or Utility Terrain Vehicle make up the 4-wheel market for the workhorses on the farm or ranch.

ATVs have their own Motocross and off-road racing events. The Grand National Cross-Country series began racing ATVs in 1980 and the ATV National Motocross Championship series started in 1985. ATVs also own a larger share of the market compared to dirt bikes.

FIG.3.10 SPORTS ATV

In 2012, 71,535 dirt bikes were sold compared to 225,244 ATVs - a figure that does not include UTVs, a segment of sales the Motorcycle Industry Council did not report on. However, UTV and side-by-sides sales were expected to surpass the sales of ATVs so the 4-wheel market combined far exceeds that for dirt bikes and if UTV sales projections were accurate the 4-wheel market exceeds Dual-Sport, Dirt bike, motorcycle and scooter sales combined.

Whether for sport, fun or getting the job done, ATVs offer a different alternative to off-road adventures and provide a now necessary extra farm hand with help in the field. The ATV's popularity seems to only be increasing and the available features and options simply make this segment of the riding community worth checking out.

4.1ATV'S IN INDIA:

Although they have a long way to go, off-road vehicles hold a strong potential to flourish in India, especially considering the Indian topography – from plain to hills and oceans to mountains. All-terrain vehicles could also be a future for those loving adventure and power sports. To discuss the opportunities of off-roader vehicles in India and its business dynamics, Ramesh Kumar Raja spoke to Pankaj Dubey, Managing Director of Polaris India Private Limited, Indian subsidiary of Polaris, world's No.1 off-road vehicle company. Edited excerpts:

Could you let us know about your organization and products you deliver in India?

Polaris is a world leader in the powersports industry with annual 2014 sales of $4.5 billion. It designs, engineers, manufactures and markets innovative, high quality off-road vehicles, including all-terrain vehicles (ATVs), snowmobiles, motorcycles and on-road electric/hybrid powered vehicles.

Polaris entered the Indian market in 2011 and today the company offers a large range of products covering various applications. Our products in India include ATV, RANGER® and RZR® side-by-side vehicles and snowmobiles and Indian motorcycles.

Other than our line of ATVs, Polaris India also launched the iconic motorcycle brand Indian® in India. Raking up the past, the company bought in the entire Indian Motorcycle's Chief range –Indian® Chief® Classic, Indian® Chief® Vintage and Indian® Chieftain™ and Indian Scout to India.

How has been your experience in Indian market so far? How is it different from other markets?

For us, India is a key market and presents numerous opportunities as a company. It is a rapidly growing market and we are witnessing good response across the product line. It is different from other markets, in a sense that power sports vehicles as an industry is still in its nascent stage. The biggest challenge for Polaris is not only to create awareness for its vehicles, but also respond to market trends by offering the customers the best off-road experience that the brand promises to its customers. Polaris off-road vehicles are now also part of Indian army and many state police forces in the country.

Creation of Polaris Experience Zone (PEZ) is a step in that direction. PEZ are places where visitors can get a chance to enjoy an adventurous ride on a range of Polaris ATVs and exploit their full capability in these specially built off-road tracks. Besides serving the purpose of an "adventure park", PEZ also allows potential customers to get a hands-on experience of the vehicles. Today we have 30 PEZ in the country with a few more lined up.

How is the off-roader market in India growing? Who are major clients?

Demand for all terrain vehicles has been increasing year-on-year and that is why we are tapping this growing market aggressively with new products from our parent table.

Our major clients include sports vehicle aficionados and HNIs. We are also catering to the demands of the defence and police forces as Indian army command forces and state police forces have already included our vehicles in their fleet for various utility use. World over Polaris vehicles are the first choice of adventure sports lovers, a trend which we are seeing in India as well.

We are also seeing demand picking up for mini quad all-terrain vehicles (ATVs) for children of different ages. These ATVs with 50 to 90 cc engines are typically designed for children belonging to the age group of six to twelve years.

Overall, we are seeing a robust demand across our product line, which includes off-road vehicles, all-terrain vehicles or quad bike (quadricycle) or dirt bike ranger, snowmobiles and Indian motorcycles.

Defence sector could be a large client for your products. Do you track that segment too?

In order to serve the needs of the Armed forces of United States, Polaris Defence was founded in 2005. Over the years Polaris Defence has steadily developed a range of vehicles to serve the US and allied forces including the MRZR, MV850, and RZR-SW to meet the increasing demand for light off-road mobility platforms. Polaris Defence launches the next generation of ATV and LT-ATV's to meet the demanding needs of U.S. and international special operations, expeditionary and light infantry forces. Polaris is awarded several contracts from the US and other allied governments for the MRZR (LT-ATV) and MV850 (ATV) vehicles.

Polaris Military vehicles are the solution for easy movement of military personnel in tough off-road terrains like hills, forest, snow, water, marshy land, desert, rocky land etc. Built to match the tough working of the Defence and Police, reaching the unreachable, achieving the impossible has become easily attainable with the range of Polaris Vehicles. Polaris "Light

Tactical Vehicles" are most suitable for anti-insurgency, anti-terrorist & anti-naxal operations for quick movement in guerrilla war operations.

Our off roaders are now an integral part of Gujarat Police, Tamil Naidu, Kerala and Jammu Kashmir. The model is specifically designed to take on off-road terrain and hold tremendous potential to be a dependable and effective force multiplier.

Do you have a manufacturing base in India? Any plans for the same?

As of now, Polaris and Indian Motorcycles are coming in as Completely Built Units (CBU) from the USA. We are watching the market closely in terms of market dynamics, consumption matrix etc. Currently, Polaris India has no manufacturing base here. However, the ATV market in India is witnessing growth and is expected to continue along this trajectory. Any decision on establishing a manufacturing base in India will be taken after evaluating various factors and continued interest of various customers in the country.

Describe some of the specialized activities that the ATVs can do and where all have they been deployed for such activities?

Polaris vehicles can be deployed in all difficult terrains. These ATVs can be used in desert, slushy and marshy land, besides snowbound areas. It is particularly useful for helping border forces. The magnitude of last year's flash floods of J&K shook all of us. As a responsible corporate, Polaris joined hands with NDRF (National Disaster Response Force), and helped in the government rescue operations by providing four off-road vehicles (ORVs) to NDRF (National Disaster Response Force), to assist the flood victims.

The volunteered vehicles included Ranger 6×6 800, Ranger Crew 800, RZR XP 4 900, Sportsman MV 700. These specialized off-road vehicles helped in accessing the areas cut off due to the floods. Besides this, we also sent modified Ranger 6X6 ambulance. The Polaris ambulances helped in supplying medical help to certain far off areas on the treacherous terrains.

Polaris is reported to have extended similar kind of help during Uttarakhand floods. Can you tell us something about that?

Uttarakhand floods of 2013 were among the worst natural calamities to hit the country ever. A large part of the network of roads in and around the state got destroyed. During this hour of crisis, Polaris India donated five Off Road Vehicles such as one Sportsman Big Boss 6X6 800, one Sportsman 550 Hunter EPS, one RZR S 800 EFI and two Ranger 900 Diesel to Uttarakhand Government for carrying out the rescue operations successfully.

Recently there was news that Kerala Police procured four ATVs for anti-Maoist operations. Tell us something about it?

Last year Kerala Police took the delivery of four Polaris all-terrain off-road vehicles (ATVs) to their armoury. These ATVs will be used for the anti-Maoist operations in the northern districts of Kannur, Wayanad, Kozhikode (rural) and Malappuram. These ATVs will help the police in chasing anti-social elements in difficult terrains, particularly in forest areas. It can also be used for beach patrolling. The vehicles are powerful enough even to pull a heavy load attached to it. It can cruise to a speed of 100 km per hour in just five seconds. We have also trained policeman to familiarize them with driving these vehicles.

You are also into super bikes. Do you think there is a market for such bikes in India?

Indian Motorcycles is an icon and is the first American motorcycle company…. We are happy to have received a great response from the customers. When we acquired Indian Motorcycle in April, 2011, we set out to capture the heart, soul of the bike and legendary heritage of this iconic American brand and then infused it with unparalleled design, engineering and state-of-the-art technology. The entry of other motorcycle brands in the space and the presence and growing popularity of Polaris in India, prompted us to launch the Indian here.We are very excited with the positive response received by Indian Motorcycle launch in India. The Chief range has already termed by customers as CHIEF of all bikes in India. The newly launched Indian Scout has received tremendous response too. The premium superbike segments have also witnessed a high growth from 2007 onwards. Indian Motorcycles will redefine the cruiser superbike market in India. We give enthusiasts a chance to own a piece of history in a modern package.

5.SUSPENSION SYSTEM

5.1 THE NEED FOR SUSPENSION

The study of the forces at work on a moving car is called vehicle dynamics. Some of the concepts are needed to be understood in order to appreciate why a suspension is necessary in the first place. Most automobile engineers consider the dynamics of a moving car from two perspectives:

- **Ride -** a car's ability to smooth out a bumpy road
- **Handling -** a car's ability to safely accelerate, brake and corner
- These two characteristics can be further described in three important principles - road isolation, road holding and cornering. These principles are explained below and also how engineers attempt to solve the challenges unique to each.
- **Road Isolation** -The vehicle's ability to absorb or isolate road shock from the passenger compartment. Allow the vehicle body to ride undisturbed while traveling over rough roads. Absorb energy from road bumps and dissipate it without causing undue oscillation in the vehicle.
- **Road Holding -** The degree to which a car maintains contact with the road surface in various types of directional changes and in a straight line (Example: The weight of a car will shift from the rear tires to the front tires during braking. Because the nose of the car dips toward the road, this type of motion is known as "dive". The opposite effect "squat" occurs during acceleration, which shifts the weight of the car from the front tires to the back. Minimize the transfer of vehicle weight from side to side and front to back, as this transfer of weight reduces the tire's grip on the road.
- **Cornering -** It is the ability of a vehicle to travel a curved path. Minimize body roll, which occurs as centrifugal force pushes outward on a car's centre of gravity while cornering, raising one side of the vehicle and lowering the opposite side. Transfer the weight of the car during cornering from the high side of the vehicle to the low side.

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two.[1] Suspension systems must support both road holding/handling and ride quality,[2] which are at odds with each other. The tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

Live axle with Watt bar

Suspension like on a bike fork

Swing axle

Double wishbone suspension

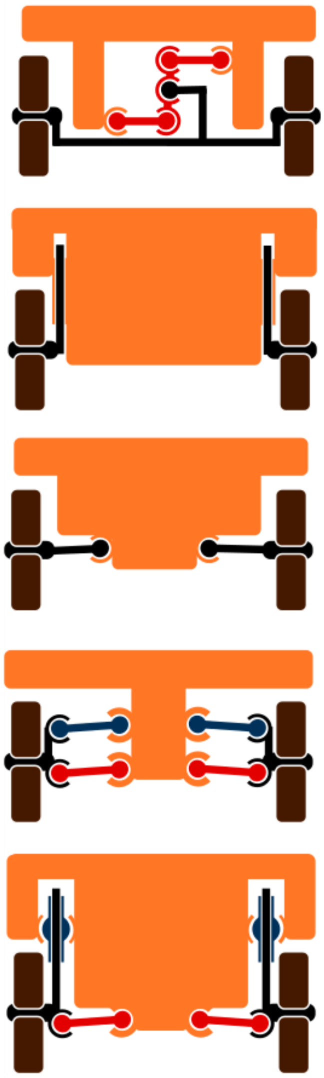


FIG 5.1 TYPES OF SUSPENSION

- **MacPherson**

Suspension systems can be broadly classified into two subgroups: dependent and independent. These terms refer to the ability of opposite wheels to move independently of each other.

A *dependent suspension* normally has a beam (a simple 'cart' axle) or (driven) live axle that holds wheels parallel to each other and perpendicular to the axle. When the camber of one wheel changes, the camber of the opposite wheel changes in the same way (by convention on one side this is a positive change in camber and on the other side this a negative change). De Dion suspensions are also in this category as they rigidly connect the wheels together.

An *independent suspension* allows wheels to rise and fall on their own without affecting the opposite wheel. Suspensions with other devices, such as sway bars that link the wheels in some way are still classed as independent.

A third type is a *semi-dependent* suspension. In this case, the motion of one wheel does affect the position of the other but they are not rigidly attached to each other. A twist-beam rear suspension is such a system.

- **Dependent suspensions**

Dependent systems may be differentiated by the system of linkages used to locate them, both longitudinally and transversely. Often both functions are combined in a set of linkages.

Examples of location linkages include:

Satchell link

Panhard rod

Watt's linkage

WOBLink

Mumford linkage

Leaf springs used for location (transverse or longitudinal)

Fully elliptical springs usually need supplementary location links and are no longer in common use.

Longitudinal semi-elliptical springs used to be common and still are used in heavy-duty trucks and aircraft. They have the advantage that the spring rate can easily be made progressive (non-linear).

A single transverse leaf spring for both front wheels and/or both back wheels, supporting solid axles, was used by Ford Motor Company, before and soon after World War II, even on expensive models. It had the advantages of simplicity and low unsprung weight (compared to other solid axle designs).

In a front engine, rear-drive vehicle, dependent rear suspension is either "live axle" or deDion axle, depending on whether or not the differential is carried on the axle. Live axle is simpler but the unsprung weight contributes to wheel bounce.

Because it assures constant camber, dependent (and semi-independent) suspension is most common on vehicles that need to carry large loads as a proportion of the vehicle weight, that have relatively soft springs and that do not (for cost and simplicity reasons) use active suspensions. The use of dependent front suspension has become limited to heavier commercial vehicles.

- **Independent suspensions**

FIG.5.2 INDEPENDENT SUSPENSIONS

A rear independent suspension on an AWD car.

Main article: Independent suspension

The variety of independent systems is greater and includes:

Swing axle

Sliding pillar

MacPherson strut/Chapman strut

Upper and lower A-arm (double wishbone)

Multi-link suspension

Semi-trailing arm suspension

Swinging arm

Leaf springs

Transverse leaf springs when used as a suspension link, or four quarter elliptics on one end of a car are similar to wishbones in geometry, but are more compliant. Examples are the front of the original Fiat 500, the Panhard Dyna Z and the early examples of Peugeot 403 and the back of the AC Ace and AC Aceca.

Because the wheels are not constrained to remain perpendicular to a flat road surface in turning, braking and varying load conditions, control of the wheel camber is an important issue. Swinging arm was common in small cars that were sprung softly and could carry large loads, because the camber is independent of load. Some active and semi-active suspensions maintain the ride height, and therefore the camber, independent of load. In sports cars, optimal camber change when turning is more important.

Wishbone and multi-link allow the engineer more control over the geometry, to arrive at the best compromise, than swing axle, MacPherson strut or swinging arm do; however the cost and space requirements may be greater. Semi-trailing arm is in between, being a variable compromise between the geometries of swinging arm and swing axle.

- **Semi-independent suspension**

In a semi-independent suspension, the wheels of an axle are able to move relative to one another as in an independent suspension but the position of one wheel has an effect on the position and attitude of the other wheel. This effect is achieved via the twisting or deflecting of suspension parts under load. The most common type of semi-independent suspension is the twist beam.

- **Tilting Suspension System**

Tilting Suspension System[23] (Also known as Leaning Suspension System) is not actually a different type or different geometry of construction, moreover it is a technology addition to the conventional suspension system.

This kind of suspension system mainly consist of independent suspension (e.g.- MacPherson strut, A-arm (double wishbone)). With addition with these suspension systems there is a further tilting or leaning mechanism which connects the suspension system with the vehicle body (chassis).

This kind of suspension system improves stability, traction, turning radius of vehicle and comfort of riders as well. While turning right or left passengers or objects on a vehicle feel G-force or inertial force outward the radius of curvature that is why Two-Wheeler riders lean towards the centre of curvature while turning which improves stability and decrease the chances of toppling. But for vehicle more than two wheels and with conventional suspension system could not do the same till now so the passengers feel the outward inertial force which reduce the stability of passengers and comfort as well. This kind of tilting suspension system is the solution of the problem. If the road do not have super-elevation or banking it will not affect the comfort with this suspension system, the vehicle tilt and decrease the height of centre of gravity with increase the stability. This is also used in fun vehicle.

Some trains also use tilting suspension (Tilting Train) with increase the speed at cornering.

5.1 HISTORY ON LEANING SUSPENSION

An early form of suspension on ox-drawn carts had the platform swing on iron chains attached to the wheeled frame of the carriage. This system remained the basis for all suspension systems until the turn of the 19th century, although the iron chains were replaced with the use of leather straps by the 17th century. No modern automobiles use the 'strap suspension' system.

Automobiles were initially developed as self-propelled versions of horse-drawn vehicles. However, horse-drawn vehicles had been designed for relatively slow speeds, and their suspension was not well suited to the higher speeds permitted by the internal combustion engine.

The first workable spring-suspension required advanced metallurgical knowledge and skill, and only became possible with the advent of industrialisation. Obadiah Elliott registered the first patent for a spring-suspension vehicle; - each wheel had two durable steel leaf springs on each side and the body of the carriage was fixed directly to the springs which were attached to the axles. Within a decade, most British horse carriages were equipped with springs; wooden springs in the case of light one-horse vehicles to avoid taxation, and steel springs in larger vehicles. These were often made of low-carbon steel and usually took the form of multiple layer leaf springs.[3]

Leaf springs have been around since the early Egyptians. Ancient military engineers used leaf springs in the form of bows to power their siege engines, with little success at first. The use of leaf springs in catapults was later refined and made to work years later. Springs were not only made of metal, a sturdy tree branch could be used as a spring, such as with a bow. Horse-drawn carriages and the Ford Model T used this system, and it is still used today in larger vehicles, mainly mounted in the rear suspension.[4]

This was the first modern suspension system and, along with advances in the construction of roads, heralded the single greatest improvement in road transport until the advent of the automobile.[5] The British steel springs were not well suited for use on America's rough roads of the time, so the Abbot Downing Company of Concord, New Hampshire re-introduced leather strap suspension, which gave a swinging motion instead of the jolting up and down of a spring suspension.

FIG.5.1.1 MORS MACHINE

Henri Fournier on his uniquely damped and race winning 'Mors Machine', photo taken 1902

In 1901 Mors of Paris first fitted an automobile with shock absorbers. With the advantage of a damped suspension system on his 'Mors Machine', Henri Fournier won the prestigious Paris-to-Berlin race on 20 June 1901. Fournier's superior time was 11 hrs 46 min 10 sec, while the best competitor was Léonce Girardot in a Panhard with a time of 12 hrs 15 min 40 sec.[6]

Coil springs first appeared on a production vehicle in 1906 in the Brush Runabout made by the Brush Motor Company. Today, coil springs are used in most cars.

In 1920, Leyland Motors used torsion bars in a suspension system.

In 1922, independent front suspension was pioneered on the Lancia Lambda and became more common in mass market cars from 1932.[7] Today most cars have independent suspension on all four wheels.

In 2002, a new passive suspension component was invented by Malcolm C. Smith, the inerter. This has the ability to increase the effective inertia of a wheel suspension using a geared flywheel, but without adding significant mass. It was initially employed in Formula 1 in secrecy but has since spread to another motorsport.

6.METHODOLOGY

6.1 METHODOLOGY USED TO MAKE QLSV

QLSV is a concept in which is developed keeping in mind the conditions and requirements of small farmers or farmers with small lands. We have fabricated a prototype using various manufacturing techniques but we have not designed it completely using design formulae's, principle, tables etc. We have used pre-designed old materials of various vehicles and modelled it to give the shape of a ATV keeping in mind the dynamics and basic structure of a ATV.

We have used a Bajaj Pulsar of 150cc and its chassis, gear box. The front single wheel system was converted to two wheels with suspension, the front suspension and steering system used here is ball joint and drag link steering mechanism. Remaining all accessories and materials except for metal plates, poles, anglers were newly purchased. The following schematic diagram gives the methodology which we followed in the process of making ATV.

- MARKET SURVEY OF ATVS
- CONCEPT OF NANO ATV
- PLANNING AND MATERIAL SURVEY
- BASIC DESIGN AND SCALING
- PURCHASING OF MATERIALS
- MODIFICATION OF CHASSIS
- ASSEMBLY OF VARIOUS PARTS
- PERFORMANCE TESTING
- FIELD WORK ANALYSIS

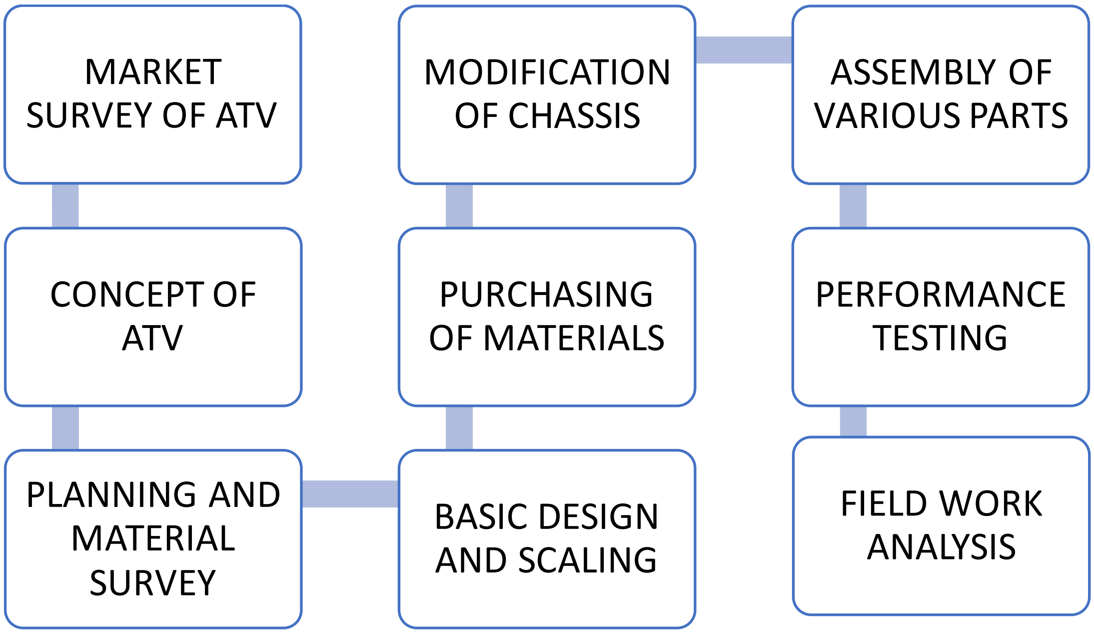


FIG 6.1.1 METHODOLOGY

- ### CONCEPT OF QLSV

After a clear survey, we found that there is a need for low cost ATVs for a category of farmers having lands less than 7 acres. Hence for these reasons there was no need of high cost large ATVs instead they need less power, small, high load carrying ATVs. Therefore, we came to conclusion, and developed a concept of QLSV. The term QLSV was given based on the quad leaning bike which was manufactured based on similar ideas.

- ### PLANNING AND MATERIAL SURVEY

After getting the idea of the vehicle to be made it was time to decide how it should be brought up from what materials of what specifications. Therefore, a survey on Engines was done various engines were considered. Then chassis and gear box were selected so that it matches our selected engine and provide good bedding for engine. Since two-wheeler bike matches with the requirements and it is cost efficient. Hence the basic body of the QLSV was planned.

- ### BASIC DESIGN AND SCALING

After planning and selecting of materials it was time to put a basic design of QLSV with respect to our materials selected, as to how it can be given the shape of a ATV and various metal plates, anglers, sheets, poles and other materials needed to give that shape. Since we are using pre-designed material we have no need of designing based on design principles considering stresses and loads. Then the chassis was to be scaled to our size requirements based on the concept of QLSV. This scaling was done keeping in mind the balance and turning radius required and the load carrying capacity.

- **PURCHASING OF MATERIALS**

After final design and planning it was time to start fabrication for which materials had to be purchased keeping in mind the objective of low cost. Hence materials were purchased at low costs. The cost of engine, chassis, gear box accounted for 70% of the ATV cost, whereas remaining materials accounted for 20-25%. Quality of materials was also considered since the vehicle is to be used in rough and harsh conditions.

- **MODIFICATION OF CHASSIS**

The chassis used here was of a Bajaj Pulsar 150cc auto and the size was reduced to our requirements. The length was scaled and the thickness was maintained the same since weight of chassis was to be maintained. The net weight of scaled chassis was 140 kg. The modification was done keeping in mind the balance and turning radius.

- **ASSEMBLY OF VARIOUS PARTS**

It was time to assemble all the parts as per the design and using various manufacturing processes work on the external body and various parts was done. Thus, fabrication was done of the QLSV by assembling the parts using gas welding, arc welding, bolts nuts, screws etc. hollow MS pipes was used to make the outer body. Seating and various other accessories were attached and the silencer was placed below. The gear system was same as the parent bike. Wheel alignment was done at the last and QLSV was painted to give final touches.

- **PERFORMANCE TESTING**

Finally, the QLSV was ready and it was tested for some of its technical specifications mileage, net payload, angle of tilting, fuel consumption. These testing were done using traditional methods and approximate values were obtained. A good result were obtained, if new testing methods were applied even better results can be achieved.

➢ FIELD WORK ANALYSIS

The best part of whole process was the field work analysis. The QLSV was tested on field to see how it works and best results were obtained. The reviews were taken and according to reviews it was quite successful since we had not designed it using design principles. The farmers were happy with the results and more over they were excited about the cost of that QLSV. Therefore, successful field work analysis was done and finally a report was prepared.

This was the complete methodology followed to make QLSV.

FIG 6.1.2 FIELD WORK

LIST OF PARTS:

Sl. no	Parts
1	Chassis
2	Upper Wishbone
3	Lower Wishbone
4	Shock Absorbers
5	Ball Joints
6	Wheels
7	Disc Brakes
8	Supporting Brackets
9	Steering Components
10	Universal Joint
11	Engine Kit
12	Wiring Kit
13	Fasteners
14	Sprocket kit
15	Propeller shaft

6.3 MATERIALS AND COMPONENTS USED IN QLSV

6.3.1 CHASSIS

FIG.6.1 BAJAJ PULSAR 150 CHASSIS

In the process of developing of chassis frame, a proper designed method is employed. The conceptual design is first developed using sketches. Then computer aided design is used to help the process of design. Once the three-dimensional drawing was completed, a basic finite element analysis was performed. It is important that the result of analysis satisfy the technical requirement of the vehicle. After all the process was completed, only then the fabrication of the frame was then conducted.

6.3.2 ENGINE AND GEAR BOX

FIG.6.3.2 ENGINE

We have used Pulsar 150 engine. With the following specifications as listed below

Engine: 4 stroke, Single Cylinder, Natural air cooled.

Bore x Stroke: 58.00 mm x 56.40 mm

Engine Displacement: 149.01 cc

Compression Ratio: 9.5 + 0.5: 1

Max. Net Power: 15.05 Ps at 9000 rpm

Max. Net Torque: 12.45 Nm at 6500 rpm

6.3.3 STEERING COMPONENTS

FIG 6.3.1 STEERING COMPONENTS

6.3.4 SUSPENSION SYSTEMS AND WHEELS

FIG 6.3.2 SUSPENSION SYTEM

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheel and allows relative motion between the two.

We have used double wishbone system for the both front and rear suspension of the vehicle.

Why double wishbone suspension?

It is an independent suspension design using two wishbone shaped arms to locate the wheel. It allows carefully controlling the motion of the wheel throughout suspension travel, controlling such parameters as camber angle, caster angle, toeing pattern, rolling centre height, scrubbing radius.

WHEELS

FIG 6.3.3 WHEELS

We have used light alloy wheels based on the use of light metals such as aluminium and magnesium. The specification of the alloy wheels are tabulated below.

Specification of Alloy Wheel	
Diameter of Wheel Rim	431.8 mm
Perimeter of Wheel Rim	2711.704 mm
Weight of Alloy Wheel	1.98 kg

6.3.5 HOLLOW PIPES AND ALUMINIUM BRACKETS

FIG 6.3.4 HOLLOW PIPES AND ALUMINIUM BRACKETS

6.3.6 BRAKING SYSTEM

FIG 6.4.1 BRAKING SYSTEM

Disc brakes are a brake system that slows a wheel's rotation by squeezing an attached metal disc in a vicelike calliper. A disc brake consists of a brake disc, a brake calliper and brake pads. When the brake is applied, pressurized hydraulic fluid squeezes the brake pad friction material against the surface of the rotating brake disc. The result of this contact produces friction which enables the vehicle to slow down or stop.

6.3.7 TRANSMISSION

FIG 6.4.2 TRANSMISSION SYSTEM

Transmission system in any vehicle is used to propel the vehicle forward with the help of the torque and power generated by the engine and transferring it to the tires. The tires, which are in contact with the surface produce a reaction force called traction. Traction requirement is what governs the design of any transmission system. Design of any gearbox or gear train takes into account a number of factors like the contact ratio, diametric pitch and the center distance value. The latter being the most important of all.

The entire dimensions of a gearbox are based on the centre distance and the torque. All the components in the gearbox have to designed or selected by considering the suitable life and factor of safety.

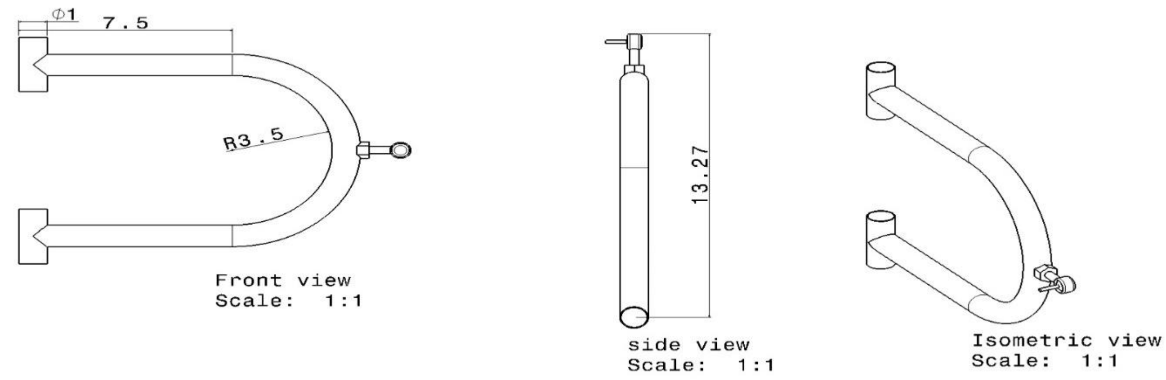
Common transmission elements follow:

- Chain drives
- Gears
- Cams
- Clutches
- Power

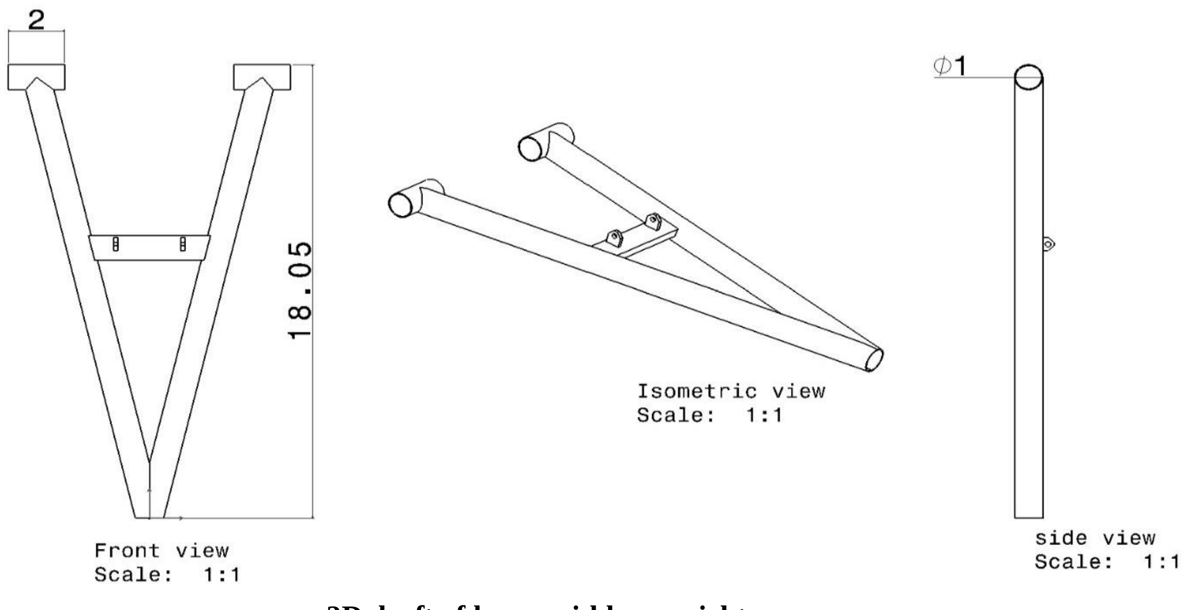
6.3.8 MISCELLANEOUS

Apart from the above shown materials other miscellaneous materials were used like- screws, nuts, bolts, washers, poles, ply wood, metal plates, accelerator and brake pedals, various oils and petrol.

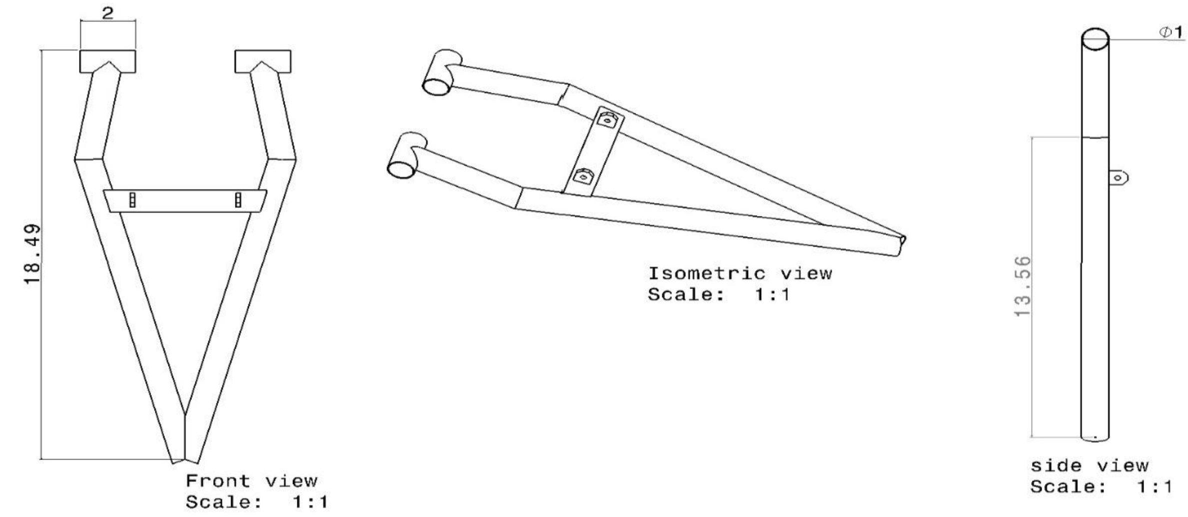
6.3.9 2D DRAFT OF PARTS



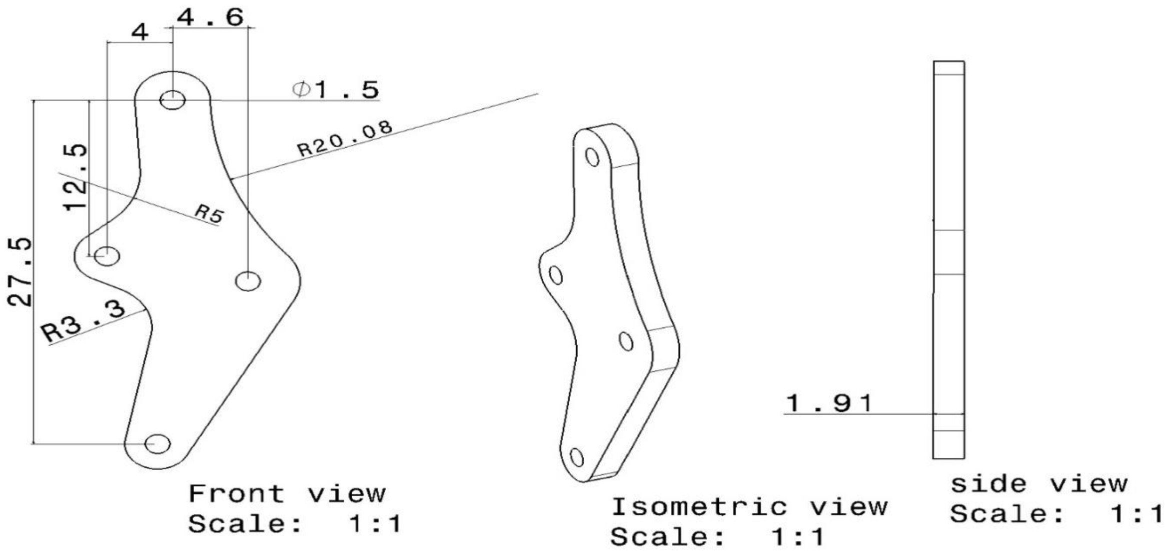
2D draft of upper wishbone



2D draft of lower wishbone: right



2D draft of lower wishbone-left



2D draft of supporting block

6.4 ASSEMBLY

The main components of assembly of an automobile can be sub grouped in the following assemblies.

- Engine
- Basic structure
- Driving system
- Basic control system
- Electrical system
- Basic structure

The frame of the vehicle is modified all holds the major of parts together. The wheels and tyre assemblies support the frame and the units are attached to it, through front and rear suspension so as to follow the road irregularities.

Driving system

The driving system comprises of the clutch, transmission, driveline and rear axle are assembled

Basic control system

The steering and braking system are assembled next this forms the basic control system of the vehicle.

The steering system consists of handle bar, holder handle, flanged bolt, control switch and many more parts are assembled.

Similarly, the braking system consists of disc, pin cotter, bearing ball, brake fluid and many more parts are assembled.

Electrical system

The electrical system is a part of both chassis and body. The system includes the starting, charging, ignition and horn circuit. Some electrical circuits are for engine operation, some for power transmission.

7.RESULTS AND COMPARISONS

7.1 SPECIFICATIONS

Mileage on road:	38 km/lit
Performance on field:	26 km/lit
Total Load carrying capacity:	up to 400 kg
Net weight of the vehicle:	190 kg
Top speed on road:	50 km/hr
Turning radius:	26°approx.

7.2 APPLICATIONS

- QLSV are one piece of farm equipment that most farmers can't do without. Although they are not designed to be a tractor, on most small farms they can reduce the need for one.
- Tourism: In tourism QLSV used for entertainment.
- Adventure: It can be used as adventurous sport.
- Construction fields: In this mainly used for the purpose of loading and UN loading the material. Military: In military mainly used for carrying the weapons and also easily move in hilly and uneven surfaces.

7.3 ADVANTAGES

- Major advantages by using QLSV are that it produces less pollution through exhaust or silencer.
- It is designed and fabricated by less in economically less.
- Main advantage is simple in construction while comparing to tractor.
- Also having more fuel efficiency compare to original engine.
- It can run in any path.
- Lighter vehicles cause less damage to roads, resulting in lower maintenance cost.

7.4 DISADVANTAGES

- The main disadvantage having less torque or output power comparing to tractor.
- Might have chances in tilting in the vehicles.
- Wheel alignment should be good and uniform.
- Drivers must be strictly follows the tips for driving or riding the quad bike.
- It does not have a reverse gear.

7.5 COMPARISON BETWEEN A QLSV AND ATV

SL. NO	TECHNICAL SPECIFICATIONS	QLSV	ATV
1	WEIGHT	190KG	300KG
2	LENGTH	55”	86.5”
3	WIDTH	41.4”	47.5”
4	GROUND CLEARANCE	15”	10”
6	TYPE	4 STROKES	4 STROKES
7	HORSE POWER	15HP	16-27HP
8	CAPACITY	150CC	500CC
9	RPM	2600RPM	3200RPM
10	COOLING SYSTEM	AIR COOLED	AIR COOLED
12	CLUTCH	DRY FRICTION PLATE	DRY FRICTION PLATE
13	GEAR BOX	4 FORWARD	3 FORWARD/1 REVERSE
14	TURNING RADIUS	26°	19°

7.6COST ESTIMATION

Sl. No.	Particulars	Cost (₹)
1	BIKE	15000
2	MS PIPES	7000
3	RIMS, TYRES	8000
4	FLAT PLATES	2000
5	SHOCK ABSORBERS	4000
6	LATHE WORK	6000
7	WORKMANSHIP	25000
8	RAW MATERIAL	10000
9	ALUMINIUM MOULDINGS	4500
10	MISCELLANEOUS	8000
	TOTAL	89500

7.7CONCLUSION

The tests conducted on the QLSV are a brand-new field and little engineering work has been conducted on these machines outside of factory testing. Due to the preliminary nature of these tests, comparison to other testing is difficult to assume. However, it is suggested that future testing look at how thrust from acceleration and rapid deceleration (such as encountering an obstacle), various terrains, and human error affect crash risk.

8.REFERENCES

Gohl, J. (2003). Narrow tilting vehicles: modeling, steering based tilt control. Masters Thesis. University of Minnesota, April.

Gohl, J., Rajamani, R., Alexander, L. and Starr, P. (2002). The development of tilt-controlled narrow ground vehicles. Proceedings of the American Control Conference, Anchorage, AK, May 8–10.

Hibbard, R. and Karnopp, D. (1993). The dynamics of small, relatively tall and narrow tilting ground vehicles. ASME Publication DSC 52, Advanced Automotive Technologies, 397–417.

Hibbard, R. and Karnopp, D. (1996). Twenty-first century transportation system solutions a new type of small, relatively tall and narrow tilting commuter vehicle.

Maciejowski, J. M. (2002). Predictive Control with Constraints, Prentice Hall. New Jersey.

Rajamani, R., Gohl, J., Alexander, L. and Starr, P. (2003). Dynamics of narrow tilting vehicles. Mathematical and Computer Modeling of Dynamic Systems 9, 2, 209–231.

Internet Websites:

www.KVF750_08-09_Manual.pdf.com

www.ATV_Tire_Sizes.pdf.com

frame_and_chassis.pdf.com

ijsrp- p3621.pdf.com

IJETRO22512.pdf.com Internet website, pulsar engine.wikipedia.com

QUAD LEANING SUSPENSION VEHICLE