CS840 Project 6:

LSP Method for Sportbike Evaluation

Samuel Gluss

Jozo Dujmovic

5-16-2016

Abstract – In the words of Kevin Cameron, “who are you? And, being who you are, what do you require from your motorcycle? Ask yourself,” and that is just the purpose of this paper (Cameron 8). There is a moment in everyone’s life where they are interested in purchasing a motorcycle, and many reasons can drive this decision. What motorcycle should they buy? Who is the buyer, what kind of motorcycle are they looking for, and what do they want to use it for? The motorcycle itself is a complicated multivariable system, and it is matched in complexity by the parameters of the buyer. The stakeholder in this case could be a 5’2” college girl looking for a suitable bike to get her to school, or a 6’1” AMA champion looking for a new ride to secure his next trophy with. Will the college student be satisfied with a 200 horsepower machine where, once astride, she cannot place both feet securely on the ground? This is not likely, nor is the Champion going to be satisfied with anything less than the fastest possible motorcycle. Everyone else is on a continuum, so the evaluation of the motorcycle must necessarily take into account its operator. This paper will propose a design of an evaluator for motorcycles using the LSP method, and a plan for diversifying this evaluator to adapt to the needs of varying stakeholders.

Introduction

For the purposes of our paper, we will consider the stakeholder to be an American man aged 25, of average height and weight. For that age, the average weight is 170 pounds, and the average height is 5’10”. By contrast, the weight and height of the average woman is 135 pounds and 5’5”, markedly lighter and shorter. This means a motorcycle with satisfies the physical requirements of the average man may not fit the average woman correctly. Furthermore, many other factors can play into the suitability of a motorcycle, such as its intended use, the environment in which it will be used, and how often it is used. The properties are all under the umbrella of ‘Stakeholder Properties’ which define who will use the motorcycle, what it will be used for and how, and why it will be purchased in the first place.

The LSP system itself is based around combining attributes with aggregators, to determine the resulting suitability of the system. Each individual attribute will have a percentage of suitability, based on how effectively it satisfies the needs of the stakeholder. An example of this would be an engine with 40 horsepower, which satisfies the basic necessity of having enough power to safely accelerate onto the freeway, but not much more. This motor, while sufficient for the needs of the road-going motorcyclist, lacks the power necessary for acceleration-based thrills. Thus, its degree of satisfaction is less than a more powerful engine.

Each attribute in the system must be as close to independent from the others as possible. Sometimes, this is not possible. For example, to capture a good idea of the power delivery of a motorcycle, both the power, and rpms of max torque are recorded. However, these values are somewhat correlated, as a more powerful racing engine will inherently have more torque delivery at higher RPM values. Regardless, these two values provide a very good idea of the character of the engine, and so they are sufficient for determining engine power delivery.

The attributes must be combined with aggregators, to determine the suitability of subsystems and, ultimately, the system as a whole. These aggregators combine the suitability of attributes according to their importance, and necessity to the system. Of course, properties like the weight of the bike are much more important than the color of the bodywork, so these attributes receive more weight in their corresponding aggregators.

An attribute may be necessary, sufficient, or optional, depending on the degree to which it must be present in the system in some satisfactory form. A bonus may be granted for the presence of an optional characteristic, but the system may not be penalized as harshly for the absence of an optional asset. A necessary attribute, on the other hand, must be satisfactory for the system to be considered suitable. An example of this juxtaposition is the fitting of a center stand on a motorcycle, versus extremely low horsepower output of the engine. A center stand is a good convenience, but its absence it not missed by the average rider. Conversely, an extremely low power output is considered to be dangerous on public roadways, as adequate acceleration can help the motorcyclist avoid unsafe situations. So, while a motorcycle without a center stand is still a good purchase decision, a motorcycle with very low horsepower would be harshly penalized.

Once all the attributes and resulting subsystems have been evaluated, the result is the suitability of the system as a whole. Systems can be compared based on these values, or price can be factored in to create a cost/benefit analysis. The purpose of the LSP method is to help the stakeholder determine which (if any) of the available solutions will best satisfy their needs, so the cost benefit analysis also takes into account the relative importance of cost to the system suitability.

Contents

[Introduction 1](#_Toc452004204)

[Motorcycles 4](#_Toc452004205)

[Engine 5](#_Toc452004206)

[Power Delivery 5](#_Toc452004207)

[Engine Physical Characteristics 7](#_Toc452004208)

[Engine Comfort and Convenience 8](#_Toc452004209)

[Transmission 8](#_Toc452004210)

[Clutch Type 8](#_Toc452004211)

[Chassis 9](#_Toc452004212)

[Frame 9](#_Toc452004213)

[Front Suspension 10](#_Toc452004214)

[Rear Suspension 12](#_Toc452004215)

[Dimensions 13](#_Toc452004216)

[Physical Dimensions 13](#_Toc452004217)

[Rideability 14](#_Toc452004218)

[Capacities 15](#_Toc452004219)

[LSPNT Report 16](#_Toc452004220)

[LSPNT Attribute Tree 16](#_Toc452004221)

[LSPNT Elementary Criteria 17](#_Toc452004222)

[LSPNT Competitive Systems 25](#_Toc452004223)

[LSPNT Evaluation Results 26](#_Toc452004224)

[LSPNT Cost/Preference Results 28](#_Toc452004225)

[Conclusion 29](#_Toc452004226)

# Motorcycles

Since the first time a motor and a bicycle were combined in the late 1800s and early 1900s, motorcycles have advanced technologically, and become a useful method of transport, hobby, profession, and way of life for people around the world.

At the fundamental level, the draw of the motorcycle is that it is an engine and gearbox attached by a frame to suspension, and a pair of wheels. This keeps cost low, so motorcycles are easily obtainable by anyone interested in riding. Furthermore, they are light, quick, and small, so they are favored as a form of transport in many rapidly developing countries.

Our stakeholder is a young man in California, either in college or just out, who has decided to get a new motorcycle. He has decided that he has outgrown his trainer bike, or he has decided that he is interested in trying something new. He is planning to use the bike to commute to work or school, so the bike must be suitable for riding on public roadways, with some usage on the freeways. He enjoys going for rides in the canyons with his friends, and is even thinking about taking his bike to the racetrack. He wants a comfortable and controllable motorcycle, but also one with enough performance to keep his interest. Being in California means that the bike must also be nimble and light enough to maneuver easily in traffic

The stakeholder will demand that the major subsystems on the bike, such as motor, gearbox, suspension, and chassis be suitable for his requirements. Small issues, like an overly racy powerband, or a somewhat noisy exhaust, may be forgiven. This means that as the granularity of the subsystems reduces, the level of conjunctivity of the aggregators must increase. A missing kickstand may be forgiven, but an anemic engine, or useless suspension, will not be tolerated, and the suitability of the system will be impacted accordingly.

The aggregator weights, conjunctivity, and attribute criteria may change quite a bit from stakeholder to stakeholder. Corey Call the AFM champion will place higher importance on engine power delivery and light weight, with low importance on fuel capacity or mileage. Ana Mora on the other hand, will require a shorter seat height to accommodate her 5’2” height, and will probably not notice an exotic braking system as she commutes to work. This means that the structure of the LSP tree will change quite a bit from one stakeholder to the next.

## Engine

The motor lies at the heart of the motorcycle, and in certain motorcycles such as the Ducati Panigale, even serves the role of the frame, as the primary structural member of the motorcycle. The motor must produce the power to propel the motorcycle, and comprises the most complex control systems on the motorcycle, including carefully modulated ignition and fuel delivery systems. Modern bikes even have electronically controlled throttles and closed loop traction management systems to make them easier to ride.

The modern street-legal motorcycle typically utilizes a four-cycle reciprocating piston internal combustion engine. This glorified air pump is carefully regulated to smoothly produce torque from a displacement that would just fill a large cup of beer. This system must also be able to pass all emissions and safety regulations, and be reliable enough to satisfy the requirements of a factory warranty, which is no trivial engineering achievement.

To the stakeholder, the meaningful characteristics of the motor are how comfortable it is to use, how it delivers its power, and its physical characteristics. Power delivery is the principle concern, with physical characteristics coming in secondary in importance. Of course, an engine that constantly overheats or rattles the bolts out will be unacceptable, so this aggregator has a high level of conjunctivity.

### Power Delivery

The most important aspect of the engine is how and when it generates the power required to motivate the motorcycle and rider into motion. This is split into maximum power, the percentage of maximum engine cyclic rate at which peak torque is developed, and the relative sophistication of control systems and rider aids which are available to make it easier to apply the power in a way that is intuitive and confidence inspiring for the motorcyclist.

The stakeholder is principally interested in riding his motorcycle on public roads, so having a reasonable amount of power available at lower engine RPM is his principal concern. Large amounts of power available only at the tip of the rpm range will be difficult or pointless to make use of when commuting to work, going for a ride in the canyons, or riding through the city. Control systems such as advanced fuel injection and traction control will also be important, so the bike will start up and behave predictably and forgivingly. The stakeholder is not a tremendously experienced rider, so any aid to controllability is valuable for him. Maximum power is still an important factor, but definitely of secondary importance, as the stakeholder will not be racing this bike, and most modern motorcycle engines have plenty of power for most purposes.

**Maximum Power -** The peak power developed by the engine determines important characteristics such as acceleration and top speed. Below a certain threshold, the motorcycle cannot easily accelerate to avoid dangerous situations, or maintain a safe speed for freeway travel. This is not as much of a problem in these modern times, when motorcycles can easily have the power of a family sedan, and for around $10,000 or less. In the range of 100 to 150 horsepower, the motor will completely satisfy any needs, whether for the rush of acceleration, or more utilitarian purposes. Beyond 150 horsepower, though, the engine produce too much power to be reasonable for an intermediate rider, and so these power levels are penalized.

**% Of Redline For Maximum Torque -** A perfect motorcycle for street riding would have instant power from the moment the clutch is released. With ICE (Internal Combustion Engines) this is rarely the case, as torque delivery is generally optimized for the middle to top of the RPM range. This is one reason why electric motors, with their instantaneous and smooth torque, are ideal motors for motorcycles. But, due to other engineering challenges, the ICE motor still dominates. The stakeholder will primarily use the bike for purposes other than racing, so torque delivery at the bottom of the rev range is strongly rewarded.

#### Engine Control Systems

The systems that control ignition, fuel, and torque output for the engine are important from a usability perspective, because they determine how easy it is to operate the motor, and how easily it’s running parameters can be adjusted to adapt to a motorcyclists preferences. This aggregator is relatively conjunctive for an aggregator at this level of the tree, because one control system which operates poorly can break the effectiveness of the others.

**Ignition Control System** – The fuel/air mixture is ignited by spark plugs in each cylinder. While spark plugs have not changed much in the last few decades, the electronics that drive them has. Ignition systems used to be based on a spinning rotor driven by the crankshaft, which suffered from limited adjustment during running, and inconsistent operation. An ICE requires precise ignition timing to produce optimal, predictable torque, and early systems were not able to produce this reliably. The results were bikes that were hard to start, often broke down, and were harder to ride smoothly. These are all characteristics of an unsuitable system. As time when on, mapped ignition curves were run on individual coil systems, and these advanced to become the fully computerized ignition systems found on modern bikes, driving direct ignition coils mounted on the spark plugs, and regulated from feedback from a detonation sensor fixed to the block. These systems are able to adapt to varying fuel quality, perform reliably, and deliver even torque for the motorcyclist’s disposal.

This criteria is discretized to simplify the selection of an ignition system for a motorcycle evaluation.

**Fuel Delivery System –** Depending on the RPM and changing load conditions, the fuel system may need to adapt rapidly to produce an optimally combustible mixture of fuel and air. If this mix is too lean or rich for the prevailing conditions, the burn may be inconsistent, not occur at all, or worse, detonate prematurely, causing engine damage. As late as the early 21st century, motorcycle have been fitted with carburetors that work off airspeed through a venturi to meter fuel flow, but these systems do not allow for adaptation to changing environmental and engine conditions. These changes can vary dramatically, such as barometric pressure changing with altitude, or fuel atomization characteristics changing as the engine internal surfaces heat up.

Modern fuel injection systems can meter fuel per cylinder and on a per-revolution basis. These systems can adapt to different conditions, and often feature secondary injectors to provide additional fuel, while the primaries are optimized for atomization of the fuel. These systems can offer useful functionality, like prolonging injection after throttle closure, which helps reduce engine surging, and makes the motorcycle lurch less when the throttle is rolled off. These features were not possible with less primitive carburetors.

Fuel delivery as a criteria is discretized to make selection easier, and it is important to the stakeholder because a bike with a more sophisticated fuel system will start more easily, get better fuel economy, respond to changes in throttle input, load, and rpm more smoothly, and be easier to adjust.

**Traction Control –** Modern motorcycles are increasingly powerful and inexpensive. These characteristics mean that they often end up in the hands of relatively inexperienced operators, who may not be prepared for a machine that can propel them to freeway speed in a handful of seconds. Traction control aids riders by limiting torque output of the motor to smooth the torque curve, limit total power, or limit lifting of the front wheel or spinning of the rear wheel. These systems often have user-adjustable interference levels, so that the rider can dial in which aids are desired to help maintain control of the motorcycle.

Rudimentary systems may be quite simple, and limit the maximum acceleration of the engine to prevent wheelspin. The system can get more complicated, with wheel speed sensors and inertial measurement units (IMU) which can limit engine power based on lean angle, relative wheel speed, and other factors. When correctly implemented, these systems become less intrusive, and limit power delivery more optimally to exactly what the tire contact patch and chassis can handle. More sophisticated systems will be more desirable.

Riders at any level can take advantage of a well-designed traction control system, and it can be disabled if it is not desired, so there is little downside to having it equipped. The stakeholder is still an intermediate level rider, so having traction control aids will help him to explore the capabilities of his bike with some safety net in the event of a misstep.

## Engine Physical Characteristics

**Compression Ratio –** Compression ratio is the difference in volumes of the cylinder between when the intake valve closes, and when the piston reaches top dead center. In internal combustion engines, “efficiency is governed by the difference between the maximum and minimum cycle temperatures,” so raising the compression ratio will also increase the efficiency of the engine due to adiabatic heating (Cameron 27). However, this produces a diminishing return. The hotter the mixture burns, the more likely detonation is to occur as a result, which can cause engine damage. To combat this, higher quality fuel is required, and the motor will likely require more maintenance as well.

The stakeholder is a relatively casual rider, and is more excited by the prospect of riding his bike than working on it. Furthermore, higher-spec fuel is more expensive, so the potential saving of running on cheaper gas is a draw. For the purposes of aggregation, only the negative effects of higher compression ratio will be considered, since horsepower and fuel economy are evaluated separately. As a result, suitability decreases with increasingly high compression ratio.

**Cylinder Cooling –** The method by which the cylinder walls and valve seats are cooled. This may be achieved by either air cooling with fins, an oil bath in the cylinder head, or a coolant jacket. More sophisticated cooling systems do a better job of keeping the engine at a consistent temperature, and as a result make engine performance more consistent. This benefit outweighs the additional weight and complexity created by these systems, and so there is a suitability improvement with improved cooling.

### Engine Comfort and Convenience

Engine performance is all well and good, but for a motorcycle which the stakeholder must live with on a day to day basis, refinement is required as well. Getting the motor started up, and how much noise and vibrations it produce are important factors. This aggregator combines the mean of these two values, since they are approximately the same in terms of value.

**Engine Noise (Decibels) –** This value is a useful measure of how much noise and harshness is generated by the motor. An aggressive exhaust note may be nice at times, but a motorcycle that is too loud may be uncomfortable to ride. This value is increasingly penalized for very high values.

**Starting Method –** May be either kick start or electric start. Electric start is more complex and heavier, but far more convenient. The stakeholder will prefer the convenience of electric start over kickstart, so kickstart is penalized.

## Transmission

The transmission is the mechanism which transmits power from the engine to the rear wheel. In addition to transferring power, it is used to change gears to keep the engine operating at an optimal speed. A good transmission will shift smoothly and quickly between gears, have a consistent clutch that engages smoothly, and sufficient gears to keep the engine within its powerband. The final drive, whether it be a chain, belt, or driveshaft is the major concern, since maintenance of the drive system is the most interaction the stakeholder is likely to have with the transmission system. After that, the number of speeds is a significant contributor to this aggregator, as having too few can leave any rider hunting for the right gear and not finding it. Of last importance is any quickshift functionality, or back-torque limiting capabilities in the clutch. These are of minor importance because they are not easily noticeable, and can be retrofitted to the bike relatively easily as well.

**Number of Speeds –** The engine on the bike will produce peak torque and power in a subset of its RPM range, and having appropriate gearing is important for staying in this range throughout the speed range for which the motorcycle is used. This way, the motor is kept from bogging at low revs, or racing unnecessarily at high revs, under common operating conditions. 6 forward speeds is standard, and counts below this are increasingly penalized, with 3 being completely unsuitable for a street ridden motorcycle.

**Final Drive Type –** The final drive may be either a driveshaft, belt, or chain which connects the transmission output shaft to the rear wheel. A chain is a great power transmitter, but requires regular maintenance and adjustment. A belt is quiet, light and more maintenance-free, but may snap at an inopportune moment, especially if something is caught in it. A driveshaft is the heaviest, but also the most maintainence-free. A driveshaft does come with a loss of power through the joints, but this is evaluated separately by the horsepower criteria.

The stakeholder will benefit from a maintainence free system, so the belt is slightly penalized compared to the driveshaft. The chain, with its regularly required adjustments and lubrications, is penalized the most.

### Clutch Type

The clutch controls transmission of power from the engine to the transmission. The clutch may be bathed in oil or dry, and may be back torque limiting or not. The back-torque limiting feature is not as perceptible of a benefit to the casual operator, and so receives a much lower weight in this aggregator. Both are useful, but not necessary features, so the arithmetic mean is a suitable aggregator.

**Dry or Wet Clutch –** Dry clutches may be more convenient to service, but they are prone to overheating in traffic and with repeated use, and are quite noisy. To the stakeholder, these are considered serious disadvantages, and so dry clutches are penalized compared to oil-bathed clutches.

**Slipper Clutch –** A back-torque limiting clutch or ‘slipper’ clutch prevents large amounts of engine back-torque from causing the rear tire to slip under sudden engine deceleration, or aggressive downshifting of the transmission. This is achieved by ramps built into the clutch hub, which partially disengage the clutch under engine back-torque conditions. These benefits are offset by faster consumption of the clutch material if these functions are abused.

While the benefits of a slipper clutch are primarily realized on the racetrack, the slipping function attenuates most of the shock from imperfect downshifts, making the bike smoother to ride in deceleration. Any rider can benefit from being able to focus less on downshifting perfectly when coming towards a corner or a stop, so although the benefit is small, it is still of utility to the stakeholder.

**Quickshifter –** A quickshifter enables seamless shifting, usually upshifting, but occasionally supporting downshifting as well. Usually this is achieved by cutting the ignition to suddenly drop engine RPM for upshifts, and quickly opening the throttle plates to blip the RPMs for downshifts. Quickshifters generally have a strain switch in the shift linkage to detect a shift event, then make the appropriate action with ignition or throttle. This system is convenient in that it frees the rider from having to manipulate the throttle and clutch to upshift or downshift.

For the stakeholder, the quickshifter is a neat convenience, and can save some wear on the clutch and gear dogs. On top of that, it can be enjoyable to use. However, it is not a huge asset, so it’s weight in the aggregator is quite low.

## Chassis

The chassis of the motorcycle is what ties everything together. It connects the engine and transmission unit to the wheels via a carefully engineered frame, and suspension to control attitude changes, and absorb bumps. The chassis includes the braking system as well. The frame is the most important part of this system, as it is difficult to upgrade, and defines how rigid (or flexible, as need be) the chassis will be to flexion and torsion in different directions. The suspension can be adjusted or swapped out, but it is preferential to get a bike with good parts to begin with, so the suspension importance is not weighted too low.

### Frame

The frame connects the suspension to the engine and gearbox, supports the bodywork, fuel tank, and other hardware. Its properties are important to how the bike will handle in any situation, whether leaned over for a corner, accelerating onto the freeway, or braking to a stoplight. The Frame is generally made out of aluminum or steel, and may be of several different types. As a bonus, there may be a center stand fitted to the bike as well.

The frame type is the most important property of the frame, as this determines how well engineered the frame is overall. Material is secondary, as this determines the rigidity and weight of the frame unit. The center stand is convenience, and so doesn’t carry much weight. Arithmetic mean is used, as no attribute is strictly mandatory: a steel frame is still acceptable, for example.

**Frame Material –** A frame can be produced from either steel or aluminum. Aluminum is quite a bit lighter than steel, and can achieve greater structural rigidity for the same weight. This is generally desirable, but aluminum has certain disadvantages, such as being susceptible to stress fractures, and being more difficult to weld. In general, an aluminum frame is more desirable, but not by a large margin. Many manufacturers still produce competitive motorcycles with steel trellis frames.

**Frame Type –** There are many different frame types available, so for simplicity the most common modern frames are available for selection: double cradle, trellis, beam, and frameless. Double cradle is the oldest design, with a perimeter frame around the motor/gearbox unit. They are notorious for flex, but are cheap and proven. Trellis and beam frames became more common in the late 1980s to early 1990s on motorcycles such as Yamaha’s Genesis, which utilized a Delta-box beam type frame, and are now extremely common. Frameless bikes use the drive unit as the primary stressed member, and are extremely light and rigid as a result. The disadvantage is that lateral flex is harder to tune on frameless bikes, which can cause them to have handling issues when leaned in a corner, as the bike cannot absorb bumps as well as a trellis or beam frame.

For the stakeholder, frameless is ideal for its simplicity. Beam and trellis are penalized somewhat, and double cradle has the lowest rigidity and so receives the lowest score. Despite this, even a double cradle frame bike is acceptable to ride, so the penalty is not very large.

**Center Stand –** The center stand is fitted to the bottom of the frame, and lifts the entire bike off the ground. This makes maintenance and repairs much easier. While a center stand is definitely a nice piece of equipment to have, it is quite easy to acquire a set of stands, and so it is not of great significance to the stakeholder.

### Front Suspension

The front suspension of the bike controls the movement of the front tire, and is very important to the stability of the motorcycle. An articulating structure secures the front wheel to the frame, and allows it to steer and absorb bumps. The front suspension also carries the front brake system, which is the determining factor in deceleration. The suspension itself determines the larger part of the suitability of the system, while the brakes serve a simpler purpose and are weighted slightly less. Both are very important to control of the motorcycle though, so the aggregator is relatively conjunctive for this level of the tree.

**Front Suspension Type -** Losing traction with the front tire very quickly precipitates a crash, and so having high quality front suspension is a desirable state of affairs. Suspension systems differ in terms of their rigidity, sensitivity to velocity changes of the wheel, and their geometry. For example, telescoping forks tend to dive sharply under braking, whereas control arm front suspension keeps the motorcycle flat in deceleration, which enables bump absorption to happen normally.

The types of front suspension which are typically available fall into two primary categories: telescopic fork and control arm. Telescopic forks have been the most common for many years, and come in a variety of formats, from traditional oil pistons to more exotic upside-down cartridge forks. These upside down forks place the broader diameter tube at the top, improving resistance to flex under braking.

Control arms systems range from the relatively pedestrian such as BMW telelever, to the highly exotic such as the Bimota Tesi, or the late John Britten’s revolutionary design. These designs may solve some of the problems telescopic forks, but are often heavy and complex, and may introduce new problems.

Our stakeholder is more interested in proven designs, so the state of the art upside down forks are highest in suitability. A system such as Telelever would be preferable to simpler conventional forks, because in that case the tradeoff is worth it. No suspension is perfectly suitable though, as each has known drawbacks, and so each is rated at less than 100. Even a regular fork can work decently as well, so the simple fork as a suitability of 60.

**Front Brakes –** The front brakes on most motorcycles are strong enough to lift the entire rear end off of the ground, and so can be considered to be one of the most important factors in decelerations. These systems may have a computer controlled anti-lock capability, but are generally a simple system: calibers carry pads, and grip rotors.

Front brake count and ABS are the most important factors, with rotor size playing a relatively minimal role. The aggregator is only slightly conjunctive, as not all parts of the system must be perfect to be suitable.

**Front Brake Count –** On extremely light bikes, only one front brake is needed, but heavy bikes benefit from having a second. Their extra mass creates more load on the pad and rotor, and spreading this out to a second system can improve brake performance in harsh operating conditions, preventing the rotors from warping and the pads from glazing.

While a single system is sufficient, having dual systems will make the braking far more robust, and result in perfect suitability.

**Front Rotor Size –** Larger diameter rotors can store more heat, and permit the brake pads to exert more torque on the front wheel, increasing brake sensitivity and strength. A slight bonus for larger rotors is possible.

**Antilock Brake Configuration –** The danger of locking the front wheel under deceleration is quite serious, as the bike will immediately begin to fall quickly. A well-developed antilock brake system will be able to detect this situation and release the brakes before an unaware human pilot. As a result, such a system can often prevent accidents due to debris or other adverse road surface conditions. Furthermore, advanced systems utilizing an inertial measurement unit (IMU) can use telemetry data to infer the motorcycles attitude, and recalibrate the sensitivity of the ABS system accordingly. Such a system can brake effectively at the limit of traction, even when leaned over in a corner.

For the stakeholder, the best ABS system possible is the ideal. Anything which reduces the likelihood of a crash in a panic situation has a lot of value to any street motorcyclist, and given the stakeholder’s skill level, such a system would even be advantageous on the race track. The absence of any system receives zero suitability for this stakeholder, standard ABS is acceptable, and IMU based dynamic ABS is the ideal.

### Rear Suspension

The rear suspension controls how the rear wheel responds to bumps, cornering, and acceleration loads. Rear suspensions have evolved quite a bit over the years, but generally involve one or more shock absorbers with a linkage as needed, a rear swingarm, and the rear brake. The shock is a very important part of this system, as it determines how the rear tire’s velocity relative to the bike will change depending on forces applied to it. The brake is of secondary importance, since it is largely used in low traction environments, or for attitude control.

**Rear Shock Configuration –** The rear shock(s) can be configured in a few different ways. On older motorcycles, and some retro styled bikes, dual shocks are fitted, connecting directly from the swingarm to the frame. These systems are not inherently bad, but have extra moving parts compared to single-shock systems, and are more laborious to adjust. Single shock systems with a linkage became very popular in the 80s, and are still on most all motorcycles produced today. A simple linkage can be easily changed out to adjust height or rate, and the shock itself can easily be swapped out for a higher performance unit at the behest of the owner.

The latest technology available for rear shocks is computer adjusted damping and spring preload. These systems are switchable on the fly to different riding modes such as street, sport, track, and cargo carrying. These systems offer a slight advantage for riders who ride in diverse circumstances, giving them on the fly adjustments over damping rates.

Computer controlled systems are somewhat more desirable than manual systems, but the manual systems can still be tailored to the stakeholders needs. So, the computerized system is only somewhat more desirable than a standard rear shock unit. The dual setup receives a penalty for being cumbersome and redundant, but it is a rather rare system on modern machines.

**Rear Brake –** The rear brake is generally a very simple single rotor/caliber unit. It is small by comparison to the front system, as the rear tire becomes unloaded during braking, and does not have much traction left for the rear brake. The rear brake is typically used when the prevailing traction conditions are too slippery to safely apply the front brake without slipping, and occasionally during cornering to tighten the arc of the motorcycle through a corner. In both these case, a small brake unit is perfectly sufficient.

Some bikes utilize a drum and shoes style rear brake, which is bulky and difficult to service. These units are relatively undesirable compared to the simpler disc brake systems, and receive a penalty.

## Dimensions

The size, weight, and capacities of the motorcycle are also critical components of its suitability. The most important characteristic is the rideability, because without that the motorcycle will not be confidence inspiring and easy to ride. The physical size and weight of the bike is also a major part of its suitability, as an overly massive bike will be hard to maneuver in traffic. Lastly, having sufficient range and oil capacity will keep the stakeholder on the road enjoying his machine, rather than filling it with gas, or performing oil changes.

The aggregator for dimensions is C+-, as the subsystems here are all mandatory for the system to be considered suitable.

### Physical Dimensions

Physical dimensions covers the size and weight of the motorcycle. The stakeholder will be using the motorcycle for a variety of purposes, so it is necessary for the bike to satisfy requirements for length, weight, and width.

Weight is the most important factor because it affects the handling of the bike under all riding conditions, except steady state riding in a straight line. It has been established that the stakeholder will not do much long range riding, so a light weight bike will have few disadvantages. Max width of the bike is next in order, because it determines how easily the bike will stow for parking, as well as how easy it will be to laneshare with traffic on public roads. Lastly, the wheelbase can help determine whether the bike is a suitable compromise for mixed riding between mini-bikes and long cruisers. It is not as pertinent to the needs of the stakeholder, and so it has the lowest weight.

A CA aggregator is used here, to strike a compromise of conjunctivity. Each subsystem is important, but a slightly wider bike may still be suitable. This holds for somewhat heavier or longer bikes: these are not strictly deal-breakers.

**Wheelbase (inches) –** The wheelbase is the distance between the front and rear axles. Shorter bikes will tend to turn in faster, but at the expense of high-speed stability. Furthermore, shorter wheelbases are more prone to stoppies and wheelies under excessive braking and acceleration, respectively.

Motorcycles with long wheelbases will be more sluggish to turn, but are more stable at high speed, and under aggressive braking and acceleration. This tradeoff has a drop off, as at some point the benefit of stability is outweighed by sluggish handling.

The optimal value for the average motorcyclist is between 54 and 60 inches. The average rider does not need exceptional stability at ultra-high speeds, so there is a slight penalty for wheelbases over 54 inches, which is optimal for turn-in speed and stability. Outside of this range, suitability drops off quickly.

**Width (inches) –** The width at the widest point on the motorcycle. A narrow bike is comfortable to ride at most speeds. Wider fairings can be a pleasant luxury for longer rides, but this is not a serious concern for the stakeholder. He will be concerned with how to store it on his limited rent allotment, and how it will get through cramped traffic at stop lights. The narrowest bikes are around 25 inches wide, the optimal value. This drops off to 40 inches, a wholly unsuitable value for storage or traffic navigation.

**Curb Weight (pounds) –** The curb weight is reported by the manufacturer of the motorcycle with all fluids and the battery, ready to ride. A heavier bike will be more stable at high speed, or in a crosswind, but suffers numerous disadvantages. All systems on the bike responsible for acceleration, deceleration, and turning must work harder. Furthermore, the motorcycle will not be able to do any of these things as effectively as a lighter bike.

The stakeholder will be using the bike principally for commuting and sport riding, so lighter weight will be an advantage in the majority of his use cases. He will ideally have a motorcycle in the 200 to 450 pound range, but may still consider a heavier bike, provided it satisfies his other requirements.

### Rideability

Rideability addresses the issue of being able to ride the motorcycle in the first place. The stakeholder requires a motorcycle on which he can have confident footing at stops and when parking, and which will not bottom out on potholes or speedbumps. The seat height is much more important, as ground clearance is rarely a problem for modern motorcycles on public roads.

The aggregator is only somewhat conjunctive, which leaves the option open for supermoto style bikes which may have extra-high seat heights, but also have extra ground clearance which enables creative riding in urban environments.

**Seat Height (inches) –** The higher the seat height, the more difficult it is to securely plant one or both feet on the ground for stops and parking whilst astride the motorcycle. This is not an issue when underway, but for anyone who commutes and rides in traffic, this is a critical property of the bike.

The stakeholder can comfortably place both feet flat on the ground on a motorcycle with a 30 inch seat height. As the seat height increases to around 32 inches, the bike will become less manageable, and over 35 inches will be quite challenging to maneuver from the saddle. This value obviously depends greatly on the shareholder, someone who is 6 feet and 4 inches tall can comfortably flat-foot most any motorcycle, whereas a 5 foot tall individual will be hard pressed to find any bike that allows them to plant both feet square on the ground.

**Ground Clearance (mm) –** This determines the capability of the motorcycle to clear obstructions in the roadway. Speed bumps can be as tall as 100mm, so any clearance under this value is penalized quite dramatically. Over 100mm is quite sufficient for most uses, and higher values do get a slight bonus as they are useful when it comes to go up or down curbs.

### Capacities

This category is based on the effective range and oil change interval requirement of the motorcycle. As mentioned previously, the motorcycle is primarily an instrument to ride, not to take to gas stations, or to practice draining and refilling oil. As a result, any motorcycle that gets extraordinarily bad fuel range, or requires inordinately frequent minor services, would be penalized. The stakeholder would rather be riding the machine.

The aggregator is conjunctive to ensure both range and oil system are satisfactory, as both these systems are crucial to the suitability of the motorcycle. A slight preference is given to the oil system, as it directly affects engine longevity.

**Fuel –** Almost all modern motorcycles run on gasoline. Some new models are available that are electric, but these are still rare and beyond the reach of the stakeholder. Motorcycles tend to get sufficient miles per gallon that the cost of fuel is not the principle issue, rather, how often the motorcycle must be pulled into a fuel station is a greater inconvenience. The range of the motorcycle is determined by multiplying the mile-per-gallon efficiency of the motorcycle by the total fuel capacity. As a result, this aggregator is relatively disjunctive at DA: the motorcycle just needs adequate mileage or capacity. Mileage is weighted higher as fuel does cost money.

**Gas Mileage (mpg) –** How many miles the motorcycle can go on one gallon of fuel. Modern fuel injected bikes can get quite good mileage, and a high number here means that the stakeholder can ride his motorcycle as much as he wants, without as much concern for the state of his bank account. Superior gas mileage also makes the motorcycle a more desirable form of transport for commuting, as it reduces the cost compared to other methods of getting to work or school.

Gas mileage of 40 mpg and above is considered satisfactory, and this is about the average for modern sport motorcycles. Any motorcycle with fuel economy of 60 mpg or over is completely suitable, as this motorcycle is more fuel efficient than almost any hybrid vehicle available for purchase.

**Fuel Tank Capacity (gallons) –** How many gallons of fuel the motorcycle is capable of carrying in its fuel tank. This, multiplied by the mileage, results in the range of the motorcycle. Most street motorcycles are equipped with 4 to 6 gallon tanks, and this is considered satisfactory. Many off-road motorcycles come equipped with extremely small 1-2 gallon tanks, but it is quite easy and economical to upgrade these tanks to larger capacities.

**Oil Capacity (quarts) –** The capacity of the oil sump is an important part of how often the oil must be serviced. The larger the capacity, the more thermal inertia the oil system has, and as a result, the more resistant it is to overheating. Furthermore, the breakdown of the oil, as well as its dilution with combustion byproducts and engine wear material is protracted if the sump capacity is larger. This means that the effective life of the oil is extended, for any user.

The stakeholder, and most people, would prefer to service their bike as little as possible, while keeping it in good working order. Oil changes are messy operations, and taking the bike to a shop for this relatively frequent service is inconvenient. As a result, a motorcycle with a larger sump capacity is a desirable characteristic. Capacities over 3 quarts are satisfactory, providing forgiving service intervals. Any value under 3 quarts makes services much more frequent, which is not a desirable situation for a streetbike.

# LSPNT Report

## LSPNT Attribute Tree

**1 motorcycles**

**11 Engine**

**111 Power Delivery**

**1111 Maximum Power**

**1112 % of redline for max torque**

**1113 Engine Control Systems**

**11131 Ignition**

**11132 Fueling**

**11133 Traction control**

**112 Engine Physical Characteristics**

**1121 Compression Ratio**

**1122 Cylinder Cooling**

**113 Comfort**

**1131 Noise (db)**

**1132 Starting method**

**12 transmission**

**121 # of speeds**

**122 Final drive type**

**123 Clutch type**

**1231 Dry or wet clutch**

**1232 Is slipper clutch**

**124 Quickshifter**

**13 Chassis**

**131 Frame**

**1311 Frame material**

**1312 Frame type**

**1313 Has center stand**

**132 Front Suspension**

**1321 Front Suspension Type**

**1322 Front Brakes**

**13221 Count**

**13222 Rotor Size (mm)**

**13223 ABS configuration**

**133 Rear Suspension**

**1331 Rear shock configuration**

**1332 Rear brake type**

**14 Dimensions**

**141 Physical Dimensions**

**1411 Wheelbase (in)**

**1412 Width (in)**

**1413 Curb weight (lbs)**

**142 Rideability**

**1421 Seat height (in)**

**1422 Ground clearance (mm)**

**143 Capacities**

**1431 Fuel**

**14311 Mileage (mpg)**

**14312 Fuel tank capacity (gallons)**

**1432 Oil Capacity**

## LSPNT Elementary Criteria

|  |  |  |
| --- | --- | --- |
| **1111** | | **Maximum Power** |
| Value | % | Maximum power produced by the engine in horsepower. Sufficient power to operate on roadways will be required. Most riders will be entirely satisfied by a motorcycle with above-required power, to a point. Excessive power makes the motorcycle difficult to manage in many situations on public roads, and is penalized accordingly. |
|
| 5 | 0 |
| 75 | 75 |
| 100 | 100 |
| 150 | 100 |
| 200 | 50 |
|  |  |  |
| **1112** | | **% of redline for max torque** |
| Value | % | More low to mid range torque indicates an easier to ride motorcycle, which will easily accelerate from a stop, or out of a corner. Peakier powerbands are better for racing, but require more work on the part of the rider, and are not suitable for the street. |
| 0 | 100 |
| 60 | 80 |
| 100 | 0 |
|  |  |  |
| **11131** | | **Ignition** |
| Value | % | Ignition Control System |
| 0 - points |
| 1 - distributor |
| 2 - coil packs |
| 3 - transistorized direct ignition |
|  |
| Superior ignition systems afford better reliability and superior control of engine power |
| 0 | 10 |  |
| 1 | 30 |  |
| 2 | 75 |  |
| 3 | 100 |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **11132** | | **Fueling** |
| Value | % | 0 - constant velocity carburetur |
| 1 - fuel injection |
| 2 - staged fuel injection |
|  |
| More sophisticated fuel delivery systems improve rideability of the motorcycle |
| 0 | 75 |  |
| 1 | 95 |  |
| 2 | 100 |  |
|  |  |  |
| **11133** | | **Traction control** |
| Value | % | 0 - no traction control |
| 1 - fixed traction control (not user adjustable) |
| 2 - adjustable traction control |
| 3 - IMU traction control (TCS paramaters controlled by high frequency 6-axis gyro) |
|  |
| Increasing levels of TCS help mitigate traction loss from engine power |
| 0 | 75 |  |
| 1 | 85 |  |
| 2 | 90 |  |
| 3 | 100 |  |
|  |  |  |
| **1121** | | **Compression Ratio** |
| Value | % | Compression ratio indicates the degree to which the piston compresses the air/fuel mixture during the compression stroke. Higher compression ratio allows for higher performance, but requires higher quality fuel, and may shorten maintainence/overhaul intervals. |
| 10 | 100 |
| 12 | 75 |
| 14 | 0 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **1122** | | **Cylinder Cooling** |
| Value | % | 0 - Engine is cooled by air only |
| 1 - Engine cylinder head is cooled by oil flow |
| 2 - Engine cylinder and head are cooled by water-based coolant |
|  |
| While liquid cooling systems impart additional complexity, their performance has become so good that this complexity is dramatically outweighed by benefits to engine longevity and performance. |
| 0 | 50 |
| 1 | 80 |
| 2 | 100 |
|  |  |  |
| **1131** | | **Noise (db)** |
| Value | % | Maximum noise level of motorcycle in decibels |
| 0 | 100 |
| 85 | 95 |
| 90 | 85 |
| 95 | 70 |
| 100 | 60 |
| 105 | 40 |
| 110 | 0 |
|  |  |  |
| **1132** | | **Starting method** |
| Value | % | 0 - kick start |
| 1 - electric start |
| 0 | 50 |  |
| 1 | 100 |  |
|  |  |  |
| **121** | | **# of speeds** |
| Value | % | More transmission speeds allows the rider to have more control over engine speed when riding in varying conditions. |
| 3 | 0 |
| 4 | 50 |
| 5 | 80 |
| 6 | 100 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **122** | | **Final drive type** |
| Value | % | 0 - chain |
| 1 - belt |
| 2 - driveshaft |
|  |
|
|
|
|
|
| 0 | 80 | Chains are robust for high-horsepower operation, but have high maintainence requirements. |
| 1 | 90 |  |
| 2 | 100 | Belts are very quiet and light, but require periodic replacement and can snap. |
|  |  |  |
|  |  | Driveshafts are extremely reliable. |
|  |  |  |
| **1231** | | **Dry or wet clutch** |
| Value | % | 0 - dry clutch |
| 1 - wet clutch |
|  |
| Dry clutches are slightly lighter, but suffer rideability, durability, and noise penalties compared to oilbath wet clutches. |
| 0 | 60 |
| 1 | 100 |
|  |  |  |
| **1232** | | **Is slipper clutch** |
| Value | % | 0 - regular clutch |
| 1 - equipped with slipper mechanism |
| 2 - computer controlled variable back-torque |
|  |
| Back torque limiting systems make it easier to manage engine torque when downshifting. These systems are most effective when downshifting is extremely aggresive and/or done during heavy braking, so the layman may not notice much more than increased smoothness with such a system fitted. |
| 0 | 90 |
| 1 | 95 |
| 2 | 100 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **124** | | **Quickshifter** |
| Value | % | 0 - no QS equipped |
| 1 - QS without adjustable timing |
| 2 - QS with adjustable timing |
| 3 - QS with closed-loop control (system detects when next gear is fully engaged) |
|  |
| QS is definitely a nice to have feature, which temporarily suspends ignition to enable the rider to upshift the transmission without releasing the throttle. Advanced versions give additional smoothness and performance, but will have barely perceptible improvements to the average rider. |
| 0 | 75 |
| 1 | 90 |
| 2 | 95 |
| 3 | 100 |
|  |  |  |
| **1311** | | **Frame material** |
| Value | % | 0 - steel |
| 1 - aluminum |
| 0 | 85 |  |
| 1 | 100 |  |
|  |  |  |
| **1312** | | **Frame type** |
| Value | % | 0 - double cradle - weak, heavy |
| 1 - trellis - strong, somewhat heavy |
| 2 - beam - light and stiff |
| 3 - engine is stressed member |
| 0 | 70 |  |
| 1 | 85 |  |
| 2 | 95 |  |
| 3 | 100 |  |
|  |  |  |
| **1313** | | **Has center stand** |
| Value | % | Center stand adds some weight and reduces ground clearance, but is extremely useful for working on the bike. Positives outweigh downsides for the average motorcyclist. |
| 0 | 75 |
| 1 | 100 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **1321** | | **Front Suspension Type** |
| Value | % | 0 - traditional fork |
| 1 - cartridge fork (increased sensitivity) |
| 2 - upside down fork (increased rigidity) |
| 3 - exotic front suspension (superior geometry, more complexity) |
| 0 | 60 |  |
| 1 | 80 |  |
| 2 | 95 |  |
| 3 | 90 |  |
|  |  |  |
| **13221** | | **Count** |
| Value | % | (Motorcycles with single perimeter rotor, or motorcycles with a wet weight under 325 pounds and a single front rotor, should use the value '2' for this element) |
| 1 | 75 |
| 2 | 100 |
|  |  |  |
| **13222** | | **Rotor Size (mm)** |
| Value | % |  |
| 200 | 0 |
| 280 | 60 |
| 300 | 80 |
| 320 | 100 |
|  |  |  |
| **13223** | | **ABS configuration** |
| Value | % | 0 - No ABS system |
| 1 - simple ABS system |
| 2 - IMU based dynamic ABS |
| 0 | 0 |  |
| 1 | 75 |  |
| 2 | 100 |  |
|  |  |  |
| **1331** | | **Rear shock configuration** |
| Value | % | 0 - dual rear shocks |
| 1 - single rear shock |
| 2 - computer controlled single rear shock |
| 0 | 75 |  |
| 1 | 90 |  |
| 2 | 100 |  |
|  |  |  |
| **1332** | | **Rear brake type** |
| Value | % | 0 - rear drum brake |
| 1 - rear disc brake |
| (Rear brake is relatively unimportant, but disc brake is more compact and easier to maintain) |
|
| 0 | 75 |
| 1 | 100 |
|  |  |  |
| **1411** | | **Wheelbase (in)** |
| Value | % | Wheelbase is a useful way to describe the overall length of a motorcycle, and strongly affects how it handles in straightline performance versus cornering. Short wheelbases turn quickly but are unstable and prone to wheelies/stoppies, whereas long bikes are very stable but do not turn as easily. |
| 45 | 0 |
| 55 | 100 |
| 60 | 90 |
| 70 | 0 |
|  |  |  |
| **1412** | | **Width (in)** |
| Value | % | Overall width of the motorcycle. Narrow is better for maneuvering in traffic, and makes the bike generally easier to manage. |
| 25 | 100 |
| 40 | 0 |
|  |  |  |
| **1413** | | **Curb weight (lbs)** |
| Value | % | A light motorcycle is much easier to handle, and will perform better in cornering and braking than a heavier bike. A heavy bike will be more physically exhausting, when not riding long distances on the freeway. |
| 200 | 100 |
| 400 | 85 |
| 500 | 75 |
| 600 | 50 |
| 1000 | 0 |
|  |  |  |
| **1421** | | **Seat height (in)** |
| Value | % | Higher seat heights make the motorcycle harder to control at low speeds, and reduce confidence when coming to or leaving a stop. |
| 25 | 100 |
| 30 | 90 |
| 32 | 75 |
| 36 | 50 |
| 40 | 0 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **1422** | | **Ground clearance (mm)** |
| Value | % | Ground clearance enables riders to easily clear large obstacles in their path. This can be especially useful in urban environments where obstructions and damaged roadways are quite common. |
| 50 | 0 |
| 100 | 60 |
| 125 | 80 |
| 150 | 90 |
| 200 | 100 |
|  |  |  |
| **14311** | | **Mileage (mpg)** |
| Value | % | Higher mileage means the motorcycle can go further on a gallon of fuel |
| 20 | 0 |
| 30 | 40 |
| 40 | 70 |
| 50 | 85 |
| 60 | 90 |
| 75 | 100 |
|  |  |  |
| **14312** | | **Fuel tank capacity (gallons)** |
| Value | % |  |
| 1 | 0 |
| 2 | 25 |
| 3 | 50 |
| 4 | 75 |
| 6 | 100 |
|  |  |  |
| **1432** | | **Oil Capacity** |
| Value | % | Measured in quarts. Total capacity of the sump system. Measured in quarts |
| 1 | 0 |
| 3 | 75 |
| 4 | 100 |

## LSPNT Competitive Systems



## LSPNT Evaluation Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Id** | **Attribute** | **WR450F** | **cbr600rr** | **speed\_triple\_r** |
| **1** | **Motorcycles** | **49.74** | **77.02** | **78.81** |
| **11** | **Engine** | **77.54** | **70.42** | **66.21** |
| **12** | **Transmission** | **80.54** | **86.18** | **89.35** |
| **13** | **Chassis** | **64.21** | **78.37** | **93.39** |
| **14** | **Dimensions** | **31.64** | **79.59** | **81.26** |
| **111** | **Power Delivery** | **73.9** | **73.34** | **69.36** |
| **112** | **Engine Physical Characteristics** | **73.31** | **59.07** | **53.53** |
| **113** | **Comfort** | **88.44** | **88.44** | **88.44** |
| **123** | **Clutch type** | **97** | **97** | **97** |
| **131** | **Frame** | **85.5** | **95.5** | **95.5** |
| **132** | **Front Suspension** | **37.71** | **55.1** | **91.52** |
| **133** | **Rear Suspension** | **91.97** | **91.97** | **91.97** |
| **141** | **Physical Dimensions** | **75.55** | **86.01** | **83.71** |
| **142** | **Rideability** | **36.95** | **75.21** | **75.21** |
| **143** | **Capacities** | **18.09** | **79** | **89.63** |
| **1113** | **Engine Control Systems** | **82.04** | **93.93** | **93.93** |
| **1322** | **Front Brakes** | **25.13** | **39.62** | **87.69** |
| **1431** | **Fuel** | **73.03** | **77.81** | **79.25** |
| **1432** | **Oil Capacity** | **10.12** | **80** | **100** |
| **14312** | **Fuel tank capacity (gallons)** | **17.5** | **85** | **81.25** |
| **14311** | **Mileage (mpg)** | **85** | **70** | **77.5** |
| **1422** | **Ground clearance (mm)** | **100** | **84** | **84** |
| **1421** | **Seat height (in)** | **27.5** | **73.12** | **73.12** |
| **1413** | **Curb weight (lbs)** | **94.45** | **84** | **84.7** |
| **1412** | **Width (in)** | **50** | **86.67** | **72.67** |
| **1411** | **Wheelbase (in)** | **94.6** | **89** | **99** |
| **1332** | **Rear brake type** | **100** | **100** | **100** |
| **1331** | **Rear shock configuration** | **90** | **90** | **90** |
| **13223** | **ABS configuration** | **0** | **0** | **75** |
| **13222** | **Rotor Size (mm)** | **37.5** | **90** | **90** |
| **13221** | **Count** | **75** | **100** | **100** |
| **1321** | **Front Suspension Type** | **95** | **95** | **95** |
| **1313** | **Has center stand** | **75** | **75** | **75** |
| **1312** | **Frame type** | **70** | **95** | **95** |
| **1311** | **Frame material** | **100** | **100** | **100** |
| **124** | **Quickshifter** | **75** | **75** | **90** |
| **1232** | **Is slipper clutch** | **90** | **90** | **90** |
| **1231** | **Dry or wet clutch** | **100** | **100** | **100** |
| **122** | **Final drive type** | **80** | **80** | **80** |
| **121** | **# of speeds** | **80** | **100** | **100** |
| **1132** | **Starting method** | **100** | **100** | **100** |
| **1131** | **Noise (db)** | **79** | **79** | **79** |
| **1122** | **Cylinder Cooling** | **100** | **100** | **100** |
| **1121** | **Compression Ratio** | **63.75** | **67.5** | **43.12** |
| **11133** | **Traction control** | **75** | **75** | **75** |
| **11132** | **Fueling** | **95** | **100** | **100** |
| **11131** | **Ignition** | **75** | **100** | **100** |
| **1112** | **% of redline for max torque** | **80** | **50** | **44** |
| **1111** | **Maximum Power** | **56.79** | **100** | **100** |

## LSPNT Cost/Preference Results

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **System** | **Cost** | **Relative importance of high score (w)** | | | | | | | | | | | **Overall** |
| **0%** | **10%** | **20%** | **30%** | **40%** | **50%** | **60%** | **70%** | **80%** | **90%** | **100%** | **score [%]** |
| **WR450F** | **9990** | **100** | **95.5** | **91.21** | **87.1** | **83.19** | **79.44** | **75.87** | **72.46** | **69.2** | **66.09** | **63.11** | **49.74** |
| **CBR600rr** | **11490** | **87** | **87.97** | **89** | **90.05** | **91.11** | **92.18** | **93.27** | **94.37** | **95.48** | **96.6** | **97.74** | **77.02** |
| **Speed Triple R** | **10400** | **96.1** | **96.44** | **96.83** | **97.22** | **97.62** | **98.01** | **98.4** | **98.8** | **99.2** | **99.6** | **100** | **78.81** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Normalized value** | | |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **System** | **Cost** | **Relative importance of high score (w)** | | | | | | | | | | | **Overall** |
| **0%** | **10%** | **20%** | **30%** | **40%** | **50%** | **60%** | **70%** | **80%** | **90%** | **100%** | **score [%]** |
| **WR450F** | **9990** | **100** | **99.02** | **94.19** | **89.59** | **85.22** | **81.06** | **77.1** | **73.34** | **69.76** | **66.35** | **63.11** | **49.74** |
| **CBR600rr** | **11490** | **87** | **91.21** | **91.91** | **92.62** | **93.34** | **94.06** | **94.78** | **95.51** | **96.25** | **96.99** | **97.74** | **77.02** |
| **Speed Triple R** | **10400** | **96.1** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **100** | **78.81** |

# Conclusion

After running the numbers through the LSPNT system, the result is that the Triumph Speed Triple R is the optimal motorcycle for this shareholder. This is due to a variety of reasons, including the Triumph’s reasonable cost, powerband, and seat height. Interestingly, the WR450 got punished badly for its fluid capacities, brakes, seat height, and many other characteristics that make it an unsuitable streetbike, despite having the most suitable engine.

In future experiments with LSP, it would be of value to explore building the criteria tree dynamically for different stakeholders. In this experiment, the target individual is an extremely specific use case, covering only a very small portion of the population. A future system would take in basic physical properties of the motorcyclist, as well as information on the intended usage of the motorcycle. This could take the form of separate aggregator trees for street, racetrack, commuting, and offroad perhaps. Furthermore, the trees would have to be tailored to the characteristics of the rider such as height, weight, gender, inseam, and aggression level to build a suitable criteria tree for that individual.

Within this aggregator tree, there are certain aspects that could be improved as well. Power to weight ratio is an important characteristic of a motorcycle, but is not properly reflected because engine power and weight are not aggregated until the top of the tree. This could be remedied with a separate power to weight ratio aggregator, most likely in the engine system. Perhaps being able to set multiple criteria with the same value would be a useful feature, so that in order to build a system with power, power to weight ratio, and weight, the base values for power and weight would only need to be entered once.

Lastly, the absence of partial absorption aggregators means that this system does not correctly handle optional criteria, such as the presence of a kickstand. This allows the absence of a kickstand to negatively impact the suitability of a motorcycle, when this is not necessarily accurate. This is, however, adequate for relative comparisons of systems.

References

1. Cameron, Kevin. Sportbike Performance Handbook 2nd edition. Minneapolis: Motorbooks, 2008

2. Foale, Tony. Motorcycle Handling and Chassis Design. Spain: Tony Foale, 2002

3. halls.md (for information on average human height/weight)