Huskies Blastoff

MTU's Keweenaw Rocket Range Team's Expedition Into the New Mexico Desert 2019

By: Clark Sprague

Michigan Tech's *Keweenaw Rocket Range* (hereafter referred to as KRR) is a student team passionate about building high powered rockets. We formed in the Fall of 2018 and competed in our first rocket competition June of 2019. The competition in question was IREC, or the *Intercollegiate Rocket Engineering Competition*, hosted in the New Mexico desert at Spaceport America. This international competition is the largest of its kind in the World and a mere twenty-seven hours by car for us to attend. Despite being a young team with minimal resources, we worked hard for an entire semester to design, build and test our rocket so that we could compete. A contingent of ten team members in three vehicles volunteered ten days of their summer to represent the Michigan Tech, KRR and the Keweenaw Peninsula at this premiere event.

In your hands or on your screen is the comprehensive trip report detailing the Keweenaw Rocket Range's debut onto the international stage of University high powered rocketry.

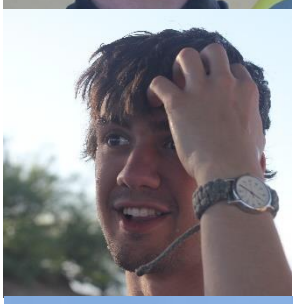
Meet the team

A brief and incomplete introduction to our traveling team-members

Anders Carlson
Treasurer and recovery team member. Made sure we could afford gas and food. Voted most likely to experience heart palpitations during a rocket launch.

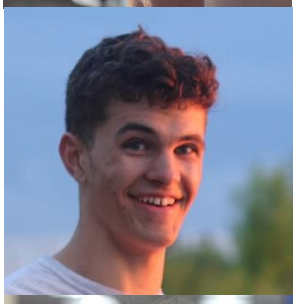
Clark Sprague
Photographer and videographer. Took lots of pictures, wrote silly reports and sometimes did useful things. True passion is in supersonic sandwich delivery.

Daniel (Dan) Faber
Vice President, co-founder and launch team member. First team alum but hoping not to be the last. Expert in what things could go through a woodchipper but not as to which things should.



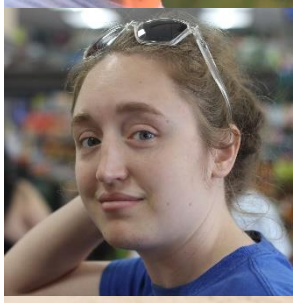
David Hoffman
Payload and recovery team member. Successfully performed rocket surgery with a Dremel. Most emotional stargazing performance.

Emi Colman
Outreach Coordinator, Recovery team and rocket simulation guru. Operated powerful JavaScript software that made the rocket not take highly energetic core samples of the desert.



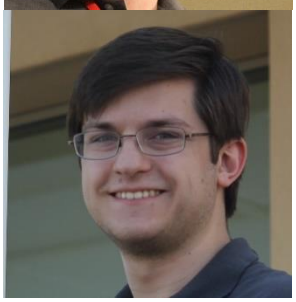
Erik Van Horn
Payload team member. Voluntarily strapped months' worth of his work into a fiberglass tube with highly volatile reactants at one end and expresses interest in doing so again.

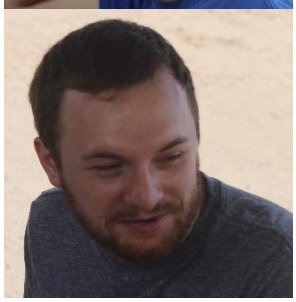
Jacob Longstreth
Structures team member. Responsibly shoved rocket igniters into our rocket and nothing too bad happened. Most invested in radio astronomy.



Elizabeth (Liz) McVay
Range and Safety officer/Team Mom. Stopped us from doing dumb things and kept us alive. Very excited about pushing buttons.

Matthew (Matt) Gauthier
Payload team member. Unlikely to pursue a career in properly quoting movie lines. Best in 'I hate sand.'





Patrick Guyon
Team Captain and co-founder. Master of the altimeters and most spirited extrovert. Extremely observant of the temperature of things.

Friday June 14 - Day 0 - Preflight Checklist

Day zero of the trip started off at the crack of 4:30... PM EST. After finishing up a half day of work I quickly packed my scattered belongings into my car. Just a duffle and a backpack. Also, a camera bag. I added in a sleeping bag along with a sleeping pad for good measure. That didn't seem like quite enough stuff so I also loaded up a storage tote with hiking boots, a water jug, camping stool, a toolbox just for emergencies, a drill, a flashlight, a deck of cards, spare underwear, an entire box of granola bars, water shoes, a toolbox not just for emergencies and a kite. I also convinced myself that bringing a six inch Dobsonian reflector telescope plus base was not a luxury but in fact a necessity for a ten day road excursion into the middle of the New Mexico desert. The telescope, securely wrapped in a heavy blanket and strapped into the passenger seat of my car, looked like something I didn't really want to have to explain to a state trooper. I met fellow team member and rocket enthusiast Emi Colman in the Walmart parking lot of Houghton and we set off to caravan down to Ashland Wisconsin about 150 miles southeast, to meet with another team member, Erik.

"Not a body" wrapped and strapped for the road

About five miles later I encountered the first anomaly of the trip. My aged car developed a randomly intermittent vibration emanating from the front of the vehicle. My engineering training dictated that I not stop the car and find the nearest mechanic, but instead continue driving and attempt to recreate the anomaly. The frequency of the vibration seemed proportional to the speed of the vehicle with a lower bound of ~55mph, and the amplitude was strongly correlated with engine power. Several more miles of testing revealed that the anomaly would ONLY occur when I was driving straight; even a slight turn of a few degrees would eliminate the vibration. This had sufficiently perplexed me to the point that I called my father, an actual engineer, and relayed my observations to him. He reassured me that he also had no clue what was going on but encouraged me to continue driving until I found out. After performing a set of slaloms on a vacant stretch of road (much to the concern of Emi, observing me in her rear-view mirror), I determined that the left front wheel bearing was likely the source. Catastrophic failure was probably thousands of miles further down the road, but I only needed to go a hundred miles, so I decided not to worry about it.

Erik and Emi watching the sunset in Ashland

We hit Ashland shortly after 7:00 PM CST and transferred vast quantities of personal belongings, camping equipment and one lightly tested rocket into Erik's van. The three of us took a quick sunset bike ride by the local waterfront before turning in for the night. Erik's family was kind enough to host us college kids on their floor and couch so we could get a fresh start in the morning.

- End Day 0 -

Saturday June 15 - Day 1 - Connection Established

Clark, Emi and Erik ready to tear out

At this phase, our team is split into three vehicles simultaneously traveling from Illinois, Southern Michigan and Wisconsin, intending to rendezvous at a campsite in northern Missouri. Our plan is to find each other and pitch our tents in the dark, pass out and then get up at the crack of dawn to drive the remaining 15 hours to New Mexico. Emi, Erik and I set out at 7:45 AM CST heading for Minneapolis to grab our team treasurer. Three hours later we reshuffled all our cargo to shove Anders into the van. Miraculously everything fit into the 2010 Toyota Sienna without zip tying anything (or anyone) to the roof rack. A relatively uneventful six more hours of driving we pulled into Wallace State Park and officially united the team and set up camp. I managed to wrangle everyone together to shoot our first team portrait, a series of daily photographs throughout our trip. Our first day concluded with a light dinner of grilled pasties (generously donated by Suomi Restaurant in Houghton!) and pop around a campfire.

KRR members catching up and enjoying a warm pasty around the campfire

- End Day 1 -

Sunday June 16 - Day 2 - The Long Haul

12:30 AM CST

The tenting situation has the ten of us split across four tents. David, Anders and Jacob in tent one, Emi and Liz in two, Matt and Dan in three, and myself, Erik and Patrick in four. We turned in at around 10:30 PM planning on a 5:00 AM wakeup.

At midnight, I'm still awake. As I lay there, exhausted, I reflect on why that might be. It could perhaps be the excitement of competing at an international rocket event, alternatively, the strain of crossing time zones in a vibrating car might be getting to me, or maybe sleeping in a tent is just plain uncomfortable. A leading theory eventually emerges that the person attempting to start a snowblower in my tent for the last hour is likely the culprit. Erik lurches up next to me and pleads for me to give Patrick a shove. Evidently, he too is not a fan of freight trains barreling through his tent. I give Patrick a good shove, which merely causes him to redouble his efforts. "It sounded like someone was revving a Harley," Erik later recalled. I give Patrick a solid whip with my wristwatch and he immediately goes quiet. Erik and I finally get some sleep.

5:00 AM CST

(Some of) The cows of Kansas

Alarms go off. Panic ensues. Erik wants five more minutes. Groggily we break camp as the sun begins to rise. There's 940 miles to cover today and we'll be driving for about fifteen hours. After a quick McDonald's breakfast and a gas stop, we agree to caravan our three vehicles. This pact lasts approximately forty-five seconds before Liz's car rapidly pulls out to the left, Patrick's car turns right and Erik, bringing up the rear, is left with no choice but to boycott the ill-conceived vehicular logistics. We depart for New Mexico separately.

'Objects in mirror are closer than they appear'

We soon leave Missouri, cross into Kansas to enjoy the scenery. Erik and Emi were enamored of the sheer quantity of free-range cows milling around. The expanses of fields gave me a mild feeling of agoraphobia. The last three years living in the Houghton-Hancock valley have acclimated me to more closed terrain where I seldom see the horizon. I suspect this feeling will become more pronounced as we progress into the desert where only the occasional shrub will break up the landscape until the Rocky Mountains.

Oklahoma proved to be more engaging. The flora and fauna were gradually becoming more arid as we drove. Our route eventually ran parallel to a rail line where we were adjacent to a half mile long west-bound freight train for nearly an hour. The engineer was kind enough to blow his horn for us. When we stopped for lunch and gas, I spotted a gem of a car sitting on a trailer. It was the Bluesmobile complete with loudspeaker and Sister Penguin in the backseat.

'It's 630 miles to Truth or Consequences. We got a full tank of gas, half a pack of rocket igniters, it's bright and we're wearing sunglasses.'

Texas was big. Lots of cows, lots of shrubs and lots of space. To pass the time we turned on the FM radio and watched as it scrolled across the entire spectrum without finding a station.

'...and there was much rejoicing.'

Without much fanfare we at last crossed into New Mexico. Merely another five and a half hours to the campsite. Marveling at the desert, we thoroughly rubbernecked and photographed the outcroppings of rock, mesas and shrubs. The desert proved to be the wettest portion of our entire drive, dumping sheets of rain on us on multiple occasions. Despite the rain and clouds, it was still in the 70s as we rolled towards our destination. One of our cars had a brief hiccup when the check engine light popped on. A quick detour to the nearest AutoZone told us that an oxygen sensor had failed and that we'd probably survive all the way to Elephant Butte.

11:00 PM MDT

Our distributed caravan began to lurchingly arrive at the campsite. The park staff had already gone to bed for the night so we couldn't check in. Since we'd already reserved and paid for our campsites, we decided it'd probably be ok to just let ourselves in. Everyone was beat, we'd been on the road for seventeen hours. A hushed team meeting was held where we determined that sleeping in was probably a good idea. We tried to pitch camp as quickly and quietly as possible under the light of a rather impressive full moon. With much protest I corralled everyone into one spot to shoot our Day-Two portrait. A few team members were staring daggers at me obviously tired, frustrated and very much not in the mood to deal with my documentation request. We managed to get the portrait with 54 seconds to spare in the day.

"Sure, we'd love to have you take our photo."

- End Day 2 -

Monday June 17 - Day 3 - Calibration

5:00 AM MDT

My 1st alarm went off. I shut it off and went back to sleep.

7:00 AM MDT

My 2nd alarm went off. I shut it off and went back to sleep.

7:30 AM MDT

I woke up, blinded and bleary eyed. Before I could formulate the string of obscenities necessary to properly express my frustration at whoever was beaming the holy light of God into my face, it dawned on me that it was in fact the sun, miraculously shooting the tiny gap in the tent rain fly to strike me square in the eyeballs. Everyone was starting to wake up anyways, so why not start the day? Plus, the tent was starting to become uncomfortably warm.

Our lovely desert campsite in an RV park

In the daylight we could finally see our campsite. We were staying in the middle of an RV park surrounded by sand, shrubs and a few cacti. We manage to spot some hares, and small lizards could be seen scampering between spots of shade. Us Yooper engineers are acclimated to subzero temperatures, dozens of feet of snow and months of darkness. The New Mexico desert in June is a far cry from our native habitat. Evidently, our love for rocketry is greater than our fear of the Sun.

We didn't need to report for check-in at IREC until late afternoon so the consensus was that we should go down to the lake and cool off. Several bottles of sunscreen later we were prepared to take on the beach without risking our engineering tans. The water was cool, wet and flush with algae. The wind picked up our camping shelter at one point, causing it to make a good run for the hills.

Team members Erik, Anders, David and Dan go out on a recovery mission for our camping shelter after it experiences an unscheduled flight

Post-beach outing, we split into two groups. Four folks headed out by car to check-in our team in at Las Cruces while the rest stayed behind to finish assembling the payload. Erik, David and Emi worked on mounting a window in the side of the payload bay for our camera to look out. We didn't have much in the way of scientific payload, but we all agreed that putting a camera onboard was a must. The camp shelter proved to be a very hot, but well-ventilated rocket workshop. Working with a Dremel and epoxy, a port was cut into the body tube and a section of polycarbonate water bottle affixed atop it.

Erik and Anders demonstrate that rocket surgery can be performed anywhere

Recalling the adventure our camping shelter had at the beach, I thought to pull out my box kite. We flew the kite for a while, but the wind was well in excess of what it was rated for. The sun, getting low in the sky, was shining underneath our

Dan experiences child-like wonder

camping shelters causing us to work harder to find shade. The check-in team had yet to return, so a filling dinner of bratwurst and beans was fashioned by David.

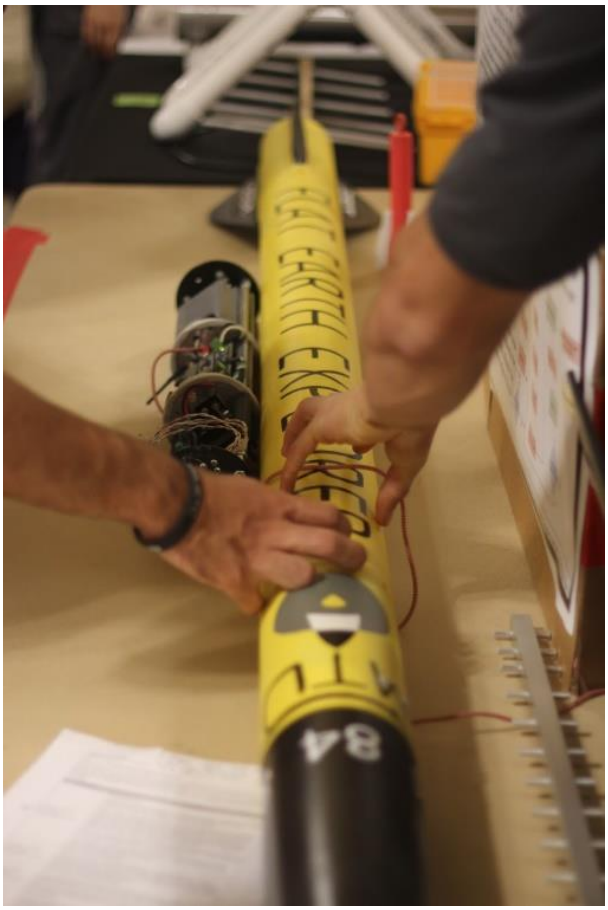
The sun finally set giving us a respite as the evening began to cool off. We brought out the telescope and watched the spectacle of the full moon rising over the mountains. Patrick, Dan, Matt and Anders finally got back from Las Cruces looking slightly worse for wear, likely due to the sheer quantity of Mexican food they'd consumed for dinner. We quickly laid out the detailed plan for Tuesday. Get up at 4:00 AM, leave at 4:30 AM and arrive at the Las Cruces convention center at 6:00 AM. Beyond that we were gonna wing it.

- End Day 3 -

Tuesday June 18 - Day 4 - Acquisition Of Signal

4:00 AM MDT

We promptly wake up, make oatmeal packets and hit the road. We're headed to the Las Cruces convention center for opening ceremonies and to show off our rocket hardware. We arrived 27 minutes before setup was supposed to end, requiring us to be hustle. There were 113 teams all setting up in a ballroom with posters and rockets of various sizes. It quickly became apparent that we had designed one of the smallest rockets at IREC. Our rocket is 1.2 Jacobs tall (~8 freedom units), several of our competitors are in excess of 20 feet (~4.5 Jacobs). We had a poster about our rocket to display but had forgotten to bring poster board backing to hold it up. Crunched for time and being resourceful engineers, we trash picked a cardboard box and quickly fashioned a trifold poster just in time for the event to start.



KRR's rocket on display in Las Cruces

This was the first official day of IREC where everyone gets to show off their hard work and ingenuity with other teams and judges before their rockets start getting dashed into the ground on Wednesday. One of the biggest sponsors for the event is Virgin Galactic, the first private company to carry humans to space. They had their chief pilot and lead astronaut trainer, both members of their spaceship's first flight to space, speak about the importance of University based aerospace projects. They added that we should all follow our dreams and "get lucky." Next, we got a safety lecture on how to not die in the desert. With triple digit temperatures and no shade, the biggest concern is staying hydrated. Their presentation helpfully even told us what color our urine should be to help the more visual learners stay engaged. The other big concern is the abundance of shade seeking, venomous critters that live in the desert. Scorpions, black widows and rattlesnakes (oh my). Three hundred inches of snow and hypothermia are starting to look pretty attractive.

We gave our rocket the gift of sight

The rest of the day was spent meeting other teams and talking with the sponsors. Several team members left our booth to go talk to other teams, and it became clear that there was a lot of innovative

technology being displayed. We learned about features ranging from air-brakes that would slow rockets down midflight, to drones that would deploy at apogee (the highest point in a rocket's flight) and fly around via radio communication, to a rover that would roll out of the payload bay as soon as the rocket landed. The teams were largely from The United States, but a sizeable contingent of international teams were present from as far away as Australia (the one place that makes New Mexico seem tame). We also talked to teams from Canada, Brazil, China, Switzerland, India, Poland, and Norway.

David signs the rocket

We were still wiring and bolting components of our rocket together at our display table until the end of the event. We found a pack of googly eyes and placed a pair on the M of our MTU logo. Inspired by one of the neighboring teams we decided to sign our rocket while we "still have the chance." We talked with a few other teams from Michigan, namely U of M Dearborn and MSU, who informed us that historically only approximately one third of the teams experience a nominal flight. The other two thirds were roughly split even between suffering a CATO (Catastrophe at Take Off) or performing a lithobraking maneuver due to recovery system failure. In non-rocket scientist speak, the rockets blow up or hit the ground too hard (or may be even both). It was clear that many teams would consider clearing the launch pad a success. Our team re-evaluated our expectations, as the bar for achievement was much lower than we'd originally anticipated.

5:00 PM MDT

The poster session came to a close and everyone packed up their tables. The last thing they had us do was all gather in the parking lot for a group photo. The sight of dozens of rockets towering over the crowd was an incredible experience. Then I remembered that many of them would not survive to the end of the week, and the experience was even more awesome. We grabbed a team dinner at a local Mexican restaurant before heading back to Elephant Butte for the night. We'd left camp before sunrise that morning and weren't driving back until after the sun had set. Even though we'd been out of the sun with air-conditioning all day, we were exhausted. We didn't need to be out on the range until early afternoon, so we decided to catch up on some sleep in preparation for our first launch opportunity on Wednesday.

Teams gather to show off their rockets while they're still shiny and in one piece

- End Day 4 -

Wednesday June 19 - Day 5 - Launch Window Missed

8:00 AM MDT

Despite wanting to sleep in, everyone was up. The rising sun turned the tents into high efficiency nylon convection ovens of pain. We had a breakfast of instant oatmeal and loaded the rocket into the van ready to head out. The Spaceport is located in the middle of the desert proper. Thirty five miles of flat open range with zero cell reception. The entire valley is restricted airspace intended to be the launch and landing site of current (and hopefully future) manned spacecraft. Spaceport America hosts the IREC rocketry competition just a few miles from the actual Spaceport.

And I thought the U.P. was desolate

We reach the security checkpoint and show the guards our rocketeer badges. They wave us in with minimal hassle. The teams set up tents to assemble their rockets and keep out of the sun. The standard seems to be a ten by ten frame tent, but with our cobbled-together supplies and resources, we have two tents, neither of which are square. We waste about 25 minutes trying to set up a stake and pole tarp shelter before admitting that it's just not going to work.

A rocket takes flight over the New Mexico desert

Our sister team Platteville Pioneer Rocketry, who we met at one of our test launches in Bong Wisconsin a few months earlier, took pity on us and offered up their tents for us to use. Platteville had already launched their rocket that morning and recovered it successfully, though their motor underperformed. Rockets were being launched periodically in salvos of usually 4-10. An announcer would read out the team's rocket specifications and mission description before starting a countdown from ten. When rockets were flying, you weren't allowed to be under the tents because if rocket debris was falling towards you, it'd be better if you were looking for it.

There were four classes of rockets flying. Teams could launch for 10,000 feet or 30,000 feet and they could use either COTS (Commercial Off The Shelf) or SRAD (Student Research And Designed) rockets. The COTS rockets made up most of the competition and tended to be the most reliable. The SRAD rockets often had advanced hybrid motor designs built by the teams and had a variety of exciting failure modes. The most benign failures were under/over performance of the motor. The range I heard of was a lowest being 400 of 30,000 feet and a high of 109,000 of 10,000 feet. I was impressed to see a rocket achieve 1090% of its target altitude and curious as to how they over-specified their motor impulse by two orders of magnitude. The more 'exciting' failures usually would leave very little pieces of the rocket spread across a large area. We watched some rockets shred their fins on ascent and saw several control surfaces fail resulting in very sharp, low altitude turns sending the rocket miles laterally. Others suffered a failure mode known as a RUD (Rapid Unplanned Disassembly) where the airframe would be annihilated by the forces exerted on it. The forces would sometimes originate outside the vehicle, other times it would be from the inside. Either way, they became very expensive fireworks.

"Troposphere is hard."

4:15 PM MDT

The MTU team was working hard to assemble the rocket and get the payload operational. One of our altimeters was not properly connecting to the computer preventing us from programming it. The altimeters are the most critical piece of electronics on the rocket as they are responsible for recording the apogee (max height) of the rocket and firing the charges that deploy the parachutes. The altimeters are so important that we have two of them on separate power supplies with separate black powder charges to give us the best

chance of recovering the rocket. If we couldn't program them, we weren't going to launch. The last window to launch on Wednesday ended at 5:00 PM which was fast approaching. Rather than rush and cram the whole rocket together in thirty minutes we decided to scrub the launch and try again on Thursday, despite that choice costing the team some scoring points.

We headed back to camp. David's parents sponsored a pizza party for the team to help lift our spirits. We briefly pulled out the telescope to take a look at the skies. Erik and Patrick replaced the altimeter that had been giving the team trouble and then called it a night. Tired but optimistic, we hit the sack.

The Moon as observed from Elephant Butte

- End Day 5 -

Thursday June 20 - Day 6 - All Systems Go

6:45 AM MDT

I woke up before my alarm, got dressed and started some water on the camp stove for oatmeal. Within a few minutes everyone had crawled out of their tents and was rubbing the sleep from their eyes. Our launch window opened at 10:00 AM but there was a safety meeting that we had to attend at 8:30 AM. Most of the team left around 7:15 AM. Anders, Dan, Matt and I left a few minutes later to go grab some food for the team lunch.

9:30 AM MDT

The whole team had made it to the Spaceport and the rocket was being carefully, yet expediently assembled. Parachutes were folded, shock cords wrapped, charges placed, fire retardant stuffing added, and payload powered on. Platteville, despite being done competing had come out to watch more rockets and to 'Mom' our team. They kept offering us Gatorade, making us eat and asking if we'd reapplied sunscreen.

Dan helping to fold the parachute for the rocket

10:15 AM MDT

KRR's 'Flat Earth Explorer' on its way to the pad

Liz and Dan shouldered the assembled rocket and carried it down to the pre-flight inspection table. This is where the waiting started. The range was running very behind and several CATO'd rockets had slowed down operations. The inspectors let us leave our rocket in the shade of their tent with our payload running, which we appreciated since it slowed down the solar cooking of our sensitive electronics. The electronics were activated

before finishing assembly and there was no way to turn them off once the rocket was put together, so our sensors and camera were recording everything to the onboard 64 gigabyte storage. The temperature was about 100 Fahrenheit and frying our electronics was a very real concern.

Erik, Patrick, Dan and Jacob loaded up to go down range with the rocket

After about an hour and a half we finally got the go ahead to send our setup team down to the range with the rocket. Erik, Patrick, Dan and Jacob loaded onto a trailer with the rocket and igniters with another team and took the half mile ride down to the solid rocket launch rails. It was about 45 minutes before all the teams finished setting up their rockets and they cleared the range and raised the red flag signifying that the range was active and not a safe place to be. We were on pad 3A and were fifth up in the salvo of solid rockets. The first three lifted off without incident, though successful recovery was another matter. The fourth rocket was from Cornell University, launching in the same category as us, 10K COTS. Our whole team, already antsy and suffering preflight jitters, intently watched as Cornell's rocket launched, and immediately detonated at only about 100 feet, scattering flaming debris all over the solid launch zone. The range halted and sent out the fire crew to put out any fires, giving us all another half hour to stress out and panic.

Liz hydrating herself in preparation for some emotionally taxing button pushing

Our rocket had now been powered up for over three and a half hours and had been cooking in direct sunlight for nearly two hours. We had no way to know if there was still any storage space left for our sensors and camera to write to, or even if the payload was still operational after all the heat it had endured. We had prepared as best we could, and the rocket was all on its own. The only outside stimulus we could give it was to light the igniter on its motor and hope that it would successfully execute the instructions we'd given it. Liz was up in the mission control tower (the top of a shipping crate) preparing to press the button that would seal the fate of our rocket. Platteville had showed up to watch and brought us chairs and water.

The announcer came back on and started reading out our mission description in an incomprehensible garble of PA noise. At long last, the countdown started.

"10"

"9"

"8"

"7"

"6"

A light breeze was blowing, and the sky was cloudless.

"5"

The range was clear, the rocket on the pad, and our hearts in our throats.

"4"

This was it, over 1700 miles, ten days of our summer.

"3"

A whole semesters' work across nearly twenty students had all led up to this.

"2"

All for just this one moment.

"1"

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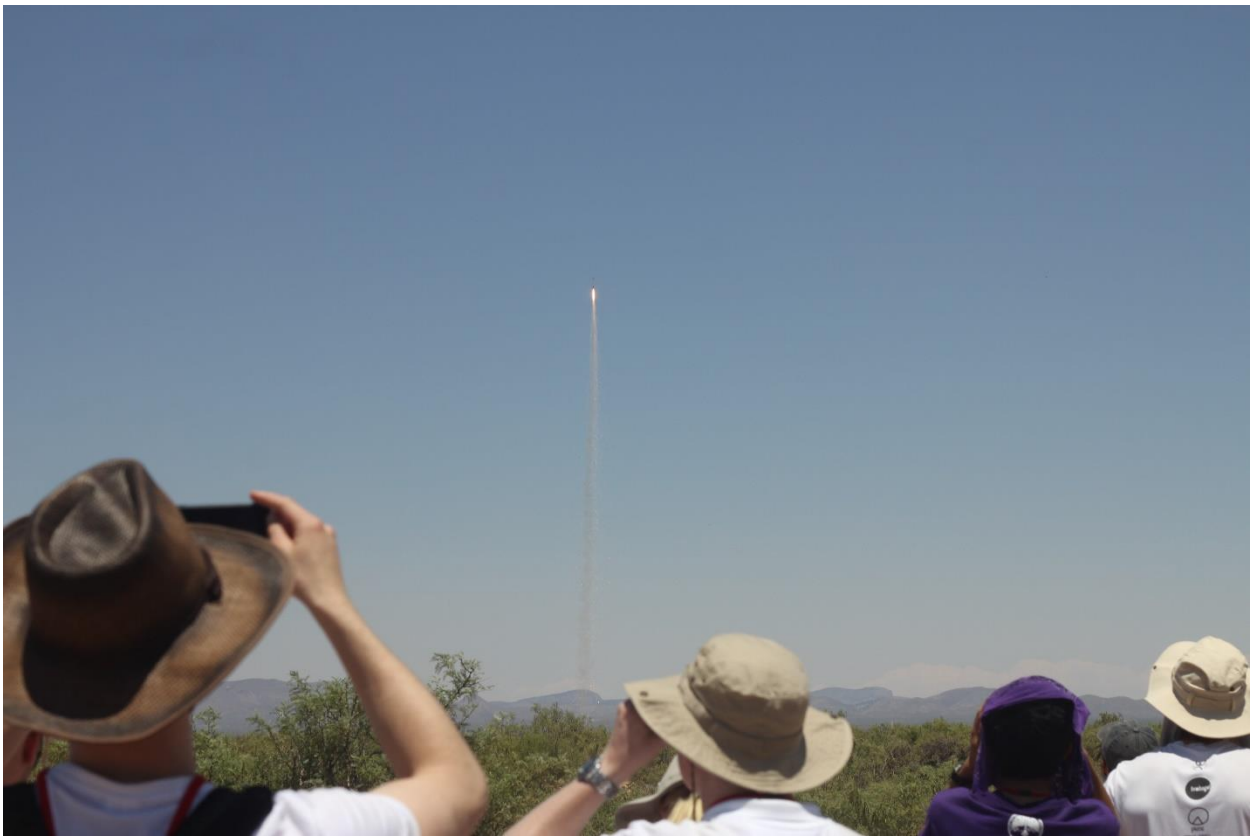
Nothing happened. Everyone stood silently waiting.



Liftoff!

Riding a jet of black and gold our rocket rose. A second later the sound reached us tearing through the air. It soared straight and stable into the sky as the motor quickly spent its fuel and receded to just a mere speck. Spectators strained to track the rocket as it coasted to apogee nearly two miles up, hoping to spot the first 'event' of our black powder charges igniting and deploying our drogue chute.

A small puff of gray smoke was the first indication that our altimeters were functioning, as this caused the rocket to split in two, releasing the red and blue drogue chute. Despite our success thus far, our mission was not free and clear yet. The rocket was still thousands of feet in the air and the drogue was not enough to safely recover the rocket, only slow its fall. The rocket got bigger and bigger as it fell, clearly showing the booster and payload sections under drogue. Our team waited with bated breath for the second 'event', main chute deployment.

A specialized motor shows off our Husky pride

Clark, David, Matt, Emi and Anders intently waiting for chute deployment (photo credit: ESRA Instagram)

At 1000 feet, our altimeters fired the second charge, ejecting the main chute from the nose cone. The red chute unfurled slowing the rocket to a much gentler rate of descent. This is the point where the entire KRR team freaked out. Ecstatic with our success and filled with euphoria and adrenaline, we simply cheered. Our rocket drifted in the breeze, lazily descending to the desert not far from where it had launched minutes before. It disappeared behind the shrub line and we gave each other hugs. The flight could be summed up in one beautiful word that all rocket enthusiasts love to hear, "NOMINAL."

"Main deploy!" (I really need a telephoto lens)

It was another two hours before we were allowed to search for (and hopefully recover) the rocket. Going out into the middle of the desert near an active rocket range is understandably a risky and regulated activity. Every recovery team was given a backpack with a radio and a GPS transmitter on it and had to check in with the recovery tent every fifteen minutes. Our recovery team was Anders, Emi, David and me riding out in a van. We got to follow Cornell down-range; their recovery operation was going to be a little less rewarding than ours.

Our rocket actually landed a scant hundred yards from Launch Rail 3A but had managed to touch down on the far side of a restricted proprietary testing zone owned by Spaceport America. After a few minutes of hurried discussion and radio calls, officials agreed to give us an escort through the site so we could retrieve our rocket. After climbing a barbed wire fence (with permission) we located the rocket intact, if slightly windblown, with a functioning payload bay merrily beeping at us. Anders, David and Emi gathered the chutes and sections of the rocket, packed them and unpowered the payload bay before loading everything back into the van. I took pictures.

One googly eye miraculously survived the 600 mph wind shear and 12 gees of launch

Components of our rocket lay in the sand, tied together by shock cord

Apart from a lot of dust and a few paint nicks from being dragged across the rocky terrain by its chute, our rocket was given a clean bill of health at the inspection table. Patrick, after much muttering and frustrated rebooting of the altimeters, managed to finally get our altitude data to the judges. The closer you get to the target, the more points you get. Our simulations had been predicting an altitude of about 11,000 feet, roughly 1000 greater than our target apogee of 10,000 feet. The altimeters had recorded an apogee of 9,681 feet. A mere 319 feet off target!

It was official. As a first year team, we had successfully designed, built, tested, launched and recovered a rocket at an international competition and were set to score easily within the top half! Without a doubt this was one of the best possible debuts our team could have ever hoped for and we'd managed to pull it off. A brief round of packing, celebrations and photo ops later we decided that we had had enough rockets for one day and headed back to camp.

KRR victorious at Spaceport America

- End Day 6 -

Friday June 21 - Day 7 - The Day of Rest

Friday was slow.

We had been running hard all week and decided to just lounge around camp for most of the morning and revel in our success. We had developed friendships with a few teams in particular and had been invited to a pool party (very tempting considering the climate) with Platteville, MSU and one of the Canadian teams. Being able to relax and just talk with a bunch of fellow rocket enthusiasts really was the icing on the cake for our trip. We enjoyed the food, company and pool for several hours before night began to fall. Though our communal time had been fun, it sadly had to be brief as we needed to leave by 8:00 AM in the morning. Earlier, our team had been dubious about doing IREC again next year but being able to see all our new friends again was making it much more tempting.

Four teams, one big family of rocket nerds

- End Day 7 -

Saturday June 22 - Day 8 - Coast Phase

6:45 AM MDT

We woke up and broke down camp. With much grunting and shoving, all our things were slowly being re-crammed into vehicles. I wondered if similar techniques would be needed to pack us in too.

8:05 AM MDT

Somehow, impossibly, we were leaving kind of on time. Despite complaining endlessly about the sun, heat and sand, I felt that everyone on the team was going to miss this place. With one last look at the (in retrospect, lovely) RV park that had been our home for the last week we departed from Elephant ~~Butt~~ Butte.

One last look from Elephant Butte

11:00 PM CST

After a full day of driving and blasting Bohemian Rhapsody, we stopped in Emporia, Kansas during a tremendous thunderstorm to seek shelter for the night. Not inclined to pitch camp, we elected to stay at a motel and hopefully catch a bit of sleep.

- End Day 8 -

Sunday June 23 - Day 9 - The Long Goodbye

6:45 AM CST

The thunderstorm was still there.

The team got up and we shuffled back to our cars in search of McDonalds breakfast (at Patrick's insistence). I begrudgingly ordered an egg McMuffin®. After everyone had been made no longer hungry, the three cars pulled across the road to gas up before setting their destinations. One to Detroit, one to Chicago and one to Minneapolis. This was where we were to part ways.

David tries not cry as the team bids farewell

We exchanged hugs and wished one another well until we met again in September. A few last items and people were shuffled between vehicles and then we were gone.

11:00 PM CST

We'd driven from Kansas through Missouri and Iowa, dropped off Anders in Minneapolis and at long last Erik, Emi and I had made it back to Ashland Wisconsin. I decided to try and drive the last 150 miles home to Hancock that night in my car with the failing wheel bearing and/or CV joint.

- End Day 9 -

Monday June 24 - Day 10 - Splashdown

1:00 AM EST

As the farthest flung member of the team, my arrival home is the official conclusion of our trip. After an exhausting late night drive where I got to have the unique Yooper experience of driving due north into another time zone, I at long last pull into my driveway in Hancock Michigan. I drag my camera bag and backpack into my house and immediately pass out on my bed.

Travel: **3500+ miles**

Max velocity: **550+ mph**

Trip duration: **224 hours**

Flight duration: **180 seconds**

Total payload memory time: **04:28:15**

Spare payload memory time: **00:14:56**

Video: **91.7 gigabytes**

Photos: **4557**

Words in this report: **6490**

Rocket pad weight: **45 lbs.**

States: **11**

Traveling KRR members: **10**

Tents: **4**

Time zones: **3**

Googly eyes: **2** (1 recovered)

Rockets: **1**

ER visits: **0**

Adequate sleep: **No**

Friends made: **Yes**

Mission status: **Nominal**

Result: **Success**

- End of Mission -

Links:

KRR Facebook: https://www.facebook.com/KRR.MTU.EDU/

KRR Website: http://rocketry.students.mtu.edu/

KRR YouTube: https://www.youtube.com/channel/UCjbfShKNQkiyG3VUielw2Ww

IREC Website: http://www.soundingrocket.org/what-is-irec.html