

Dr. Dan's Day-by-Day Report, Clean Snowmobile Challenge, February 2015

Once again it is the time of year where some of our departments' greatest students disappear from your classrooms for a week, with some kind of an excuse about one of their classes requiring them to go snowmobiling for a week. I know...it sounds like a great excuse for a week of partying. But in reality it is anything but. In my updates this week I will do my best to describe what this experience is actually like.

Day -1.5 (Friday afternoon through Saturday)

By some small miracle, the team has all three snowmobiles running this year (our current competition sled, and two past competition sleds that are used for baseline testing and support during test days). All three snowmobiles, an entire garage of tools, storage bins, spare parts, and any diagnostics equipment that take up two garage bays must be packaged in to a single trailer - along with all the cold-weather gear, clothes, and textbooks for 15 students. The team spent most of Friday morning through evening packing the trailer, making sure to double and triple check that nothing had been forgotten. Friday evening the truck/trailer, Suburban, and Expedition get on the road to visit their 'vacation Yooper home.' Incidentally, this vacation destination has not been above freezing for nearly the entire month of February. This would only feel like Spring Break in Cabo if you were a polar bear.

Now, you spend the next 30 hours straight in a vehicle with all of the same people you have spent every hour of free time with since Christmas. You stop for fuel every 250 miles, and switch drivers periodically. The bright spot of the whole trip is dinner with some of the sled alumni. You try to sleep as a young driver (whose primary driving experience has been a tiny econo car) is piloting your SUV through a snow storm. The friend you are using as a pillow smells like a toxic combination of Doritos, energy drink, and egg-salad sandwich - largely because that is all they have eaten in the last 24 hours. Luckily for you, the "last 6 hours of the trip" only takes 14 hours. You reach Houghton, MI, your vacation destination, at 6am on Sunday morning, and you collapse in to a comfy bed...with the same Doritos-infused friend.

Day 0 (Sunday)

By 8am your team captains are shaking you awake. Yes, you've had less than two hours of sleep in an actual bed, but there are things to do. Today is a FUN DAY!! You take turns in the shower, gear up in your warmest clothes, grab some food from the most awesome continental breakfast you've seen in days, and head out to do some local testing. Local testing is important to ensure the engine programming is tuned for the local area conditions. Michigan's U.P. is a very different elevation humidity, and temperature than Moscow.

You open the door to the trailer to find that the toolbox and rear stand have played a game of "jackhammer" to the rear of your competition sled for the last few thousand miles. Luckily, you've got two complete sleds you can use to repair the damage. And who doesn't like working with metal tools and an aluminum chassis when it is 15 degrees below zero? Don't worry though, the little you remember from Biology class, you're pretty sure that your fingers will be back to normal sometime in April. And you're glad they hurt like crazy, because that means they don't have frostbite.

More testing and uncovering issues is followed by more holding frozen wrenches. But ultimately you believe you have identified and repaired all the problems that were not discovered in the previous 60 days and hundreds of miles of testing. Now it is back to the hotel, where you can play in the pool until you remember you haven't had a real sleep in over 40 hours. You crash in

your bed for your first real sleep in days. This is when you discover that your bedmate snores, or is possibly dreaming that they are a Harley Davidson.

Day 1 (Monday)

This is the first day of competition, and if you have done your job, there isn't much for you to do. Still, you are up early, enjoy another lovely continental waffle with orange juice that is so watery that it isn't even slightly orange in color. Then it is up to the competition site where you get to unload your sled and pit supplies. You breeze through tech (one of the first teams to do so), and get busy cleaning and shining up the sled. It is AMAZING what 12 students with rags and polish can do to a dirty snowmobile.

The day is full of visiting the pits of the other competitors. You are quick to discover that everyone knows who you are, and they have questions for you. They have all read your past technical papers, and want to pick your brain about a variety of topics. Luckily for you, during your 30 hours of driving across the country, you were asking all those same questions to the senior members of your team, so you feel like a BOSS because you can answer questions about engine tuning that seniors at other prestigious universities are asking you.

Now it is decal time. You are provided a packet of decals from competition sponsors that must be applied, and you also have a big box of team sponsors. It is good that you're an engineer, because you are equipped with the mathematical tools to optimize the surface area problem. Other teams don't seem to have this problem. Other teams take notice, and start asking you about your sponsors. In the midst of this discussion, one of the sponsors arrives, and greets you with a hug. You know...when an engineer gives you a hug, that's kind of a big deal. "Wow," says a member from another team "your sponsors really like you!" Indeed, they really do.

As Day 1 is winding down, everyone gets to see the fire safety presentation. We learn about A, B, C, and D type extinguishers, and are given some tips about how to use an extinguisher. After this is over, everyone gets to go outside (Yay! It's above zero!!) and practice putting out fires. Out of a few hundred students, the three people chosen to put out the fires are all from the University of Idaho. You've been putting out fires all year, and as it turns out, putting out literal fires is a lot easier than the metaphorical fires you've been putting out since Christmas break.

The day was not without some valuable lessons learned through the school of hard knocks. Some of the key lessons include:

1. As it turns out, water expands when it freezes. You've known this since you were a kid. However, most of the time you've seen this, it was in the form of a slightly ballooned water bottle, or a broken mug in your freezer. This time you are reminded as you unpack your 'spare' engine from the bin, and find out that the water you forgot to drain before packing has expanded and cracked the block and cylinders. Hmmm, that is a bummer. You are secretly hoping that one of your team connections might have a lead on a nice used set of Rotax 800cc cases and cylinders at a price you can afford.
2. So, you've packed the entire garage in to your trailer. Yet, when asked to see your custom (competition-required) emissions probe...you realize that you don't have it. You have no idea where it could be, but you know it isn't here. Luckily, one of the competition sponsors/judges gets word, and grabs the parts to make you one from their private stash of Swagelok fittings. They do this because...your sponsors really do like you.

An uneventful day at a student competition is always a good thing. When things are slow, it is a great time to pause and reflect. Here is what I came up with during some pondering today.

We live in a time when our environment has been largely supportive. We know that learners are more motivated to work hard when they feel they are doing well. Unfortunately, this can lead to an environment where "everyone wins!" That is a wonderful and positive idea, but how do you know you are really doing well when nearly 90% of your friends/peers are "above average"? The little you remember from statistics tells you that this doesn't compute. On the flip side, at a competition like this, there is only going to be one winner, and 14 losers. That seems equally biased, but in the opposite direction. Today, while observing all the teams in the pits, I was trying to look for indicators of success. I can't call it winning, but some things that immediately stood out to me as significant were:

- Every team knows our team. If not by personal past experience, they know us by reputation. When they see "Idaho" on our jacket, or name tag, they want to talk with us.
- Nearly every one of the competition sponsors knows our team, and as soon as they walked in the door they came to our pits to say hi, and hear about what we had done this past year. They expect that we have made some innovations, and they were not disappointed.
- Our team members spent more time in competitors' pits than our own. Now, I know that being the "most social engineer" is like being the "boxer with the prettiest face." There isn't a lot of competition in the world of extroverted engineers. But that's just it...our students aren't extroverts. They are more like sponges. There is a wealth of experience in the paddock, and every team has come up with a unique solution to the same set of rules. Our students are exploring the paths that other teams have chosen, and no doubt they will spend the 30 hour drive home discussing every detail of their own, and the other team's choices.
- When a TV crew enters the paddock, the competition organizers point them directly to our pit. We have a reputation of being professional, positive, and prepared. We have earned every bit of that reputation in the past 15 years of competition.
- There are a ton of two-stroke entries this year! What has historically been stereotyped as a 'dirty engine' has been busted by years of amazing performance by our team. If we perform as designed (and we have hours of dyno lab data to support what we are capable of), we could win the emissions event this year...with a two-stroke. We were within parts-per-million of winning emissions last year. Every two-stroke team has been combing through our past papers, and they have a ton of questions for us.
- It was 6:30 pm and I was looking for our students. Naturally, I went to the hotel pool. It was empty. The deck was dry, and the water was calm. Either our whole team saw me coming and hid in the sauna, or they weren't in the pool. I hope that means "they weren't in the pool...yet" because otherwise, I will be very disappointed in them. Work hard, play hard, sleep hard - repeat.
- The lady at the hotel desk knows us. "Idaho? Aren't you the team with the amazingly-clean two-stroke snowmobile that made such an impact last year?" I can hardly remember which motorcycles I owned last year, yet there was enough talk about our performance in Houghton last year that she still associated Idaho with clean two-strokes, not potatoes.

Tomorrow is another early day. We have a 100-mile endurance run to make. Even with all the preparation we have done up to this point, there are still dozens of unsuspecting, tiny failures that could sideline us (or any of the teams). Regardless of the outcome tomorrow, we will learn something. And I will do my best to fill you in on the 'day-in-the-life' of our students.

Day 2 (Tuesday)

The good news of the day is that there is nearly no news. Today was the endurance event, where each team was challenged to a 100 miles of trail riding. They also measure fuel consumption over this same trip. We started on the first pull, and ran the 100 miles with no problems at all. Fuel consumption numbers have not been released yet. But finishing is an accomplishment in itself.

Once again, members of our team stayed at the shop to help several of the other teams make repairs. The bulk of the evening was spent doing homework, reports, and polishing the final details on our technical presentation.

The most interesting things that happened today were part of the discussion session between the organizers and all of the teams. The discussion of future rule changes, and the general direction the competition should go was extremely lively. The short version is that there is a lot of interest in some significant changes for next year. We won't know the official rule changes until next Fall, but I expect that next year we will be very busy. An interesting option that was put up is that teams will be allowed to bring two competition snowmobiles if they are in different classes. This means, for example, that we could enter both a gasoline and a diesel powered snowmobile. This could save on travel funds if we decided to do these as our competition teams, as we would only have one cross-country trip to fund. But there is obviously more discussion to be had before any decisions are made on our end.

Oh, and there was a snowmoball fight.

Day 3 (Wednesday)

There were three major events today. The morning started out with our technical presentation. Our three presenting students (two seniors, and one sophomore) spent countless hours preparing and refining the presentation, and preparing and practicing what they were going to say. I probably hear the presentation a few dozen times before it was given. And unquestionably, the best version was the one they gave in front of the judges. I have no idea how we scored, but we were memorable, sociable, and displayed a technical mastery of the challenge, and the solutions we chose to pursue.

The next major event of the day was the in-lab emissions event (dyno testing). This event is famous for breaking a lot of engines. Surviving the dyno event is a small success in itself. We did survive, but our performance in the event was not as expected. So far, this has been the case for everyone in the dyno cell this year. For the last several years, we have been using our new (and, I might add, pretty incredible) dynamometer equipment for all of our testing and tuning. In the past, we would spend a week before competition testing with our older equipment, the same that is used at the competition. We haven't had the funds to update that equipment to keep it functional the last several years, so we have missed out on this step. This year, that shortcoming has finally caught up to us. Unfortunate, but not catastrophic. At this point we have many ideas about the cause, but ultimately still have more questions than answers. Answers will come.

The last event of the day is the static display in the local mall. Sponsors are there (recruiting for employees and interns), along with many interested people from the community. All the experience at show shows, and tours for prospective students have refined our students' craft at describing what we do to a widely varying audience. Today, they were as good as ever.

By 10 pm we are back to the hotel, and exhausted. In between dynamics, mechanics, and solidworks homework, there is still much discussion about our dyno troubles. So if you see some really strange scribbles about air-fuel ratios, afterburn, or the coefficient of thermal expansion for solids and liquids, now you know why.

Holy cow, did I just make a punchline out of engineering terms? We are a strange profession. :o)

Day 4 (Thursday)

You are woken up early by one of your teammates. She is telling you that it is time to get out of bed, because we need to be at the KRC in about 30 minutes. You try to pretend it is just a dream, but eventually her persistence wins, and you begrudgingly roll out of bed. You are already so tired of the breakfast that you start experimenting with just about anything 'unique' in the breakfast room. How about some maple oat meal, with banana slices? Or hard boiled eggs on my waffle? (Reality check --> the combos don't really make it any better).

Once on the KRC site, you are once again in the mode of "hurry up, and wait." While presenting your MSRP, you are simultaneously called away to get your sled ready for the subjective handling event - one where competition judges take your snowmobile out for a ride so that they can give you some feedback about what they do/don't like about it. Our snowmobile is always a favorite with the judges because it is light, powerful, and rides just like a high-end snowmobile that they would like to buy. However, this year there are several other entries that also have light, powerful, high-end snowmobiles, and theirs are nearly stock. They may not be as clean, quiet, or fuel efficient, but they are going to be a LOT of fun to ride.

We also heard the results for our fuel economy on the 100-mile run. We were just under 20 mpg (on an unspecified ratio of Isobutanol-Gasoline blend). This put us in 4th place for that event, behind three low-power four-stroke entries. From all of our previous data this year, we expected slightly better fuel economy, but we were still leaps ahead of the other two-stroke entries in the competition.

We also did the sound testing. In a private discussion with the competition organizer this evening, he let us know that only five snowmobiles beat the control sled in the noise event this year. We think we know who four of those five are. But we are unsure if we are also in that group or not. The team has done a remarkable job with sound reduction this year, and this is as quiet as we have ever been. But there is also a stock two-stroke snowmobile that has a faulty fuel injector, making it run on just one cylinder. That is terrible for performance, but it certainly made it quiet. We may not find out until Saturday evening if we are one of the teams that passed the sound event.

We also finished the in-service emissions event. In this event, the snowmobile is driven around the grounds at a specified speed while towing a trailer full of fuel/emissions data acquisition equipment. This is supposed to represent a more real-world reading of the emissions each snowmobile produces. However, after years of this, there still isn't a strong correlation of the data between the in-service emissions, and the dyno lab emissions.

Tomorrow could be the calmest day of the competition for us. Most of the other competitors still have several events they have not finished. Being well prepared has allowed our team to finish nearly all of the events (besides the special events that take place on Saturday). Tonight has been full of homework, laundry, and sleep.

Tomorrow could be a slow day for the team, but I won't be the least bit surprised if I find them spending most of the day in their competitors pits. There is a sled that needs an engine rebuild. There is a sled that caught fire earlier today. There is a first-year team that wants to learn everything they can from us about the art of tuning a modern two-stroke engine. There are cross-university friendships to renew, and new ones to create. I doubt anyone on our team will be bored tomorrow.

There are a few videos you might want to check out if you're curious about what the students have been up do. The first link is to a video created by the University of Idaho College of Engineering. It is a fantastic minute and a half video summarizing some of the things the team has worked on this year. It is probably worth mentioning the fantastic collaboration we have had between the ME and ECE departments. Many of our strongest advancements this year came through mechatronics that were developed by having a strong interdisciplinary blend on the team.

<https://www.facebook.com/video.php?v=10152710818008359&theater>

The second video is one that was made by a local news station in the Houghton, MI region. Our students provided a lot of the sound bites for the clip, although the snowmobile shown in the dyno lab is actually from Kettering University. It was a nice piece, but I would have to disagree with the final thoughts left by the narrator. He says that it is unlikely that snowmobiles like these would ever be seen in mass production, and he couldn't be more wrong. In fact, many of the technologies developed and proven by teams at this competition are adopted and refined by industry, and are usually found on production snowmobiles in as little as 2-3 years from the time they are first seen in the competition. The fact that you can buy a clean, quiet, national park certified four-stroke snowmobile was in direct response to the BMW-powered four-stroke snowmobile that the UI team designed and built back in 2001-2003. The modern clean and fuel efficient direct-injection two-stroke snowmobiles you can buy today are also direct descendants of the development that the UI team has been doing since 2004. And when you start seeing multi-mode, drive-by-wire snowmobiles with active noise cancellation a few years from now, guess where that came from?

<http://www.uppermichiganssource.com/news/story.aspx?id=1172939#.VPk9OPnF99p>

Day 5 (Friday)

The email from today will be short. There is virtually no news to report. We spent most of the day at the KRC again, primarily talking with other teams and judges. Many of the teams were busy finishing up events today that we had already completed, and we helped out where we could.

Tomorrow is the final day of competition, and there are three major events that everyone will do tomorrow.

- **Cold start.** All of the snowmobiles are currently soaking outside, where the ambient temp is around 12 F. This is warmer than the average high temperature has been all week. But tomorrow morning, one by one each team will be given 30 seconds to start their sled, and drive it away. We have always done well in this event, but we do have a microcontroller for our drive-by-wire that may not like being started this cold. Time will tell.
- **Acceleration.** As Crystal said in the College of Engineering video, all you have to do is launch hard, then hang on for dear life for the next 500 ft. Normally we are a top contender for this event since we usually have the highest power and lightest weight. But

this year, there are at least four other snowmobiles that are in the running for winning the acceleration event.

- Handling. Chase will be piloting our snowmobile through a course of cones as fast as he can, while not hitting any cones, or going off track. This course is much narrower than the course of the Formula Hybrid cars, but the turns are not as tight. Precision is everything. Normally we are also a top contender for this event, but with several other two-stroke snowmobile entries this year, we certainly have some stiff competition.

We find out the results at the banquet Saturday evening. I will try to write up a message afterwards. But I need to be on the plane at 5am in the next morning, so it may be a short update.

Day 6 (Saturday)

Today was the last day of the competition. The events today went very well. We did cold start in a single pull (a reputation we have earned, which amazes everyone because many of the sleds don't start after 30 seconds of cranking the electric starter). We were one of four very fast snowmobiles in the acceleration event. And we zipped through the handling course with speed, skill, and grace.

We did not win. We did not place in the top three. I don't actually know where we placed yet. Ultimately, we found out from the emissions testing crew at AVL that there was a major problem with our emissions. We produced more soot than they had ever measured with their equipment. That is not normal, especially for our engine. We have some diagnostics in our future to first replicate these results in our lab, then figure out why this is happening.

However, our efforts were not unnoticed. There were several awards that we did win, and some are quite significant.

- We were one of eleven teams to complete the endurance event.
- We were one of eleven (not the same eleven) to successfully cold start.
- We won the award for best handling.
- We won the award for best engine (which also came with \$500 in prize money)
- We won the award for most sportsmanlike conduct (with \$1000 in prize money)

This last award is one that is especially important. We have won it in the past. It is based on the private vote of all the competing teams. It was the short essay from the Platteville, WI team that convinced the judges that we deserved the award. However, it was also the total number of votes for our team.

The future of our involvement in this competition is still up in the air, but I know that experiences like these are one of the reasons that our program is as strong (and as popular) as it is. There are likely to be some big rule changes this next year. And there has been a huge push toward pursuing diesel snowmobiles in the competition. There are some very solid design ideas that have never been applied to small engines, and our prototyping abilities in the machine

shop, and our connections could help us do some amazing things if we choose to tread that path.

Day 7 (Sunday)

This is my best guess at what is about to happen. It is already past midnight here, and we just recently got back from the awards banquet. Our students will be waking up in about six hours (remember, it is daylight savings in a few hours) so they can enjoy one last free breakfast before loading all their bags in the trailer, and doing a final pass through their hotel rooms before heading back on the road. If everything goes as planned, they will arrive back in Moscow around 28 hours later. They will be tired, smelly, frazzled, and tired. And there is every chance that everything will not go as planned. Sometimes, despite our best efforts, educated guesses, and prior experience - the unexpected happens. Travel safe.

-Dr. Dan