Covenant Christian Academy 2017
Solar Car Team

THE POWER OF TEAMWORK

CCA Solar Car
The Solar Express

Jake* Morgan*

Kaya* Jake* Issac

* Steven* Tyler
First team meeting, on January 32nd, included introductions, reading overview of Solar Car Challenge rules and requirements, and setting expectations and receiving assignments.

CCA 2017 Solar Car Team:
Jake Caraway, Morgan Caraway, Jake Eudaly, Kaya Lane, Issac Fuller, Steven Roe, and Tyler Tarkington. sponsored by Shannon Caraway.
Our Solar Car Design Schematics:

Covenant Christian Academy Mechanical Drawing

Front View

Side View

Top View
First thing’s first. Lessons in welding for everyone. Mr. Mark Rose generously offered use of his workshop to the CCA solar car club kids.

February 25
Issac practices welding.

February 25
Jake practices MIG & TIG welding, although he had some prior experience with arc welding.

February 25
Morgan learns MIG and TIG welding as well.

February 25
Shannon learns to MIG & TIG welding. Over 30 years earlier, his father had taught him to arc weld very in shop class in high school.
Issac picks up welding quickly, with a steady hand. As a Senior, he may be ready to begin tacking the frame soon.

February 25
Everyone had the chance to use the band saw to cut the metal tubing into pieces for our frame.

March 4
Next, we had the opportunity to test our welding skills.

March 4
First, we tacked the metal tubing together.

Once we had the fit established correctly, we welded it all together.

March 4
We created the roll bar using a pipe bender and slowly bent the bar into the desired shape, using a cardboard template.

March 11
Tyler and Jake practice welding.
March 11

We use the tube bender to shape the roll bar and continue welding practice.
Issac and Steven continue welding the frame.
Steven and Jake continue to practice their welding and then weld the frame together.

March 11
Stephen, Kaya, and Morgan practice welding.

March 12
Morgan and Kaya test out the roll bar clearance around the driver. Everyone can sit in the vehicle and stretch out their legs.

March 13
March 18

Morgan and Jake are drilling some of the suspension attachments...
March 18

Jake and Tyler grind the edges of the frame smooth.
The team builds and paints the floor and battery box, and installs a temporary seat.
April 1

Securing the floor & checking panel fit. Next step...adding solar panels.
Steven, Morgan, Jake, Issac, and Jake E test the framed car.

April
Steven welds attachments in preparation for solar panels.
Issac creates the double wishbone front suspension from 1" pipe on the pipe bending machine.
Jake and Tyler continue to grind the welds on the frame and prepare for suspension installation.
Steven, Morgan, and Jake install the suspension.

April 15
Issac is welding the attachment points for the rack and pinion mount.

April 20
Jake and Steven are assembling the braking system.  

April 29
Stephen and Jake E are grinding more of the frame welds until smooth.
Mr. Mark shows Steven how the lathe works.

May 6
Jake is grinding frame, welds smooth.

May 7
Jake is grinding the frame welds smooth, which is a big job.
Kaya is grinding the frame welds smooth.

May 7
Jake is adding the steering wheel and testing out the steering system. We have ability to turn the wheels!

May 7
Issac and Jake install the springs for the suspension. Of course Jake has to test it out!

May 13
Jake and Shannon are mounting the Solar Panels!

May 20
Solar Panels are being installed on the car.

May 20
Morgan finishing mounting the Solar Panels.

May 21
Morgan and Kaya team up to grind the welds smooth on the rear suspension mount.
Issac and Jake start adding the side panels to the frame... Now it is starting to look more like the car we envisioned!
The team is encouraged that it is starting to really look like a solar car; however, there is still a significant amount of electrical work still to be done.
Jake and Morgan gave Kaya the first ride in the car. If their names were Solar, it would be "Solar Powered"!
Shannon and Jake spend Memorial Day disassembling and painting the frame.

May 29
Jake is working on the motor mount.

Mark shows the team how to create a simple mold for a fiberglass nose cone.

June 3 and 4
June 7

Kaya and her father, Rob are assembling the 48 volt electrical cables from 1/0 welding cable, applying the copper lugs for terminations, and applying shrink wrap to the ends.
Morgan and Jake continue the process of making the 48 volt, I/O cables. The Solar Express contains approximately 40' of 48 volt main power cables and there are numerous individual cables due to all the required switching and protection devices.
Issac, Steven, and Kaya create and install the dashboard.

June 10
Kaya installs the solar charge controller.

June 10
Morgan and Kaya apply fiberglass to the nose cone frame and sand it smooth.

Aesthetics and aerodynamics? Work with what you’ve got.

June 11 & 14
The 48 volt electric system is starting to come together! It’s alive!

June 14
Issac, Jake, & Tyler finish up the electrical and install the drive system.
Jake attempts to take the car out for a spin, before half the team goes to Zambia on a 2 week mission trip.
June 17
Jake and Mr. Caramay drill the revised mounting holes for the rear suspension.
Kaya hooks up the battery fan and charge controller.

Jake identifies buttons with labels and creates a water bottle holder.

July 9-10
Mr. Caraway & Mr. Rose cut our windshield design out of plexiglass. Then, we carefully installed the windshield.

The finished nose cone from our mold is looking quite nice!

July 11
Jake installed the new seat with headrest and seat belts & cup holder.

No, it's not time to apply the graphics yet!
Jake, Kaya, & Morgan test drive the finished car. Over the next few days, we only had time to accumulate about 15 miles of testing vs the 500 miles suggested by the Solar Car Challenge organization.
On Saturday, the team attended final registration, and meetings on Pre-race Orientation, Safety, Driving Etiquette / Rules, Spotting, Radio Operation, & Information Analysis, removal of disabled cars from the track, Scrutineering, judges, and other expectations.
All drivers must have a valid driver’s license. Oops! Our oldest had a birthday. Half the drivers just received their license within the last month.
Included in the registration documents were team Info, vehicle info, mechanical drawings, electrical drawings, team photo, manufacturer's data for the propulsion system, batteries, manufacturer's data for the solar cells, and manufacturer data for motor, controller, main fuse, disconnect switches, braking system, & wheels.
July 16: Day 2

We arrive with the car, and a few tools, noticing that every other team has ice chests, chairs, tool boxes, & replacement parts. Team mom, Tanya, picks up necessary basics, while the team assesses the car to prepare for scrutineering. At least they look like they have it all together in those handsome team polo shirts and matching shorts and hats from Ivy School Uniforms.
Scutineering
Station 3: Tilt
and Turning Radius
Checks -

The judge tried to
check stability by
trying to tilt to 20
degrees, with Kaya
inside. She first
instructed the jack be
placed on the wood
floor, until Shannon
requested that she
use the metal frame.
Practice for racing
on 2 wheels!
Every time the vehicle left the garage, safety flaggers waved flags and guided the driver.

July 16: Day 2
Station 1: General Scrutineering - Documentation, Vehicle Size, Roll Cage, Roll Bar, Crush Zones, Vehicle Points, Driver Conditions, & Student Involvement.

July 16: Day 2

Judges said the car was 18cm too long. This was a result of our aerodynamic nose cone being an "as built" modification that was not included in the original design measurements that complied with the dimension limits of the race rules. So we had to pivot to shorter, less aerodynamic nose cone.
Oval Presentations...worth an additional 4 laps in the final race. CCA prepared us well.
Morgan wrote the presentation, but everyone was required to participate.

Catching The Vision (Bill Eichler & Tele Sales)
- Our team gained respect from our peers and we realized that we were part of something bigger than ourselves.
- We learned the importance of teamwork and collaboration to achieve our goals.
- Worked closely with our mentor to ensure that we were on the right track.
- Appreciated the time and effort put into our project by our mentors.

Mechanical Drawings
- We gained an understanding of the mechanical aspects of the car.
  - Key components such as the engine, transmission, and suspension.
  - Diagrams showing the assembly and parts.

Final Draft - Signature Wax Indu-Bly Blank
- Our final draft was submitted and approved.

Getting Our Footing & Building On A Solid Foundation
- Establishing a strong foundation for our project.
- Balancing our tasks and responsibilities.

July 16: Day 2
Thanks to FedEx for adding a special touch to our presentation.
At the end of the 1st day of scrutineering, we realized we had a lot left to work on.

July 16 : Day 2

Mark worked nearly all night long, completely re-engineering and rebuilding the motor mount assembly to be able to handle the high torque loads associated with the electric motor. This was finally the silver bullet that solved most of our nagging chain problems, which had plagued us all through the first several days of scrutineering!
Before Day 3 scrutineering, all hands are on deck installing the required Grade 8 bolts & nuts for the seat, seatbelts, and suspension mounts.
Next, we focus on installing the completely re-engineered rear suspension with the revised motor mount structure that Mark had labor nearly all night making. This was the silver bullet that solved the chain issues we had been struggling with.
Test drive on the way to Scrutineering.

July 17: Day 3
Scrubineering Station 4:
Vehicle Handling / Slalom -
Each driver must skillfully
maneuver around the obstacles
in a driving test.
Chain issues had delayed
success the prior day.
July 17: Day 3

Scutineering Station 2: Electrical and Battery Requirements - Documentation, Propulsion Battery System, Motor and Controller Info, Assistance Devices, Supplemental Battery System, Electrical System Check, Disconnects, Main Battery Pack Fuse, Solar Array…

Minimal corrections: Adhere larger & more “High Voltage” warning stickers for solar panels, cover battery box outlet plugs, install insulation over battery cables ends.
Scutineering Station 5: Braking Tests - Competency & Safety
Passed 1st time.

July 17: Day 3

The students are responsible for submitting the car for scrutineering. No adults allowed. Enjoy the 20 minutes of peace and calm before a new storm!
Scotiteering Station 6: Endurance Test - Solar Car Inspection, lead vehicle inspection, full-speed panic stop, trailer loading / unloading.

July 18 - Day 4

The car was brought to the inside track to prove safe travel at an extended distance, adequate communication, and simulation of a mechanical failure to demonstrate procedures for safely loading and unloading the solar car.
Media Day! Several teams, who were finished with scrutineering, were interviewed by CBS, PBS, and the Fort Worth Star Telegram. Everyone was included in the group Solar Car Challenge photo at Texas Motor Speedway.
Finally, The Solar Express has earned her graphics. The team adheres the school mascot, CCA crest, team logo, and sponsor acknowledgements.

July 18: Day 4

Then, while letting her sunbathe, we realize that our charge controller had failed. We utilized a 48 volt battery charger that night to top off the batteries to start the race.
The first thing in the morning on race day #1, we have to quickly install our backup solar charge controller. This is when we learned the value of having multiple spares of every component!

First day of racing... We meet our judge. July 19: Day 5
For the 1st day of racing, the teams line up and start in 1 minute increments.
Not only did we finish a lap, The Solar Express was passing other cars.

July 19: Day 5
When the car has one last chain problem—it was not tight enough and slipped off—the team removes the car from the track. It’s all hands on deck!
The spotter has a birds eye view of the track. He gives warnings to the driver of competitors location and accidents via radio. Binoculars!

Although we lost track time twice, we still finished the day’s race in 5th place! If we had not incurred 3 penalty laps, we would have actually been tied for 3rd!
Day of Challenges: July 20: Day 6

1) Immediately, race day 2, we had a severe alignment issue, that caused Morgan to struggle just to complete the first lap, but was quickly corrected.

2) Later that morning, we were plagued with complaints that our horn was not loud enough, while passing other cars. To quickly resolve the issue, we removed the nose cone to deal with it, and later during lunch break installed a slightly louder horn.

3) Lastly, during the afternoon driving session, after Kaya had passed a car, and was going into turn 1, she turned a little too sharply to return to her lane, and momentarily set the car on two wheels. Later, we replaced the shocks with solid struts for the rest of the race to give the car greater roll stability. Now we see why SCC suggests 500 miles of pre-race drive time.
July 20: Day 6

Round and Round and Round they go.
Where they stop, nobody knows.
Even with the morning technical issues that cost us 50 to 60 minutes, we managed to pull into 3rd place for the 2nd race day!

### Day 2

#### Classic Division

<table>
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<tr>
<th>Rank</th>
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<th>Lap 3</th>
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#### Electric-Solar Powered Division

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**July 20: Day 6**
Driving made the time fly. Learning how to make the car more efficient as a team was exciting. The more engaged we were, the less we noticed the heat.

The team times each lap of our solar car, as well as our competition. We adjust our time to be just better than our competition, not maximum speed, which can overheat the car or deplete energy faster than we are receiving energy from the solar array.
Our drivers improved with every lap...communication with the other team members relating speed, consistency, energy usage...
Texas Motor Speedway Garage, Bay 3: Each team has one length of the garage, one side for working on the car, the other side for storing everything else.

July 21, Day 7

Radios and 12 volt batteries (fan & horn) were charged daily. Radios are the life-line to our drivers, spotters, safety, and leaders. Every driver brought a radio, 2 radio batteries, a fresh 12 volt battery, and their personal 32oz water bottle.
On the 3rd day of racing, we tied for 2nd place with Wylie East, bringing us up to 3rd place overall.
By the end of the week, the team was exhausted, but at least we had worked most of the kinks out and were able to relax while waiting for dinner.

The concrete floor was the coolest place in the garage!
The Solar Express has a tilting array that allows us to optimize the array angle to capture the maximum amount of sunlight early and late in the day.

Every morning & afternoon, the solar cars sunbathe to charge for the next day's race.
Issac raced 4 hrs in a.m. & Steven 3 hrs in p.m. Minimizing driver changes allowed us to stay just ahead of Wylie East, who used this same tactic.

We placed 2nd for the day, just 2 laps shy of 1st. Awesome race day!
We appreciate all the support from our encouraging friends and family!

Rob & Ruth Lane
Steve & Joanne Roe
Mr. & Christie Fuller
Tim, Regina, & Corey Tarkington
Shannon & Tanya Caraway
Heather, Carey, & Isabell Clayton
Bill & Sharon Cole
Bo & Pat Caraway
Headmaster Keith Castello
Aiden & Timmy Castello
Natalie Lucas, Cartie Spain,
& Molly McHenry
Clay Butler, Max Pofford,
& Ben Smith
Carol & Emmis Phillips
The Mineral Wells Team:
Katelynn, Tyler, & Paul

July 22: Day 8
Final walk back to the garage bay.

July 22: Day 8
Teachers skeptical about proposed bonus of $1,000

Russian says he, Sessions discussed Trump

THE SPEED OF LIGHT

Students from around the world compete in solar car race at Texas Motor Speedway

July 22: Day 8
2017 Race Results
Texas Motor Speedway

Overall Standings

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<th>Rank</th>
<th>Team</th>
<th>Total Laps</th>
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<tr>
<td>1</td>
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<td>North Shore Eagles</td>
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<td>St John's College Green Giants</td>
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<td>Floydada High School Solar</td>
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<td>South EURA</td>
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Advanced Division

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Electric-Solar Powered Division

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Special Awards

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<td>Jarrett Dunn Award &amp; Scholarship</td>
<td>Jeremy Lim, Walther Solar Car</td>
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<td>Lifetime Achievement Award</td>
<td>Jonathan Hindy, William Shih</td>
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<td>Lee Cabe Award</td>
<td>Bill Engel, Jim Duncan</td>
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<td>Fred Varian Award</td>
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<td>Gustie Terscha Award</td>
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<td>Lockheed Martin Award</td>
<td>Walther Solar Car (Advanced)</td>
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<td>Chris Jones Award</td>
<td>Iron Lions</td>
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We enjoyed cheering on our deserving competitors and were amazed at how well Isaac represented our team in his speech.
July 22: Day 8

We are incredibly proud of our Covenant Christian Academy Solar Car Team. They designed the car, worked numerous hours building the "The Solar Express," passed the 3 full days of rigorous "scrutineering," resolved a chain alignment issue, raced the 4 days in 100+ degree heat, and finished the race...in 3rd place of 13 teams in their Classic Division!

Anything worth doing is worth doing well. This was no exception. "Seize the Day!" Issac
Mineral Wells addition to CCA Team

Although they didn't complete their car in time for the race, these students worked hard on the Mineral Wells Team car and deserved to experience the Solar Car Challenge. Covenant adopted Katelynn, Tyler & Paul and they helped as spotters, and Tyler helped repair the chain issue. Thanks Mineral Wells Team.
Our CCA team wants to honor our team sponsor/advisors...

Shannon Caramag, who had the vision, Automotive and Engineering knowledge and experience, funding, enormous amount of time, motivation, and focus to see our team through to completion of the solar car and race.

Mark Rose, who generously offered his machine shop and equipment to both the Covenant Christian and Mineral Wells teams, as well as a wealth of Mechanical Engineering and racing knowledge.

Rob Lane, who shared his knowledge of Electrical Engineering and time.

We are so grateful for your generous investment into the next generation of engineers and leaders of tomorrow.
Sharing the Solar Car experience with the next generation of CCA Cougars at the New Family's Ice Cream Social.

July 27
The Rhetoric School will have a 1st day of school surprise at Covenant Christian.

Can't wait to race across the U.S. to California next year! Go Cougars!
What was your most memorable experiences in '16 - '17?

- Isaac Fuller (12th grade)
  - The experience of being able to build the framework of the car, to later see it rolling and working, and then participating on a competitive level in the race.
- Morgan Caraway (10th grade)
  - I was exposed to new experiences and activities that I would not normally have had the opportunity to do until I learned some managerial skills as well.
  - The Texas Motor Speedway scrutineering and the competition was the most memorable experience.
- Kayla Lane (10th grade)
  - Seeing the car get on two wheels and I survived!
- Steven Roe (10th grade)
  - In addition to the mechanical and electrical aspects of the car, I learned a lot of leadership skills, that I was not expecting.
- Jake Sculley (9th grade)
  - I enjoyed learning many things I want not have learned in school.
- Jake Caraway (9th grade)
  - Seeing the well-men coculated cars, like Germaine, which had impressive aerodynamics and was fit in their class, at the competition and thinking about how we can improve this coming year.
  - I want to build one of these cars (someday) (See the Walkal Car). (In English)
- Tyler Tarkington (8th grade)
  - Celebrating at the awards banquet and having winning speeches.

August 6

A few weeks later, we had a review meeting summarizing the season and making plans for next year!

Priorities for the CCA Solar Car Club in '17 - '18

- Slight refinements to the current design:
  - Add a front suspension "anti-roll bar" to improve handling
  - Downsize to 4.16 gear ratio for increased energy efficiency of driveline
  - Develop and implement cruise control for increased energy efficiency of driveline
  - Consent to a belt drive for reduced frictional losses in the driveline
  - New more aerodynamic windshield made out of resin to reduce aerodynamic drag
  - Shrink nose structure to accommodate more aerodynamic nose cone
  - Look for ways to melodically lighten the car for improved efficiency
  - Add "spud joint" location points for safe and easy lifting

- Focus on developing superior race strategy
  - Add full telemetry and instrumentation with remotely enabled data acquisition
  - Look at lots of practice runs to learn the car and its efficiency characteristics
  - Develop and optimized energy management strategy using lessons from The Winning Solar Car book

- Operational Excellence
  - Trained operations for all team members during the event (e.g., alignment, chain, etc.)
  - Develop a well organized tool management and car transport trailer logistics

- Community
  - Develop a better team website to share our learning experiences with the community
  - Develop a video documentary / Movie to document our the beginning to end experience