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Note: Those Sections labeled (*) have an Accompanying AutoCAD drawing.

Section I- Design Concept

When Designing our super mileage vehicle, we had the following Configuration goals:

- Short, Narrow, Lightweight, Aerodynamic Vehicle
- All weight is balanced along the centerline
- Frame allows the placement and mounting of:
  Drive train, Seat, Steering, Fire Extinguisher, Engine, Ballast, Mirrors, and Brakes
- Low Center of gravity
- Good line of vision
- Driver is shielded from moving parts
- Firewall protects driver

The main goals in the design of the body/ frame were to make the vehicle as lightweight and aerodynamic as possible. The 2017 super mileage vehicle is based upon the 2004 and 2012 body styles. However, carbon fiber has been used in the place of all fiberglass materials. This not only reduced the weight of the vehicle, but also increased the strength of the body components.

A plastic honeycomb based encased in the carbon fiver for rigidity replaces the aluminum honeycomb used in the 2004 car and 2012 car. Most of the steering and rear wheel mount supports are molded into the frame/chassis with relative ease.

To ensure driver visibility, a lexan panel is also partially molded into the upper portion of the body. The body then hinges forward approximately 120 degrees to allow the driver to enter the exit. This forms a strong, one-piece back section of the body that us not prone to cracking like the fiberglass body.

The 2004 South Spencer High School Super Mileage Vehicle.

The 2012 South Spencer High school Super Mileage Vehicle.

Section II- Frame/Chassis

We elected to use plastic honeycomb supplied by Nidacore of port St. Lucie, FL, for the frame of the vehicle. However, this was shipped as a 4’ x 12”x3/4’ sheet and was cut to size in the shop. The basic shape will remain the same as the 2004 and 2012 vehicles, which utilized aluminum honeycomb. The new base is encased inside of carbon fiber in an effort to reduce any and all rear end flex and body sway, yet retain a lightweight chassis.

Both the front and rear wheel mount supports are formed onto the chassis to provide for a strong and light weight setup that also reduces the number of mechanical fasteners used. Add-on components can still be bolted to the chassis and are removable to provide complete access to the engine bay. The aluminum steering structure is bolted into the carbon fiber, and the arm will be adhered to the upper body to provider extra stiffness. The engine itself bolts to a raised section of aluminum honeycomb that is affixed with epoxy to the carbon fiber. The ballast weights are also attached to the main chassis via an affixed steel plate that has a steel pipe welded to it and the weights are attached in the same way they adhere to the weight bar.

The front wheel mounts are made of reinforced aluminum. The design utilizes a U-shape with reinforcing brackets to retain most of the structure inside to body and reduce aerodynamic interference. A system of adjustable tie rods connects the steering wheel to the steering joints and allows the setup to be adjusted.

Please note that the throttle and brake controls are mounted on the steering wheel in order to provide the best access to the driver. Therefore, there are no pedals or foot controls. The steering wheel is removable for driver exit, and the flexibility of the brake and throttle lines allow them not to obstruct the driver during exit.

Section III- Body

Aerodynamic drag will be significant force against force acting on our vehicle. Clearly, this makes the body an important component of the car. We have chosen a carbon fiber over thin plastic honeycomb design for this vehicle's body.

Carbon fiber consists of thousands of tiny fibers, which are woven together in a style similar to fiberglass. These fibers have a very high tensile strength and a cloth of these fibers can be draped over a mold, and then hardened using a resin. The resin stiffens the fibers giving them compression strength.

The mold for the body was created using lightweight modeling foam. First, the 2004 body was perfected using wooden strips and aluminum sheet metal to create a more perfect curvature. The body was then scanned using a laser, and the dimensions were entered into a computer. Since no CNC machines are available for the South Spencer, Thermwood Industries of Dale, IN, helped the team create a completely symmetrical design that matched the intended 2004 body dimensions. The digital design was then transferred to a 5-axis computer numerically control machine, the block of foam placed in the machine, and the shape cut out.

The shape of the body was designed to smoothly separate air and then allows it to easily converge at the rear of the vehicle. This will mitigate the vacuum commonly found behind vehicles.

The plastic honeycomb was supplied by Nidacore of southern Florida, as no major supplies of the material existed in the area and the South Spencer School Corporation had no provisions to create such materials. The carbon fiber was formed over the honeycomb by hand, much as the same fiberglass would be created. This created a strong, lightweight, and resilient structure. The whole body structure is created off sight, in Indianapolis, IN.

The design concept, frame/chassis, and body schematics will be very similar. This results from the build of the vehicle being a unibody design. This means that the body, frame, and skin are actually all one component. Therefore, the body cannot be removed from the frame and the skin cannot be removed from the body.

The roll bar and firewall consist of a carbon fire and plastic honeycomb bulkhead that divides the driver compartment from the engine compartment. Three eighths inch thick aluminum reinforces this bulkhead and increases its resistance to fire and heat.

Ventilation is available to the driver and engine compartments. One quarter inch diameter holes have been drilled in the floor of the nose and above the windshield area for driver ventilation. The opening for the rear wheel and the gap around the exhaust exit serve to vent the engine compartment.

Section IV- Engine

The engine itself will gave optional muffler connected to a 2-inch diameter piece of tubing to exit the exhaust gases. An electric blower will be added along with a high flow air-filter to increase the oxygen flow to our engine. Further the intake air will be cooled with ice. This will lower the air temperature and increase its density. Because denser air has more oxygen, we believe this set-up will increase engine power without using extra fuel.

We will not be using a muffler at all. Rather, a straight, two-inch diameter pipe will be used to exit the exhaust gases. The pipe will be used to exit the exhaust gases at the location of the aerodynamic vacuum, but it will also help remove the exhaust gases from the engine.

The rest of the engine will remain basically “stock”. The stock carburetor model number is 9208S-20912 several fans will be used to cool the engine externally. ice will also be used to cool the air around the engine. We believe these actions will keep our engine sat optimum operating temperature.

Note: Vehicle speeds were calculated by performing the following:

$$V = S \times T1/T2 \times C \times 60$$

V= Velocity of the Vehicle (mph)
S= Speed of engine (rpm)
T1= Number of teeth from input sprocket (12)
T2= Number of teeth of output sprocket (100)
C= Circumference of Tire in feet (7.167)
60= Used to convert V to hours
5280= used to convert V to miles

$$V = \frac{1800 \times 12/100 \times 7.167 \times 60}{5280}$$

$$V = 17.59 \text{ mph}$$

Using this equation, we determined the speed that out car would be traveling for various engines speeds. The example above was for an engine speed of 1800 revolutions per minute.

Section V-Drive Train

When designed the car's drive train we wanted to accomplish the following:

- Efficient transfer of power from the engine to the tire.
- A gear ratio that will provide ample power and allow us to achieve a top of around 30 miles per hour.
- A clutch that will allow us to engage and disengage power to the engine.

During the design phase, we considered many different power train options. The basic choices were a pulley system, a gear system with a drive shaft, or a sprocket chain system. Pulleys we discovered through testing of a prototype vehicle and researching, are only around 80% to 85% efficiency. Because maximum efficiency occurs when the chain and sprocket are perfectly aligned, special care will be taken to ensure proper alignment.

A clutch would also be needed to be our drive train. Various clutches are available; however, we decided to use a centrifugal clutch. Thus, our drive train will consist of a 12-tooth sprocket welded to a Centrifugal Clutch. A chain will then connect a 100-tooth sprocket on the rear axle (This will provide a 1 to 8.33 gear ratio). Hence when our engine turns at 1800 revolutions per minute (the minimum torque producing rpm) our car will travel 17.59 miles per hour. At 2200 revolutions per car will be traveling 21.5 miles per hour, and at 3600 rpm we will be traveling at 35.18 mph.

Once again, our car's drive train will have the following characteristics: a centrifugal clutch will be attached to the engines power take off; attached to the clutch will be a 12 tooth sprocket. with the 12-tooth sprocket on the clutch. A- 26- inch bicycle tire will be attached to the rear axle. Spacers will be utilized to perfectly align the rear sprocket with the clutch.

Section VI- Braking System

When designing our braking system, we made the following goals:

- No free running resistance
- The ability to stop out car from 15 mph in less than 36 feet
- Be able to handle high temperatures and wet conditions

Several options are available to stop vehicles using bicycle wheels. Therefore, we will utilize a standard bicycle brake and feel that this system will adequately meet our needs and be the most cost effective. This type of braking system works by forcing a brake pad against the rim of the wheel, creating friction and slowing the vehicle. Another option available to stop vehicles is bicycle disc brakes, which have been chosen because they are light weight and very effective at stopping the vehicle.

The brake features a four-way adjustable brake pad with the ridges specifically designed to sweep water from the wheel (allowing for improved wet braking). Since one set of bakes has proven inadequate, we will utilize two sets of brakes will be wired into a single brake handle that is depressed by the driver during a stop. Testing of this system indicates that our car can stop in less than 15 feet even on a downward grade.

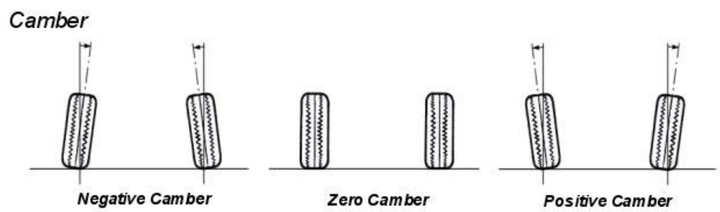
Section VII- Fuel System

The fuel system of the South Spencer Super Mileage vehicle is designed for easy of access and safe transfer of the fuel to the carburetor. The system will utilize the provided fuel tank and sixteen inches of quarter- inch clear gasoline-resistant tubing. Plastic elbows have been installed as needed in order to route the fuel line as preferred.

The positions of the fuel tank also allow for easy removal and reinstallation during the competition. The access to the fuel tank involves a door in the side of the back half of the body. Through testing, we have found that the fuel tank can be changed in this manner in less than thirty seconds. The nature of the design of the access panel and the sealed firewall eliminate the possibility of any driver interference.

It is a custom made carrier that is bolted to the firewall. The tank is retained in the carrier via two hose clamps. The fuel line is attached to the tank spigot with hose clamp. A hose clamp also attaches the fuel line to the carburetor.

Section VIII- Steering System



When designing a steering system, it is necessary to account for the steering geometry. Previously, we used a simple design based on all steering components being assembled parallel or perpendicular to each other. In short, we encountered a lot of problems with this design, particularly when the weight of the driver was applied to the vehicles. So this year we decided to totally redesign our steering system to achieve better performance and handling.

The first geometry we considered was the caster angle. Simply stated, the caster angle is the kingpin plane relationship to the wheel contacting the road or what is referred to as the contact patch. The relationship between the contact patch and the kingpin angle forces the wheels to point inward as the driver’s weight is placed on the wheels. the more angle that is applied to the kingpin, the more force or weight it will take to force the wheels inward. This combination of the angle and force will bring the steering system back to a straight position rather than pointed inward.

We experimented with different caster angles ranging for 4 degrees to 14 degrees. We decided at 6 degrees’ angle would work best on a straight line projection through the center of the kingpin to about 6.35 mm in front of the contact patch. We achieved this by welding the kingpin bracket to the steering frame at 6-degree angle.

The next geometry we considered is the camber angle. Camber is the angle that the wheels make the vertical when they are view from the car’s front or rear. If the wheel is perpendicular to the ground (90 degrees), the camber is neutral. The distance between the top or both wheels will equal the distance between the bottom of both wheels when in neutral positions. When the distance between the top of both wheels are longer than the bottom, the camber is positive.

The important consideration when dealing with camber is choosing the right wheel position to offset side forced when turning. Because the vehicle will be negotiating a relatively large turn radius at an average speed of 15 mph, the concerning forced will be minimal and should not require over-compensating the camber to offset the concerning forces. Therefore, we will use a neutral camber on our vehicle.

Finally, the last part of sheering geometry we considered in the toe. Toe-in is the angular deflection inward of each front wheel as viewed from above, toe-out is the opposite with the front wheels deflecting outward. Tow-inner toe-out used to compensate for the tendency of the front wheels to deviate from parallel when subjected to the forces of moving vehicle. We decided it would be no necessary to toe the wheels in or out due to the lightweight vehicle design, minimal concerning forces, and the slow speed the vehicle will be traveling during competition. Therefore, we will align the front wheels' parallel with each other.

The suspension system was added to, once again, improve the handling of the car. We came up with a simple design that will help absorb road shocks caused by irregularities in the track surface. We also feel the suspension system will improve safety by maintaining better contact between the wheels and the road.

This year it was decided to modify the steering design of our vehicle in an attempt to take off some weight. The previous design of the vehicle was based off of lawn mower steering. This worked but it added a lot of weight. To reduce the weight added to the vehicle because of steering, a dune buggy style steering system was added. This reduced the weight substantially and it also has allowed for smoother steering.

Section IX- Safety

The safety feature on our vehicles are designed to provide adequate protection for our driver. When designing out car, we included all of the required safety items. The outside toggle kill switch will be mounted on the top of our car in the bright yellow square markings for easy accessibility in times of emergency. The inside toggle kill switch will be located on the steering wheel for easy access for our driver.

We will mount a multi-purpose fire extinguisher, shown at left, in our car. The extinguisher will discharge 2.5 pounds of dry chemical 10 to 15 feet in 8 to 10 seconds. The fire extinguisher will be mounted against the firewall next to the driver. The fire extinguisher's nasal will protrude into the engine compartment. A small aluminum shroud will direct the fire extinguisher spray over the engine and fuel systems. By crossing the arms, the driver will be able to easily activate the fire extinguisher. During testing, this system easily extinguished a small fire in the rear of the vehicle.

The driver will be able to exit the vehicle by lifting up the front half of the vehicle. The windshield will also fold forward in case of emergency. The emergency escape system will allow the driver to easily escape the car by simply pushing up on the windshield, thus enabling the driver to exit in less than 15 seconds.

The exhaust system is designed so as to vent the exhaust fumes from the engine outside of the car. This will be accomplished by extending a pipe from the muffler to the outside of the car. The engine compartment will also be vented to provide air for combustion. Additionally, a ventilation system will be added to the cockpit. Small holes will be created in front of the driver to allow the entrance of air into the car. Such a system will create a flow through ventilation system for the driver.

Bicycle mirrors will be utilized on both sides of the car to allow for maximum visibility for the driver. The bicycle mirrors will be firmly attached to the car. They will be adjustable from the outside of the car. Large mirrors with a surface are of seven square inches will be used.

The firewall will be .75-inch thick aluminum honeycomb material coated in carbon fiber. This material is further reinforced by a 0.25-inch thick aluminum plate. We will use this sturdier material because it will not only protect our driver from the hazards of the engine and drive train, but the fire extinguisher and gas tank will be mounted on the firewall. The firewall structure will also act as a roll bar to protect the driver in the event of a rollover. Three kill switches will be mounted around the vehicle. One will be located on the steering wheel. Two additional kill switches will be mounted on the body (one on each half of the body).

Further safety features include the use of guards to protect the driver from moving steering components, helmets, and all wires and components will be securely fastened to the vehicle. All ballast weights will be contained on a steel pipe welded to a plate on the chassis. A fluid collection system will be utilized to safety collect all flammable liquids that could leak. Finally, a large front windshield will be utilized to provide an excellent line of vision for the driver.

Section X- Driver Egress

A conscious driver would be able to simply push the windshield away from the attachment points to exit the vehicle. The windshield is adequately secured via Velcro. Taller drivers can also remove the steering wheel by pulling out the attachment pin that holds the steering wheel in place. The seat beat is a single release cam lock system that allows all drivers to remove the harness quickly.

In the event of an unconscious driver, three crew members would be utilized to extract the driver. All three would stop the vehicle if it is in motion. One would then remove the windshield and secondly hit the kill switch if the vehicle was still running. The other two crew members would unbuckle the driver and lift the driver from the vehicle.

Section XI- Drivers

- Main driver: Kyle Feldmeier, 18, driver is currently above minimum weight at 155 lbs.

- Alternate driver: Austin Spinks,18, driver is currently above minimum weight at 155 lbs.

- The weight is to be achieved by adding on ballast weights.

Section XII- Team Members

- Kyle Feldmeier- Driver- 18
- Austin Spinks – Alternate driver – 18
- Leah Kirkpatrick- Secretary 19
- James Turner- 18
- Colin Buse- 18
- Jake Epperson- 17
- Brett Tooley- 18

Section XIII - Cost Estimate

Description	Quantity	Cost	Total
Engine/Fuel			
Exhaust pipe (18 in)	1	$4.50	$4.50
Exhaust pipe adaptors	3	$3.75	$11.25
Fuel line (3ft.)	3	$1.85	$5.55
Brake Costs			
Brake Levers	1	$0.00	$0.00
Brakes	1	$15.00	$15.00
2nd Brake	1	$19.00	$19.00
Brake Pads	2	$6.75	$13.50
Brake cable (6ft)	3	$3.50	$10.50
Body Costs			
Sand paper	10	$5.00	$50.00
Styrofoam	10 sheets	$14.00	$140.00
Joint Compound	6 – 5 gallon buckets	$11.00	$66.00
Paint Brushes	2	$1.00	$2.00
Carbon Fiber(Materials/Labor)			$11,000
Power Train Costs			
Clutch	3	$28.75	$86.25
Chain	1	$28.00	$28.00
Sprocket	1	$35.00	$35.00
Safety Item Costs			
Mirrors	2	$9.00	$18.00
Kill switches	4	$3.00	$12.00
Fire extinguisher	1	$28.00	$28.00
Miscellaneous			
Speedometer	1	$35.00	$35.00
1/16 in. Lexan	3 sheets	$20.00	$60.00
1/32 in. Lexan	1 sheet	$80.00	$80.00
Oil	4 quarts	$2.00	$8.00
Gas	2 gallons	$1.75	$3.50
Chain Lubricant	1 can	$5.75	$5.75
Electrical wire	4 ft.	$1.25/ft.	$5.00
Solder	1 role	$2.50	$2.50
Washers	40	$0.05	$2.00
Velcro	1 package	$10.00	$10.00
Assorted Bolts	75	$0.25	$18.75
Glue	1	$1.50	$1.50
Locknuts	100	$0.10	$10.00
Rivets	6 packages	$3.25	$19.50
Hex bolts	15	$0.50	$7.50

Camera	1	$40.00	$40.00
Video Monitor	1	$1100.00	$1100.00
Aluminum sheet metal	1 role	$11.00	$11.00
	40 in	$6.50	$6.50
Cooling Fans	4	$6.50	$6.50
Machine Work	50 hours	$25/hour	$1,250.00
Steering Costs			
Wheels	3	$300.00	$900.00
Steering Linkages	1	$40.00	$40.00
Tie rod ends	2 sets (4)	$8.00	$16.00
Tire tubes	5	$10.00	$50.00
Air hose connection	1	$0.94	$0.94
Continental Tires	3	$54.00	$162.00
Office Supplies/Publicity			
Linen Paper	1	$22.00	$22.00
Binder Rings	1	$7.50	$7.50
Tape	10	$1.00	$10.00
Labels	1	$3.00	$3.00
Stamps	50	$0.37	$18.50
Envelopes	20	$0.50	$10.00
Parade Banners	2	$100.00	$200.00
Travel Expenses			
Hotel Expenses	4 rooms, 2 nights	$60	$480.00
Hotel Expenses	4 rooms, 1 night	$75	$300.00
Food Expenses	8 meals, 8 people	$7.00	$448.00
Total Cost			**$5931.74**
Sponsors	**Donations**		**Total**
Grandview Aluminum Products	$100.00 Materials, welding		$100.00
Wagoner, Ayer, Hargis, and Rudisill, LLC	$50		$50.00
Dawson Machine Shop	Services		
AEP	$5,000.00		$5,000.00
Alcoa	$275.00		$275.00
GD Ritzy’s	$300.00		$300.00
Obermeiers	$100.00 credit		$100.00
ATTC manufacturing	$250.00		$250.00
Angelo’s	$100.00		$100.00
Martin-Serrin Insurance	$101.00		$101.00
Spencer County Journal Democrat	Quarter page ad		$0.00
Total:			**$6,276.00**

Section IX- Additional Information

Here at the South Spencer Motorsports we do tons of interesting things to get the students and the community interested in our program. Our Motorsports Team does not just consist of Super Mileage, we added in Formal One where the members build a vehicle for speed and performance. Secondly, we added in Robotics, where the members design, build, program, and operate robots of their own design to play a floor game in an alliance format. Lastly, we added in the STEM Challenge, which consist of eight different, hands-on, quiz bowl style competitions. We do this to get more student involved into our program, and having four different categories into our Motorsports helps us to find students with the talent, some may be interested in Super Mileage; but may not have the talent or ability to do the things for that specific program. This is one thing that sets us apart from other teams, we try and get different types of students involved. Having Motorsport and Super Mileage together is not the only thing that sets us apart; we also have an Apple Fest (local fall fest), where we set up our information and take the Super Mileage car to let people check it out and ask questions. It is a great way to get people interested. In previous years we have had our Super Mileage car participate in the Annual Grandview Parade to let the community check out what the car looks like. Our Elementary schools like to have a Science fair/ Open House consisting of many different things, during this event we take the vehicle for the kids and parents to check it out, and get some of the younger students interested in being in the program. Lastly, at our local Champion Ford Dealership, you can test drive a car on one of the selected cars to help us raise money for our Motorsports Program.

Throughout the years we have done many improvements and achieved many different things. Such as; multiple top three awards in Super Mileage, numerous Super Mileage Craftsmanship Awards, qualifying for the finals each year of the First Tech Challenge, and even the most unique vehicle in the Grandview Car Show. But what we are most proud of is, how well we have made the durability on the vehicle, we have improved on this a lot throughout the years. The team has designed a vehicle that is capable of standing the impacts of competitions.