



SOLAR CAR CONFERENCE 2023



Project Management

Some Background - What the hell do I know?

- Joined Blue Sky Solar Racing at the University of Toronto in 2007
- Worked on general labour on fabrication team as well as electrical team member for first two years
- Failed to finished the car for WSC 2009 & ASC 2010
- Got promoted to telemetry lead on account of everyone quitting leading up to our failed attempt at getting to WSC 2009
- Built a power hungry telemetry system for WSC 2011 all of which I blew up three days prior to start of race (We did not finish the race. Placed 24th.)
- Got reluctantly promoted again to team manager and the team finished 8th place at WSC 2013 ([Link](#))

Overview

- #0 Purpose
- #1 Set the Team Goal
- #2 Set Milestones
- #3 Get Team working towards the Goal
- #4 Make Decisions towards the Goal

#0 Purpose

- Set a Team Goal that you can use to make decisions & gauge your progress and motivate people
- Hopefully give a different perspective on how a team could be run
- Getting entire team moving in the same direction is a key part of having an effective team

#1 Set Team Goal

- **Whole Team Effort**

- What does each team member want out of project?
- What does each person want to do for the project?
- What does team want to accomplish this cycle?
- Cannot achieve team goal without entire team believing in it
- Whole team needs to make a commitment to “go for it”

- **Ambitious, but Achievable**

- Target that you can work towards that team hasn't done before
- A goal you can proudly share with sponsors & teammates
- Note: Keep in mind your end result may be worse so aim a bit higher with room for failure

- **Measurable**

- Set a Target that you could set metrics against to gauge your progress (See examples)

Team Goal Examples

- Finish position
 - Result heavily dependent on other teams
 - Difficult to gauge progress until end
- Average Race Speed or Race Finish Time
 - Use past race data to calculate average speed achieved by previous participants
 - Possible to create metrics based on past results
- Target Speed at Full Sun
 - Possible to create metrics based on your design (with varying degrees of accuracy)
- Finish the Race
 - Similar goal as “Average Race Speed” with minimum average speed required to finish race
- Pass scrutineering
 - Design & Build a car that can pass scrutineering without worrying about driving the race
 - Limit scope to design & build portion
 - Limited testing & no race logistics (No need to worry about [Race Crew Roles](#))

Team Goal Examples (Details)

- Average Race Speed
 - Maximum Solar Input Power: $4 \text{ m}^2 * 1 \text{ kW/m}^2 * 24.3 \% \text{ eff} * K_{\text{curvature}} = 972 \text{ W} * K_{\text{curvature}}$
 - Calculate/Measure Rolling Resistance based on tire datasheet/weight/number of wheels
 - Estimate Aerodynamic Drag based on CFD or wind-tunnel testing (full size or scale)
 - Use Race Route elevation + vehicle orientation to determine angle of incidence for solar array throughout race for absolute total input power
 - Add extra solar input for checkpoint & beginning/end of day charging
 - Total power draw at target speed should be less than equal to (solar input + battery input)
 - Use past race data to determine how often & how long vehicle needed to be pulled over to determine additional delays

#2 Set Milestones

- Create & Document Milestones
 - **Work with whole team to come up with high-level milestones and target dates**
 - Have whole team commit to meeting those milestones
- Refer back to Goals & Milestones throughout cycle
 - Document team's Goals & Milestones
 - Display it prominently so you can remind yourself what it is you're trying to achieve
- Review Goal after each Milestone & Adjust
 - After reaching or missing a Milestone, review your goals & re-commit to meeting the goal or adjust expectations if goal is not achievable

Milestones Examples

Aerobody

- Design Complete & Ready for Mfg
- Plug Machining Complete
- Mold Complete
- Aerobody Complete

Electrical

- PCB Batch #1 & Component-Level Test
- PCB Batch #2 & System-Level Test
- PCB Final Batch & Final Bench Test
- Telemetry & Strategy Integration Test
- Vehicle Wiring & Battery Box install
- Solar Panel Install
- Electrical In-Vehicle Test

Mechanical

- Part Design Complete & Ready for Mfg
- BOM Ready & Time-Critical Parts Ordered
- Suspension Parts Machining Complete
- Mechanical Assembly Bench Test
- Chassis install

Testing

- Chassis on Wheels
- First Drive
- Low Speed Testing
- Target Speed Testing
- Vehicle Characterization & Strategy Testing

#3 Get Team Working Towards Goal

- Start with Realistic Schedule
 - Work around school schedule
 - Use past schedule & lessons learned to estimate man hours & delays
 - Set sufficiently ambitious schedule early on with buffer room for unexpected delays
- **Get Whole Team involved**
 - **Need Buy-in from whole team on the schedule**
- Push everyone to meet the first Milestone
 - Usually a “Preliminary Design Complete” milestone that doesn’t have any external dependencies (only dependent on team members’ effort & time. No excuses.)
 - Get a complete design finished (including BOM, manufacturing plans & drawings)
 - Learn how each person works best & learn their limits
 - Don’t fall into trap of “It’s only the preliminary design. Do we really need to do it? Who cares if we don’t finish it on time?”

Learn Your Team's Limits Early

- Push your team to meet early deadline to observe how they respond to the pressure
- Keep an eye on following for each person:
 - Need close supervision? Or need to be left alone?
 - How well do they keep up with both school work & solar car work?
 - Do they prefer to cram? Or make consistent progress?
 - Can they make quick decisions under pressure? Or do they need extra time?
 - Can they debate in real time with others during decision making process? Or do they need time and space to digest information before they can contribute?
 - Are they committed to getting work done? Or will they give up when push comes to shove?
 - How much can you ask out of each person before they burn out or fall behind on school or decide to quit?
- Deadlines only become more critical as it gets closer to race
 - Take the earlier deadlines seriously so you can learn how to work with the team in the crunch time without pissing each other off

Review & Proceed to Next Milestone

- Readjust Goals & Milestones
 - If team cannot meet the milestones (either due to lack of resources or personnel), then lower expectations
 - OR Entire team agrees to commit themselves to working harder & meeting the next milestone
- Maximize Team's Potential for Future Milestones
 - Once you know everyone's limit, get everyone working at maximum capacity without overexerting them
 - If there are members that are not willing to work with the rest of the team to meet the milestones, then work on finding replacements

#4 Make Decisions towards the Goal

- How do you justify design decisions?
 - Reference back to your measurable goal
 - Create measurable metrics with calculations (absolute or comparative)
- Every decision/effort should be measured against the goal
 - How critical is the decision to meeting the goal?
 - How much time & resources should you put into this task?
 - Can you take a shortcut or skip the step and still achieve the goal?
- Use the Goal & some metrics to help navigate through difficult decisions
 - Take the emotion & gut feelings out of decision making and try to replace them with logic & numbers

Decision Making Example (Decision 1 + Goal 1)

- Goal 1: Average Race Speed
- Decision 1: Add 2kg of reinforcement to suspension to avoid having a 4 hour breakdown on the side of road again
 - 2kg weight affects Rolling Resistance proportionality throughout race
 - Need to spend extra kWh to drive at same speed throughout
 - Average Speed goes down
 - Additional weight allows team to avoid having 4 hour breakdown (based on past experience) to replace suspension parts
 - Is it worth it?
 - Need to do calculation based on your vehicle config

Decision Making Example (Decision 1 + Goal 2)

- Goal 2: Build a car to regulation (no race logistics & limited testing)
- Decision 1: Add 2kg of reinforcement to suspension
 - Perform thought exercise, but either options are acceptable to meeting the goal
 - Since the car will not be driven excessively, it probably won't need reinforcement as long as following two conditions are met:
 - Suspension can handle the transport from school to race track
 - Driver understands not to drive too aggressively during testing
 - Since car will not be racing competitively, weight doesn't matter so much

Decision Making Example (Goal 1, Decision 2)

- Goal 1: Average Race Speed
- Decision 2: Narrower aerobody with turning fairings (or opening wheel covers during turn) or wider aerobody with fixed fairings
 - Smaller wetted surface area for better aerodynamic performance with narrower fairings
 - Moving fairing may be prone to failure
 - Could result in reduced average speed
 - How long would it take to fix a breakdown due to moving fairing parts falling into wheel well?

Decision Making Example (Goal 2, Decision 2)

- Goal 2: Build a car to regulation (no race logistics & limited testing)
- Decision 2: Narrower aerobody with turning fairings (or opening wheel covers during turn) or wider aerobody with fixed fairings
 - Aerodynamics isn't a big issue since car will not be racing competitively
 - Moving fairing adds design complexity & one more thing to do in an already tight schedule
 - Apply **Keep It Simple Stupid** principle

Decision Making Example (Goal 1, Decision 3)

- Goal 1: Average Race Speed
- Decision 3: Recruit & train new members
 - What do we need out of new members currently to achieve goal?
 - Manual labour during build?
 - Nothing needed during design phase?
 - Team leads?
 - When do we need extra man power?
 - How many people do we need?
 - What training is required?
 - How & when do we begin training?
 - Hands-on training?
 - Read books & research?

Decision Making Example (Goal 2, Decision 3)

- Goal 2: Build a car to regulation (no race logistics & limited testing)
- Decision 3: Recruit & train new members
 - What do we need out of new members currently to achieve goal?
 - Manual labour during build?
 - Nothing needed during design phase?
 - Team leads?
 - When do we need extra man power?
 - How many people do we need?
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 - How & when do we begin training?
 - Hands-on training?
 - Read books & research?

Summary

- Work with whole team to set a Team Goal
- Set milestones & schedule for the Goal
- Commit to meeting early milestones to understand team better
- Always make decisions towards meeting the Goal

Questions?

- Contact Paul Park (paul_park@americansolarracing.org or on Discord or on r/solarracing)

Appendix: Race Crew Roles

Driving

- Solar car drivers (3ppl: SS, MT, JL)
- Caravan drivers (6 ppl: AS, PP, LD, SD, PS, ZG)
- 3 navigators
- Telemetry monitoring person (ZG or MT while driving)

Emergency stop

- Flag holder (MT/SS, MX)
- Milk crate carrier (?)
- Inventory manager (KY, ie. mechanical tool retriever)
- Car lifter (4ppl: KR, AD, MU, PP, SS, JL)
- Fairing detaching (3ppl lifting: KR, AD, MU, 2ppl detach: MX, KY, Heavy guys: AD, KR)
- Cable management (ZG)
- Battery checker (ZG)
- Tape carrier (MX, KY, JL, MU)
- Drill sergeant (EL)
- Tape application (front, back, side, side crews: AD, KR, EL, MT)
- Array charging team (set up array at control stops, stop over)
- Charge stand assembly (PS, SD, NW, TG)
- Array guard (Holder, shadow blocker, sprayer: PS, SD, KR)
- Cone tarp placement (SD, NW)

Every morning and night, safety check:

- Drill sergeant (EL)
- R. suspension bolt checker (SS, AD)
- L. suspension bolt checker (MU, TG)
- Tire pressure checker (NW)
- Piggy runner (NW)
- Piggy charger/compressor lifter (SD, KR)
- Axle/roll cage checker (SD/KR)
- Brake line/ pedal assembly checker (MX)
- Bearing checker (lifter: AD/KR, spinner: EL/JL)
- Brake checker (driver, pusher: KR)
- Battery checker (ZG)
- Cable checker (MT, ie check no cable is cut/crimp, cable connected)
- Telemetry checker (LD)

End of day pull-over

- Spray paint pull over point (MX)
- Lifters (PP, SD, MU, KR, AD, TG)

Off-driving hours

- Alarm clock (AS)
- Sunrise locator (AS's phone)
- Morning charging team (PS, KR)
- Breakfast team (NW, SD)
- Lunch team (MX, KY)
- Dinner team (SS, ZG)
- Tent setup/take-down (MU, KR, AD, NW)
- Morning packing team (NW, SD)
- Grocery shopping team (SS, T2)
- Water supply (AS, SD)
- Strategy telemetry review (LD, AS, S3 (in spirit))
- Wax-on (PS, NW)
- Wax-off (PS, NW)
- Tire changers (?)

Misc Notes

- The first one to run out is the guy with the flag, etc.
- Trailer: SS, TG,
- Aero: check clothes, wax car, fix wrinkles
- Array cleaner
- Need a daily schedule