TEAM VORTEX

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NAPA AUTO PARTS

Table of Contents

Meet the Team

From Left to Right: Taylor Schoenborn, Sam DeVillers, Eric Simon, Hayden McDonald, Josh Voigt, and Jordan Walsh (In Car)

- **Hayden McDonald:** Senior
  - Has completed IED (Intro to Engineering and Design) and Machine Tool.
- **Eric Simon:** Senior
  - Has completed IED, AED (Advanced Engineering a Design), and this is his second year of EDD (Engineering Design and Development).
- **Josh Voigt:** Junior
  - Has completed IED, R&D (Research and Development), and is currently in AED.
- **Jordan Walsh:** Senior
  - Has completed Welding.
- **Taylor Schoenborn:** Senior
  - Has completed IED and is currently in AED.
- **Sam DeVillers:** Senior
  - Has completed IED in preparation for this class

About Formula High School

Formula High School is the creation of Jeremie Meyer (Green Bay Preble High School) and Mike Besel (West DePere High School). The Formula High School program allows students to create a replica race car in 8 months and test it on the track. The model race car is created based off the original Mysterian formula race car created by Sugar Grove Custom Cars. In the Formula High School program, students are given a 3D model of the basic chassis to ensure safety specifications are met, but students create the rest of the vehicle by themselves. This program teaches students manufacturing and engineering techniques to create a car in the allotted time. Since the cars are sponsored, the program gives the students a real life scenario of a dead line which must be met. After the cars are complete the students are given the opportunity to test drive them at Road America in Elkhart Lake, WI.

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Parts List

Part Description	Manufacturer	Model Number	Cost	Qty Needed	Total Cost
Master Cylinder Assembly	California Import Parts	VWC-113-611-015-BH	$39.95	1	$39.95
Brake Fluid Reservoir	California Import Parts	VWC-113-611-301-L	$5.50	1	$5.50
Thrust Washer	California Import Parts	VWC-111-405-661	$1.75	2	$3.50
Ball Joint Eccentric	California Import Parts	VWC-131-498-319	$28.45	1	$28.45
Upper Ball Joint	California Import Parts	VWC-131-405-361-F	$12.95	2	$25.90
Lower Ball Joint	California Import Parts	VWC-131-405-371-G	$12.95	2	$25.90
Disk Brake Conversion Kit Blank Rotors	California Import Parts	ACC-C10-4121	$329.95	1	$329.95
Disk Brake Caliper Used for rear axle	California Import Parts	C13-98-1150-B	$55.21	1	$55.21
Front Brake Rubber Hose	California Import Parts	VWC-311-611-701-B	$9.45	2	$18.90
Wheel Bearing Clamp Nut - Left	California Import Parts	VWC-131-405-669	$5.50	1	$5.50
Wheel Bearing Clamp Nut - Right	California Import Parts	VWC-131-405-670	$5.50	1	$5.50
Dust Cap	California Import Parts	VWC-111-405-692-B	$2.75	2	$5.50
U Joint for Rack and Pinion	California Import Parts	C26-425-160	$24.95	1	$24.95
Splined Shaft for U-Joint	California Import Parts	C26-425-164	$8.50	1	$8.50
Universal Chrome Steering Shaft	California Import Parts	C26-425-011	$32.95	1	$32.95
Chrome Steering Bearing	California Import Parts	C26-425-013	$12.95	1	$12.95
14" Rack and Pinion	California Import Parts	C26-425-150	$99.95	1	$99.95
Quick Release Steering Wheel Hub	California Import Parts	C26-415-100	$16.95	1	$16.95
Brake Hub for 1 1/4" Axle	BMI Karts	600503	$14.95	1	$14.95
Sprocket Hub - 1 1/4" Axle	BMI Karts	600243	$28.95	1	$28.95

35 Series Split Sprocket	BMI Karts	6053**	$14.86	1	$14.86
35 Series RLV Extreme Chain	BMI Karts	400635GG	$14.95	1	$14.95
Steering Wheel 10" DIA	BMI Karts	410200	$21.99	1	$21.99
1 1/4"" Tubular Steel Axle Bearing Mount Kit	BMI Karts	400415	$24.95	2	$49.90
44" 1 1/4"" Tubular Chrome Moly Axle	BMI Karts	601444	$43.50	1	$43.50
35 Series RLV Extreme Chain	Fleet Farm		$10.00	1	$10.00
13 x 6 Steel Wheels 2.5" BS 4 holes on 4" BC	Bassett Racing Wheels		$49.00	4	$196.00
Sumitomo HTR 200 175/50-13	Tire Rack		$47.00	2	$94.00
Sumitomo HTR 200 205/60-13	Tire Rack		$54.00	2	$108.00
Formula High School Fiberglass Body Shell	Fiberglass Solutions	Price to be finalized late 2009	$350.00	1	$350.00
Clutch with 12 tooth Clutch Drum	600 Racing		$159.98	1	$159.98
16 HP Briggs V-Twin Engine With Shipping	Wisconsin Magneto		$958.23	1	$958.23
1 1/2" Square Tubing 11 ga 40 feet	SI Metals		$1.47	40	$58.80
1 1/2" Round Tubing 13 ga 20 feet	SI Metals		$1.66	20	$33.20
1" Round Tubing 13 ga 40 feet	SI Metals		$1.19	60	$71.40
RCI Aluminum Fuel Cell	Summit Racing	RCI-2010A	$89.95	1	$89.95
R.J.S. Racing 5 Way Harness	Summit Racing	50502-18-23	$59.95	1	$59.95
Drive Hub 1 1/4" Axle 4 on 4" BC 1/2" Studs and Lug Nuts	Jegs.com	056-9030	$25.99	2	$51.98
					$3,176.60

Rules and Regulations

All Formula High School vehicles are to be completed before all track events.
Absolutely NO fabrication will be allowed at the track events.
FHS officials reserve the right to disqualify a team if the officials believe there is a safety hazard present on the team's vehicle.

Overall Sizes:
Wheelbase: 81" – 87" measured from center of front spindle axle to center of rear axle.
Width: 52" to 58" measured to the outside edge of the mounted tire.
Max Overall Length: 144" including body shell.
Ground Clearance: 2" MIN – 6" MAX

Vehicles not within these measurements will not be allowed to compete, even as an exhibition. Vehicle widths and wheelbases are set to ensure a safe and stable vehicle for the track day events. Specifications must be followed. **There will be no exceptions.**

Chassis: All teams must use the supplied chassis model as the base for their vehicle. Chassis MUST be constructed to the chassis model within 1" of specifications. All frame members shown on the model must be present in the completed chassis.

Roll Bar Tubing: 1 ½" round mild steel tubing, 0.083" (14ga) wall thickness. Roll bar tubing must be a single continuous piece. NO SPLICING ALLOWED.

Bracing: 1" round mild steel tubing, 0.083" (14ga) wall thickness.

Floor: .0747" (14 ga) mild steel sheet, stitch welded to the bottom frame rails. The minimum weld stitch pitch should be no more than 1-3.

Body Shell: Teams must use an approved FHS fiberglass body shell. If a team chooses to use an alternate body shell, that team must submit approval directly to FHS officials. The only approved body shell materials are: fiberglass, Kevlar, carbon fiber or 0.032" aluminum sheet. Aluminum must either be polished or painted.

Appearance: All FHS vehicles must be painted, gel coated, or powder coated with school and sponsor decals appropriately placed. Bare metal frames will not be allowed.

Firewall: .032" or thicker aluminum sheet must be used for a firewall between the driver and the engine compartment. Teams must try to make all reasonable efforts to fully seal the driver's compartment from the engine compartment.

Safety Harness: All teams must use a 5-point safety harness, installed to safety harness manufacturer's specifications. Harnesses certification stickers must be within five years of event date

Engine: Briggs & Stratton 16 HP Vanguard V-twin ONLY. To further clarify, we are accepting engines in the 3034xx and 305xx (horizontal) and the 3037xx and 3057xx (vertical) model line. Provided the engine is designated as a 30 cubic inch, OHV, "V-twin" engine that is rated at 16hp, and falls in the range listed above, it will be accepted. No other engine will be allowed. NO power adders or modifications to the engine allowed, except for wiring extensions, throttle and choke connections. Engine must have a throttle return spring attached directly to the throttle shaft arm. Governor may be removed/disconnected. See suggestions in regards to RPM limit.

Kill Switch: Two paddle type kill switches are required. One switch shall be located in easy reach of the driver and labeled appropriately. The second switch shall be located on the left side of the rear roll bar but above the body shell. This location is shown on the chassis model. The switch will be marked with a red vinyl or painted 3" equilateral triangle and labeled appropriately. Both switches must be demonstrated to effectively shut off the engine.

Fuel system: Teams may relocate the stock Briggs and Stratton vacuum fuel pump to allow proper fuel supply to the pump. NO electric fuel pumps. Fuel tanks/cells must be commercially available, designed for fuel use and installed to manufacturers specifications.

Exhaust: Exhaust outlet(s) must extend past the body shell by a minimum of 1".

Transmission: Centrifugal clutch with a single overall gear ratio. No CVT or multiple gear transmissions allowed.

Overall Gear Ratio: Open. Teams are allowed to gear for various track configurations.

Tires: DOT rated tires. No racing slicks or trailer tires allowed.
Overall tire diameter: 24" maximum
Suggested tires sizes: Front: 175/50-13 Rear: 205/60-13
Rim: 13 x 6 steel rim, 2.5" back spacing suggested

Front Spindles: All teams must use standard VW Beetle spindles, ball joints, eccentric adjusters, rotors and disk brake calipers. No modifications allowed to these parts.

Rear Brake: All teams must utilize a standard VW Beetle brake caliper, actuating a single brake rotor keyed or splined to the rear axle. At least one rear tire must transmit braking power to the ground. This caliper will also be on a separate hydraulic circuit from the front brakes.

Rear Axle: Solid axle only. No independent rear suspensions allowed.
Minimum Axle Diameter: 1 ¼"

Steering: Rack and Pinion ONLY, no go-kart steering allowed.

Steering Wheel: Steering wheel must be either a continuous round or "D" shaped wheel. No butterfly style steering wheels allowed.

Minimum Tie Rod Diameter: ¾"

Driver Safety: All drivers must use the following safety equipment:

- DOT or Snell rated full-face helmet, manufactured within 5 years of event date
- Neck collar
- Closed toe shoes
- Long pants
- Long sleeve shirt/jacket
- Gloves
- Impact rated eye protection, minimum rating of Z87.

No sweats pants or windbreaker pants allowed.

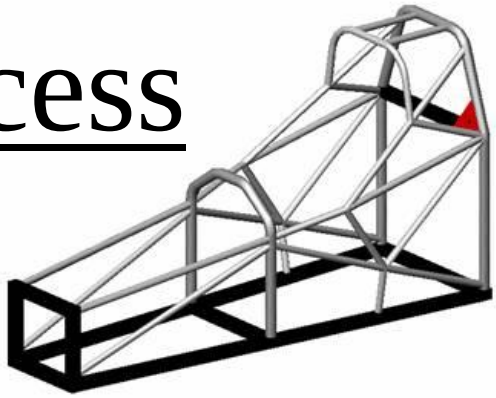
Safety Glasses: All team members must be wearing safety glasses when actively participating in repair or adjustments to the team vehicle.

Overall Rule of Conduct: Students must present themselves in a professional manner. Teams will be disqualified and removed from the track in any team member does not follow directions from the officials.

SUGGESTIONS: Rear axle bearings should be placed as close to the inner side of the wheel hub as possible to limit axle bending/twisting. Some teams have run up to a total of four bearings across the rear axle.

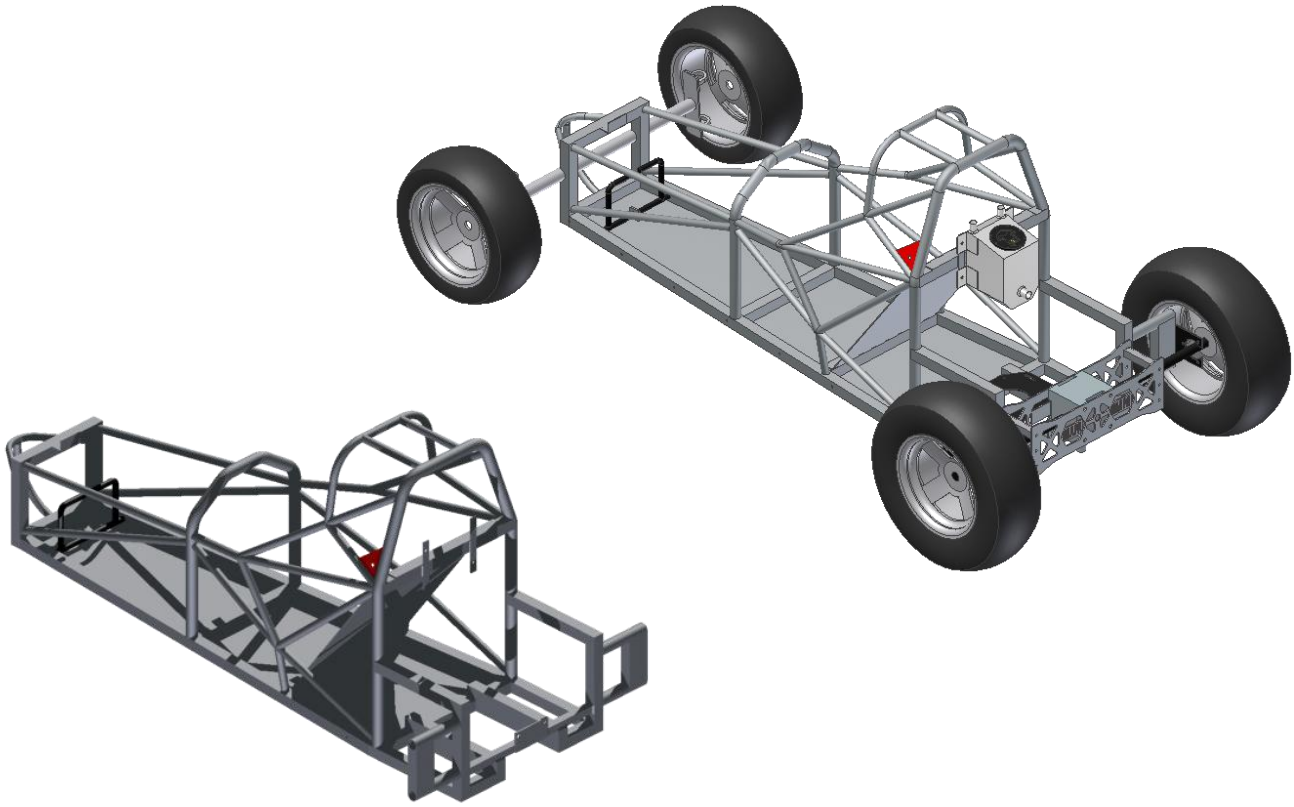
- Chrome Moly Steel axles suggested. Low quality axles have bent under load.
- Gear ratios: A good rule of thumb is to start with an overall gear ratio of 8:1 and then gear for the existing track conditions and individual vehicle response.
- Chain tensioning devices: Use a sliding engine base set-up to adjust chain tension. There was a much higher incidence of thrown chains when using idler sprocket assemblies.
- Install shaft collars on both sides of the rear hub assemblies. This is extra insurance to keep the hubs in place on the axle.
- Fasteners: Teams should try to use at least grade 5 or higher fasteners, with nylock nuts, when possible.
- Standard Formula High School wheel: Bolt pattern: 4 on 4"B.C., 2.5" back spacing.
- Exhaust: Teams have run both open pipes and mufflers. The engines seem to work the best with some type of muffler. Individual team chassis dyno testing is suggested.
- RPM: Engines should be limited to 4500 RPM. Teams run a risk a valve float above that RPM.

Design Process



September 5th, 2009

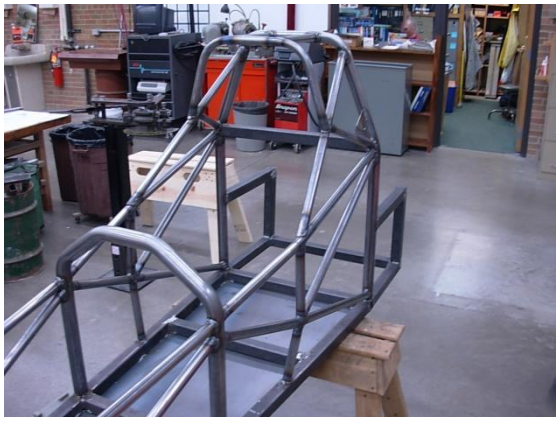
On the first day of school we were given a basic chassis design. This design was given to us for safety reasons. Since there were safety concerns, no team was allowed to modify the chassis in any way. We were required to create the basic car design using Autodesk Inventor before we were allowed to start construction on the car. It was up to our team to engineer the rest of the vehicle. This included the front end assembly and the rear end of the chassis. After we completed the CAD drawing of the car we were allowed to start construction on the vehicle.



Construction- Basic Chassis

After we completed the CAD model of the car we started to build the chassis. We started the chassis build by cutting the steel and creating the front square. After welding the front square, we noticed that the steel was welded at weird angles giving the piece a teeter totter effect. Due to the mess up we were set back a day or two on the build. We later remade the square, which allowed us to create the bottom frame of the chassis. With the bottom complete, we installed the roll bars and started to make the side bars. After we finished installing the side bars and the back roll bar of the chassis, we went to Northeast Wisconsin Technical College (NWTC) to use their water jet to cut out the floor for our car. After we cut out the floor, Jordan stitch welded the floor to the bottom of the chassis. With that complete we started on the halo bar. To create the halo we used the tube bender and the mill. The halo took us 3 tries to get it right (it was the hardest piece to build on the basic chassis). With the installation of the halo the basic chassis was complete.

The chassis with the front square, roll bars, back brace, and side bars installed.

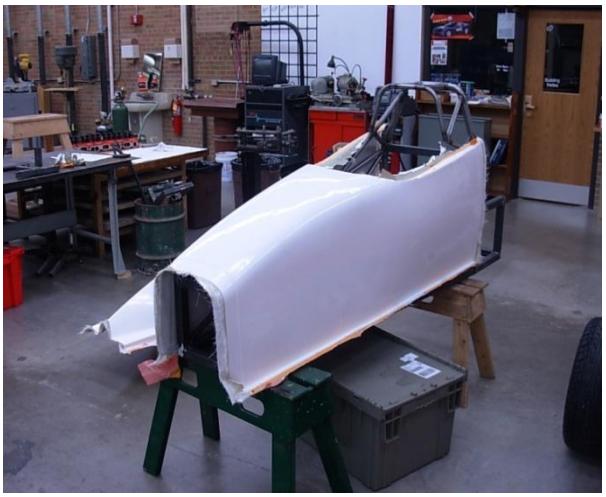


This is the completed chassis with the installation of the halo and the floor.

Kill switch plate

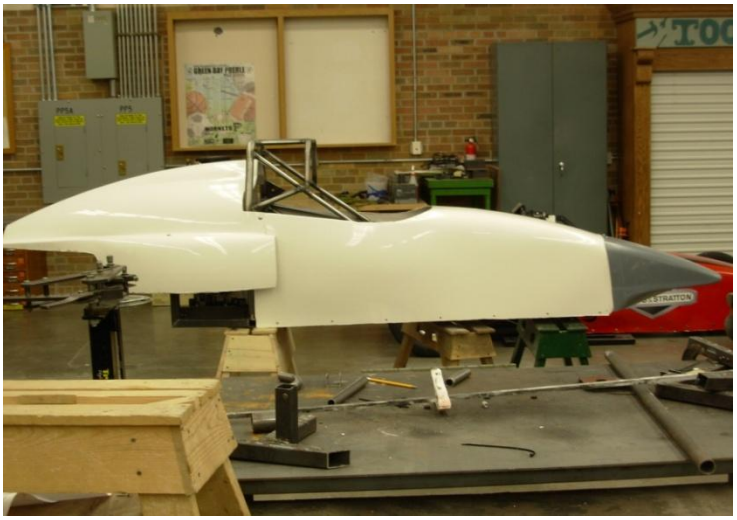
Construction- Fiberglass

On October 13, 2009, team Vortex went to Fiberglass Solutions to lay up the body for the car. In one afternoon we were able to get the body cover, tail cone, and the nose cone completed with the help of Mr. Glowacki (Owner of Fiberglass Solutions) and Mr. Meyer. Three days after we laid up the body, we picked up the fiberglass and have been busy cutting the body to get rid of the excess fiberglass. The trimming of the fiberglass took a lot of time and patience to get it just right. Once the fiberglass was trimmed, we made our mounts and mounted it fully to the frame.



Body shell the first day it came back from Fiberglass Solutions.

Taylor and Jordan trimming the body shell.



The body completely mounted to the chassis.

Construction- Front End

After the completion of the basic chassis we started to create the front end of the car. The creation of the front axle was the first thing we did. We cut the tube to the correct length at a 5 degree angle on each side. The angle was cut to compensate for the offset of the spindles. We then milled out two slots on the axle to inset it on the chassis to give us a surface to fully weld the axle to the chassis. With the axle done we made the brackets for the ball joints. We then pressed in the ball joints. After the ball joints were assembled, we made plates to hold the brackets for the ball joints and welded them on the axle. With the installation of the of the ball joints we found out where the axle had to go and welded it to the chassis. With the axle on, we put the spindles in place and put on the tires. The completion of the spindle assembly allowed us to create the steering system for the car. With the steering complete, we created the pedals for the car. The pedals were 1" round tubing with a 90 degree bend. The pedals were round tubing to allow the pedal to slide with your foot. With this completed the front end assembly was finished.

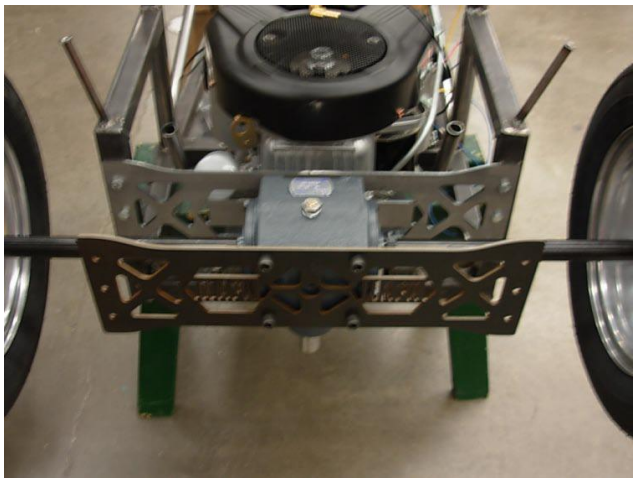
Spindle and Ball Joints

Front End Assembly

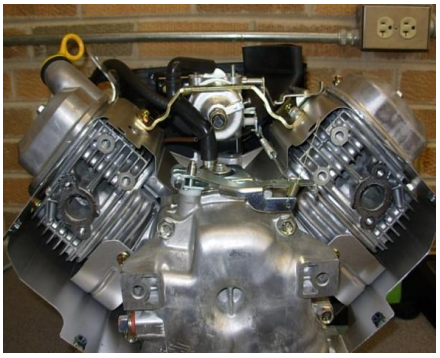
Front End Assembly on the Car

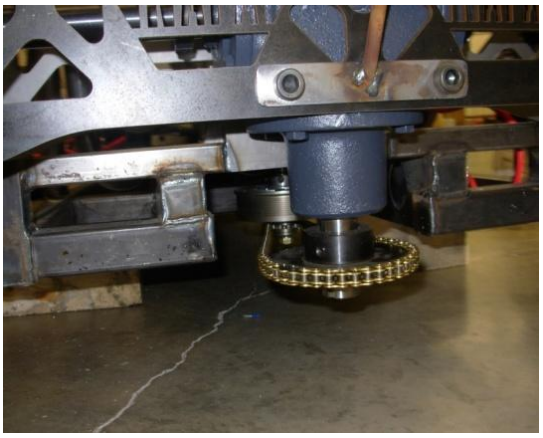
Construction- Rear End

After the front end was complete we started construction on the rear end of the car. The first thing we did to create the rear end was cut the tubing to hold the engine. After the tubing was cut we welded it to the chassis. We then created the engine mount that is movable (to correct chain tension). Once the engine was mounted we created the exhaust with 1" round tubing. The exhaust was complex so we made it in three separate parts joined with flanges. Since the engines are vertical shaft, we had to install a gear box for the rear end. Since we had to have a gear box we had to attach it to the chassis somehow. We came up with a gear box cage to hold the gear box to the chassis with six bolts. The box consisted of two custom plates and 1" tubing to hold it together. With the gear box mounted we created two side mounts for the bearings. We put the bearings as far out on the axle for the greatest stability of the rear end assembly. With that complete, we created a rear disc brake and mounted the rear caliper. With the brake installed, we placed the clutch on the engine and the sprocket on the gear box. With the sprocket and clutch on we joined the two with the chain. With the chain in installed, the car was mocked up and ready for a test drive.



Construction Pictures

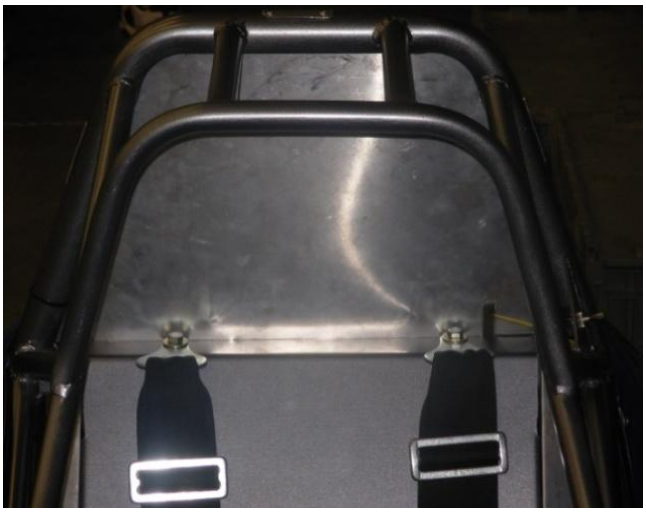




Paint and Reassembly

After the car was constructed, we completely disassembled it and sent it off to have it painted. The chassis went to Renco and the fiberglass body went to NWTC. As for the smaller pieces, we painted those ourselves. One week after the pieces went out, they came back looking great. We took the next three days to reassemble the car. With the car back together we had only one project left to do, the firewall. We started the firewall by laying out the shapes with tag board. After the templates were complete we traced and cut the aluminum to the correct shapes. With the firewall cut we installed it with rivets. The firewall was complete on April 1st, 2010 (Due date of the vehicles) which completed the construction of our formula high school race car.

The car with the painted fiberglass attached to the chassis (Missing vinyl stickers and logos)



Installation of the firewall completing the construction of the car.

Completion of the Car

With the construction of the car complete, the next thing we did was put the logos on the car. This wasn't very hard but it took a little patience to get all of the air bubbles out from under the vinyl. The addition of the decals concluded the construction of the Formula High School car of 2010. A few weeks later we took the car to the NWTC Tech Challenge on April 22nd, 2010. The car took Star First in the Prototype competition.

Race Day- April 25th, 2010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