My e-bike build story

The following is a detailed story of how I modified a carbon mountain bike frame into a custom all-purpose e-bike. I divided the text into two sections, 1. For the electrical side and one for the bike build out. The text includes details of how I designed and built a unique lithium battery and the many lessons learned along the way. This document includes some handy composite building technique I have developed over the years that are ideal for the DIY person.

The-Scott gravel bikes (Scott Addict RC eride) are quite interesting; weighting below 30 pounds, and with a range of about 50 miles. The e-gravel bike with X20 Mahle hub motor setup is what I am basing my DIY design direction on.

The hub motor for me has to be a plug and play kit, where the controller and motor were sold together. After an exhaustive search for a through axial hub motor I only found a couple: Mahle X20, Promotion Truckrun, and Keyde. The Mahle x 20 is the idea hub motor, except it is un obtainable for the DIY er due to the proprietary setup with the manufacture and distributor. Mahle is basically forbidding the DIY er to use their motor.

The Keyde s110 has an informative website with technical details, manuals, and design dimensions. The motor has a couple of configurations, but I selected the 36 volt and the standard 142 x 12mm rear axial configuration. The motor is not a true thru axial design like the Mahle, but still functions as one, as there are internal threads on the ends on the hub. Drive and non-drive side bolts goes through the frames through axial holes and into the internal threads of the hub, thus securing it to the frame. The hub has a pair left and right side of locking blocks that slots into the frame to restrict motor rotation.

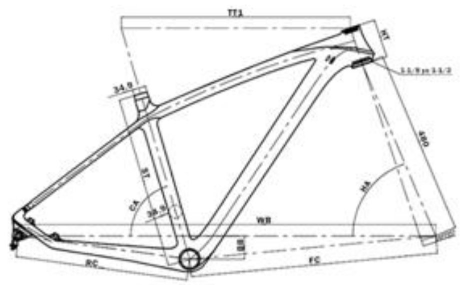
The cool design features of this hub, is that the controller and torque sensor are integral to the hub and that it has blue tooth connectivity to the monitor. It's an integrated kit, just plug and play very little setup required and no extra wiring from the motor to the monitor or the motors gear changing switch.

Bike build

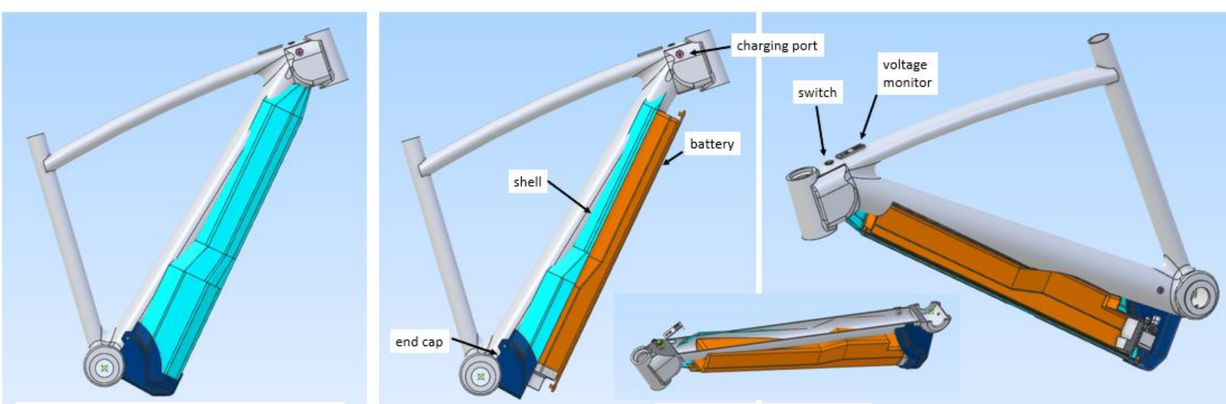
This e bike is designed around converting an off the shelf carbon mountain bike frame into an adventure bike. A medium size (17.5inch) rigid carbon mountain bike frame from BXT off of eBay was acquired at about $300, which is very inexperience for a carbon frame. Lucky, I started buying all my components before the tariffs and elimination of the **de minimis exemption** or the **de minimis rule**.

A lot of conceptualizing when on. To pull this off I needed a 3d model of the frame to get a good understanding of how to modify the frame and get the battery in place where I wanted it.

I have a pretty basic 3d cad software program, [Alibre Atom 3D](), which isn't the best but I own it for about $300 and don't have to pay an annual licensing fee. Alibre Atom 3d is kind of clunky, but you can get pretty close to representing your parts in a 3d model. I asked BXT if they had an available 3d model of the frame, but that request when nowhere. Getting a 3D model would have saved a bunch of time, but at least they had a 2d sketch of the frame geometry available. My concept was to cut the down tube up a bit to fit a battery to the frame. I would then rebuilt and reinforce the downtube to keep the original strength intact.



C-C	ST	TT1	FC	RC	BB	OFFSET	CA	HA	WB	HT
15.5"	394	575	621.5	445	60	39	73.5°	71.5°	1059.7	100
17.5"	445	592	639	445	60	39	73.5°	71.5°	1077	100
19"	483	615	661.5	445	60	39	73.5°	71.5°	1100	110
20.5"	521	639	686.9	445	60	39	73.5°	71.5°	1125.5	130



3d model with down tube shell & end cap, side view

3d model shell cut away side view

Creating the 3d model with the Alibre atom 3d software was really pushing the capabilities of the software and was quite cumbersome in trying to blend surfaces. The model at least gets you in the ball park and allows for creating a 2d dimensional drawing to aid in determining how to cut the down tube and building supporting tooling to build the shell and end cap composite parts.

Another design issue was that I wanted to use a road crankset on the mountain bike frame, as most gravel bikes had larger front chain rings than a typical mountain bike. I prefer to have a double chainring up front similar to most road bikes. My initial thoughts were to go with a road compact crankset (50/34) dura ace, as I would have a hub motor to justify pushing higher gearing. On the back wheel, I would use an 11/42 cassette to cover whatever steep hill I'd try to ride up.

I mounted the dura ace crankset on the mountain frame and soon realized it wasn't compatible for a number of reasons. The geometric specs for the frame are a 68mm wide BB, 12x 142 rear drop out spacing and spacing for a 2.4-inch-wide rear tire. The Shimano Dura Ace crankset is a 50/34 double chain ring x 175mm crank arm with a hollow tech axle at 24mm diameter and 110mm length.

The first main problem was that the axel length was too short. A typical Mountain bike crankset has an axle length of 117 to 120mm. The short axle caused 2 problems, 1. The large chainring would interfere with the frames chain stay, and 2. the non-drive side crank had about a millimeter of clearance to left side chain stay.   The other issues are the difference in the Q-factors for the mountain bike versus the road bike crankset, at about 175mm to 147mm respectfully, about 28 mm total difference, or 14mm on each side. Another compatibility problem was the chain line this crankset created with the 11/42 cassette, which may affect shifting and chain wear.

The design fix is to move the drive side chain rings closer to the frame and to reduce the width of the chain stay where the 50-tooth chain ring interferes with the chain stay. I also had to account for the smaller chain ring might interfere the wider BB area due to battery shell container.

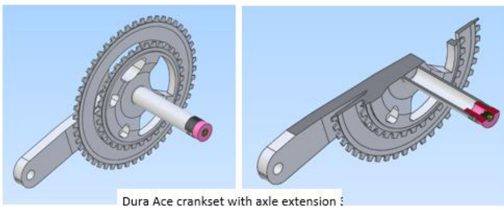

50 tooth chain ring hitting the chain stay


frt small to aft large chain line

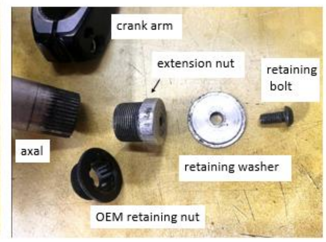

frt large to aft large chain line


frt small to aft small chain line

I came up with a design to make the road axal (110mm) as long as a mountain bike axal (120mm) by adding an extension to the end of the axal. The extension threads into the M20-1.0 internal threads of the axal. The non-drive side crank arm can still engage with about half the splines on the axal and clamp to outer diameter of the extension. The OEM retaining nut is replaced with a simple bolt and washer. The extension allowed me to put spacers on the BSA bottom bracket to position the crank set on non-drive side out a little bit for better clearance.

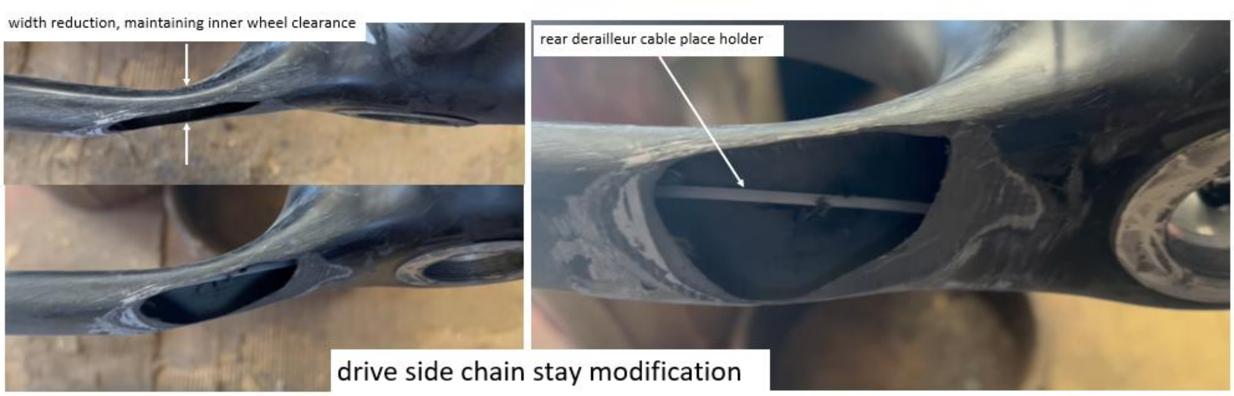

Dura Ace crankset with axle extension :


Dura Ace crank set with extension

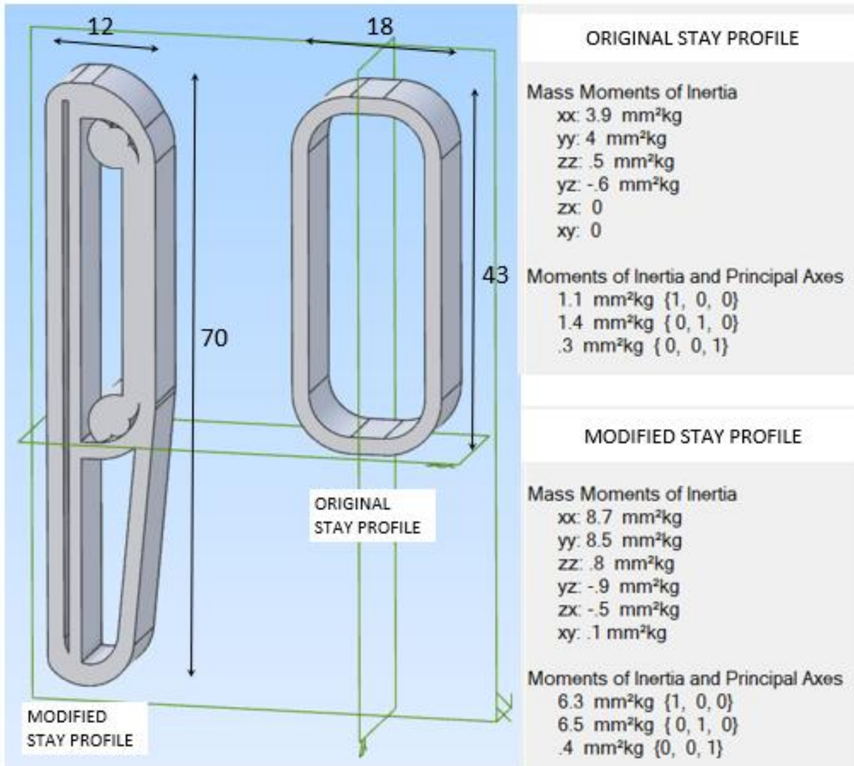


Looking closer at the existing design of the chain stay in that area shows that decreasing the width and increasing the height of the profile downward would be a good option. There's quite a lot of space below the existing chain stay, with the lower limit being the bottom of the bottom bracket shell for clearance for going over rocks. Intuitively, if the width was reduced and the height increased, as well as adding thickness to the existing wall thickness, that a similar section modules could be maintained.

I made a simple model of a 10mm section of the stay that was modified for the chain ring clearance. Roughly shaving off 6 mm from the width and adding about 27mm to the height. I fudged in the approximate reinforcement layup to the modified section to be able to compare the moment of inertia. The moment of inertia determines both the composite stiffness and strength of the part if we did a composite FEA on the stay, but with this simple analysis method would get you a ball park of the material properties. In any case the analysis indicates that the moments of inertia were increased 2 to 6 times the original geometry. The modification/repair and the stay should be fine to handle typical bicycle loads.



drive side chain stay modification



A four-step process was used to repair/modify the stay, 1. Internal reinforcement, 2, Capping the hole with a carbon sheet, 3. Blending the edges with polyester resin and 4. then overwrapping the area with 4 to 5 plies of 3k uni-weave carbon fiber material with ambient curing epoxy resin. A polyester male plug was molded, which would be used to compress the inner layup. The fiber glass rods were wrapped with about 7 layers of carbon at a [0/90] layup, then placed inside the cut out. Fiber glass rods were placed inside the tube. With 3 more plies placed over the rods and into the inner wall of the tube. The plug was mold released and clamped over the inner layup. The plug got slightly bonded to the layup and was chipped out. The layup looked ok, except that one of the rods moved out of place a little. Adhesive glue was spread on the outer edge of the cut out. A thin 3 ply carbon sheet was made to cover the hole and bonded to the stay. The carbon sheet creates the outer profile of the stay. The Dura Ace crankset with a 50/34 rings was installed in the BB to check the chainrings clearance, which looked good.

The final profile was blended into shape with polyester resin (Bondo). 4 to 8 plies of 3K carbon uni-weave fabric with epoxy was wrapped on with more plies on the top and bottom surfaces of the tube. The over wrap was then compressed by wrapping bicycle inner tube around it and then compressed by clamping it in place. The final over wrap was probably about 3-4 mm thick, which was then smoothed and sanded. The dura Ace crankset was installed in the BB and a rear wheel with a mtb 2.3” tire was installed in the frame for a final clearance check. Looks good!

An aluminum sheet was then bonded to the flat section next to the bigger chainring to serve as a chain ring guard for the frame/carbon fiber.

polyester plug

cut out with fiber glass rods

plug compressed /suck to layup

inner layup/ fiber glass rod

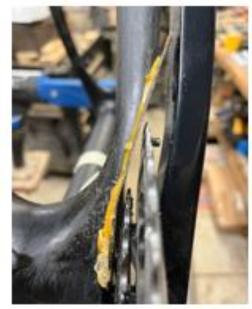
layup cleaned up/ sanded

adhesive glue on cutout edge

carbon sheet clamped in place

carbon sheet clamped

profile check with crankset



big & little ring clearance

inner wheel profile established

shaping/blending shape

over wrap
clamped/compressed

contoured compression blocks

over wrap
clamped/compressed

over wrap clamped/compressed

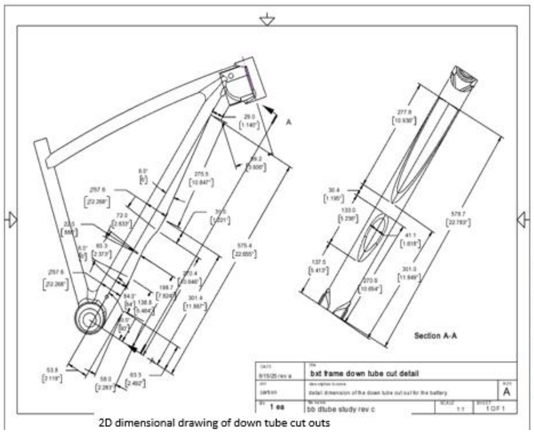
finished over wrap, inside

finished over wrap outside

finished part clearance check

aluminum chain guard

Next up; cutting and modifying the down tube to hold the battery. The 3D model helped to generate a 2D drawing with dimensions to guide in the cutting of the down tube. However, going from a 2D paper drawing to the actual parts was a challenge. I made a wooden drawing guide aid so I could measure and transfer the measurements to the adhesive taped frame and draw in the cut-out shape on the down tube.

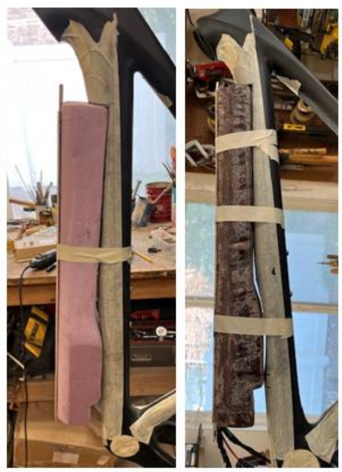


2D dimensional drawing of down tube cut outs

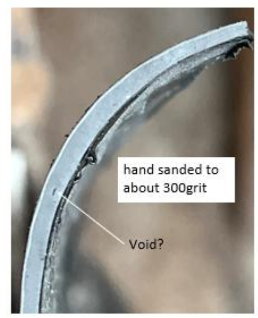

battery and chainring templates superimposed onto frame


measure aids to transfer 2d dimension to actual down tube


down tube cut out


foam battery and real battery pack fit to the cut out


down tube cut out sections



The cut out went pretty well, and yes the frame warrantee is pretty much void! The interesting thing about cutting the frame is that I could see how it was made and the quality of the composite. The sections were about 1.5 to 2 mm thick and made of a uni-directional carbon tape. The inner ply was at about a 45-degree angle, which makes sense for torsional rigidity. Kind of guessing the layup is something of 4 to 8 plies, with a few extra strips on the outer curve as its thicker there than the middle. My guess is the layup is something like this [cloth/0/0/-20/+20/-45/+45]. The composite appeared to be well consolidated. It looks like the frame was bladder molded with both a very thin black rubber layer and a black scrim cloth on the inside surface, as there is kind of a residue in the inner wall from the molding process.

I did a little test to determine if I could internally blader mold the inside of the down tube. As this is a simple one-off project I figured I could use a bicycle inner tube for the bladder. If I could get maybe 10 to 20 psi inside the tube that would help to compact the wet layup, or at least press and hold it in place till it cured. I wrapped the inner tube with a loose-fitting ploy film to allow for expansion. The inner tube was wrapped with 5 plies of uni-fabric in both 3 plies of 3K and 2 plies of 6K material. I then inserted the uncured carbon layup/inner tube into the down tube. The down tube cutouts holes were then capped off with some 4 ply carbon sheets glued to the edges of the cut out and clamped in place.

The inner tube was pressurized with a bicycle pump. It lasted a few hours before the inner tube blew out in an unsupported area well before the resin cured. Oh well, it would still be better than nothing. Probably should have spent a bit more time making this a better option by making more supports for the inner tube at the head tube, down tube and top tube junction as well as the bottom bracket area. Maybe use some polystyrene foam in those regions, and then dissolve it out later with a solvent.

bladder molding test with inner tube

ploy film wrapped on tube

top tube reinforcement for switch and charging port holes

down tube cut out caps clamped to the down tube

bottom and top down tube caps

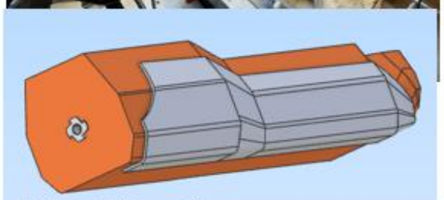
sanded part

Battery Enclosure

The battery enclosure was made up of a left and right shells that were fabricated on a wood mandrel based on the bike frames 3D model. The first set didn't fit to well to the frame and the over lapping design didn't work to well. I modified the mandrel and made another set.

vacuum baged shells

shell mandrel 3D model



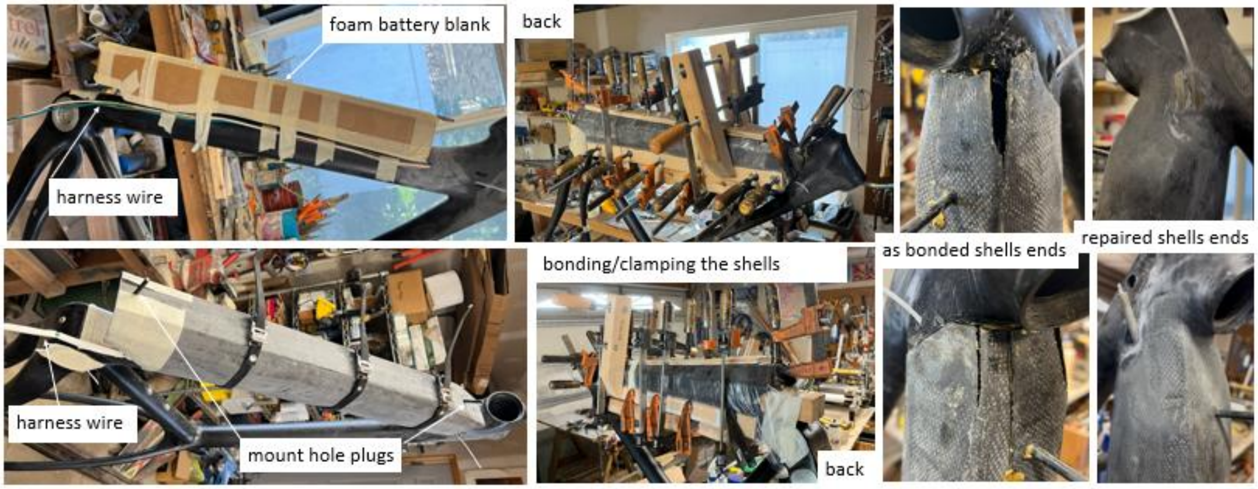
down tube battery shell on wood mandrel

down tube battery shell

Prior to installing and bonding the down tube shells to the frame a foam battery blank was made with pink insulation foam (extruded polystyrene). Card board sheets, a few millimeters thick were cut to the shape of the battery blank profile and adhered to the foam to increase the volume of the battery blank. The foam battery blank would ensure that when clamping the outer shell to the frame that I would have enough space on the inside to slide the real battery in. The outer shells were dry fit to the frame with the battery foam blank in position to determine the fit. The fork and front wheel were installed to determine wheel to battery shell clearance, which looked good.

foam battery blank inserted and shell halfs positioned. Front wheel clearance check

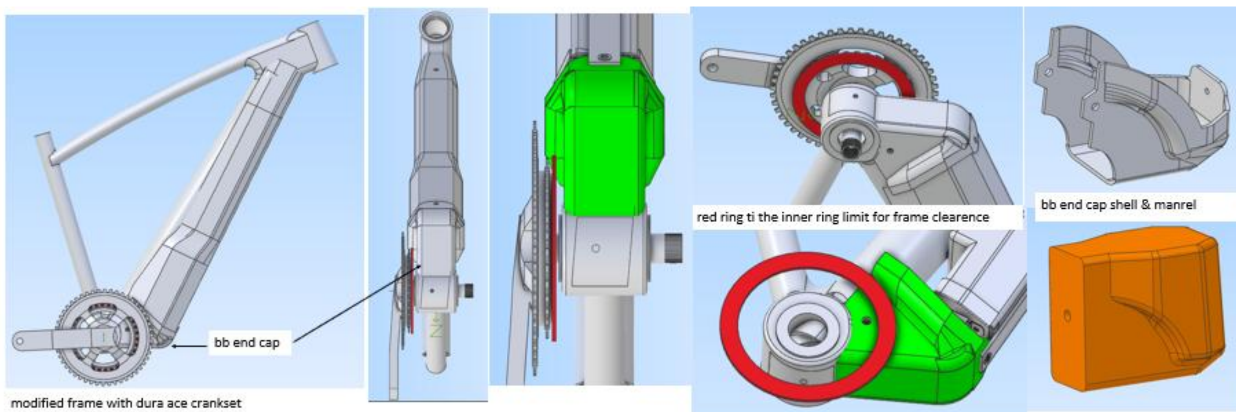
The shell was bonded to the side of the down tube and clamped in place. The fit up by the head tube wasn't the best and was repaired by slotting the shells and squeezing/ bonding in place. The ends were then over wrapped with a few plies to close it out. There was still another over wrap to tie the whole structure together.



Once the shells adhesive setup and the clamps removed a very strong solvent, Pro Thinner was poured right into the extruded polystyrene foam which dissolves it immediately through a chemical reaction. Pro Thinner is a multi-purpose solvent designed to replace traditional solvents such as MEK, toluene, and xylene, offering comparable high-solvency performance with an effective evaporation rate. This is a good method for making composite parts where there are under cuts in the design and mandrel removal would be impossible.

The resulting battery shell enclosure is about 8 plies thick [0/45/0/-45/0] plus the [30/90/0] inner shell. An extra zero-degree ply was placed on the bottom surface and the battery mount holes had extra localized 3k plies of [-45/40/-30/45] applied. Some thin flexible polyethylene sheets cut to the flat sections were placed on to the wet composite and then over wrapped with a spiral wrap release material of plastic shrink wrap packing film. Then bicycle inner tubes stretched to provide compaction was spiral wrapped over the entire part.

Creating the bottom bracket end cap to seal in the battery and wires was the most difficult part to make because the geometry in the BB area is pretty complex. The main constrains were that the inner width of the smaller chain ring could not interfere with the BB end cap and the end cap had to slide over the shell with a tight fit to make it water resistant as well have the mounting hole line up with the battery bolt hole. The attach points of the bb end cap would be a rivet nut similar to the water bottle rivet nuts. The rivet nuts were located on the sides of the down tube. The hole required for the rivet nut was small and would be filled with the nut, so would probably not cause a stress issue.



Building an acceptable BB end cap was a lengthy iteration process of making a part fitting it, then modifying the male mandrel. 6 BB end caps were built in the process first from carbon fiber and then switching to less expensive fiber glass cloth. Even a card board cut out was made to understand the actual bike geometry transferring to the mandrel geometry. Not sure that was the right way to build the BB end cap, but it worked out. It might have been better to make a clay model of the BB end cap shape directly on the frame and then make a mold of that and then either a mold or another mandrel. The inner surface of the BB end cap is what was important, so the male mandrel seemed like the correct approach.

wood BB end cap mandrel and 1st off carbon part

vacuum bagged BB end cap part

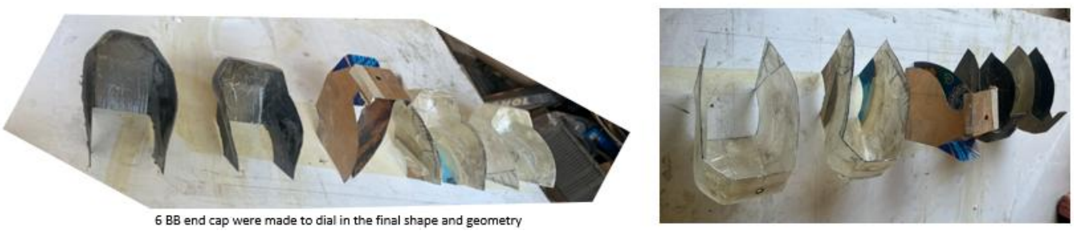
card board BB end Cap template going from 2D to 3D to determine cutout shape

1st BB end cap part, adhesive tape for edge trim lines

end shape was too boxy, shows area to modify on the mandrel

3rd BB end Cap fiber glass part, adjusting fit and finish geometry and edge trim

The fit was not acceptable as the part flared to far from the down tube, need to modify the mandrel



6 BB end cap were made to dial in the final shape and geometry

attachment bolt

Final BB end Cap, fit & finish

good chain ring clearance

flange blend to the down tube

bottom battery mount bolt

good profile match

bottom of the frame, BB door, BB end cap

finished BB area final assembly

fland edge covers

Finalizing the wiring is the next step on the agenda. Mounting the on/off switch, charging port, voltage monitor and the power cable to the hub. In the process of installing these items, finalizing the build some improvements were made. The hub motor has the power cord on the drive side of the bike which is different and concerning as there's a lot of mechanical stuff going on, on that side of the bike. The power cable has to be external to the frame because there is a cable connection from the hub to the battery. To remove the wheel from the frame to fix a flat you have to have access to the cable connection to pull the hub side from the battery side of the cable. Just zip tying the cable to the drive side chain stay would not be too reliable as those zip ties tend to break after a while and having the cable flopping around on a rocky trail could end up damaging the cable. The cable junction is used by hubs blue tooth to connect the monitor and gear shifter to the hub. I have no idea how that works, but it is key to operating the system.

The chain stays geometry is very complex, so pattern tooling was built directly on to the frame with a plastic tube acting as the power cord with various modeling clay build up to incorporate draft angles.   Polyester resin was mixed and place into the mold released molding box to create the negative of the part. This negative mold was then used to make the positive side of the tool. A carbon layup was placed on the male side, the female placed on top and the tool was vacuum bagged, which sucked out the air and provided a compaction pressure for the match mold. The guides were trimmed, sanded and bonded to the frame. An adhesive bond is all that is needed for these parts as there is really no load on it other than the possible rock hit.

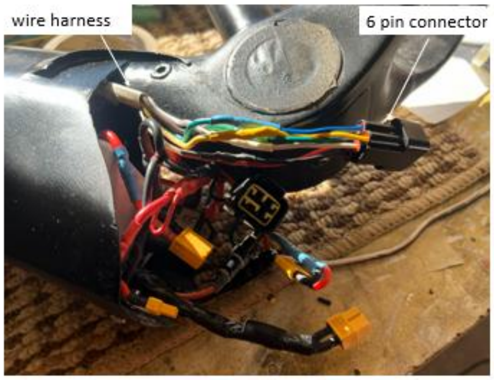
building the tooling to make the power cord guides

finished power cable guide

The internal wire harness was initially molded into the frame when the battery shells were bonded on. It was kind of a good idea, till it wasn't. The wire harness was made up of 6 wires going from the back of the battery pack up to the head tube and switch, charging port and voltage monitor. You can refer to the wire diagram previously noted for details. Unfortunately, I used an old two wire speaker cable for the voltage monitor. Hooked it all up and worked fine till it didn't; the monitor stopped working, which I figured was because it was from China and only cost a dollar.

I connected a new monitor, but that didn't work on the bike either. I tested it off line and it worked fine, so something was wrong with the bike wiring. As it turned out the speaker was pretty old and just broke somewhere in the frame. Replacing the wire harness turned out to be a two full day job as the molded path of the harness was not a straight line. In the end I somehow filed, sanded, chiseled, and drilled a straight over size hole into the battery enclosure. I installed a new wire harness and a latching on/off switch that lights up when it's on.

The Keyde hub motor has monitor and gear selector that is the blue tooth connected to the hub motor. The blue tooth connectivity make wiring the system a lot simpler. The gear power selector has 1-5 settings, with 5 being the most powerful. The power setting of 1 is like a nice 10mph tail wind, which gives it a very natural feel. I installed a voltage monitor, which is quite handy to have as it gives a pretty accurate reading to the battery's state of charge. At 40.5 volts it is fully charged. I can easily do 3 or 4, 10-mile mountain bike rides at this level or 40+ miles of hilly trail riding with 2k+ feet of climbing. When the battery gets down to about 33 volts the Keyde monitor shows it in the red zone or 10 to 13 % battery left. My custom-built battery is about 600Wh and using Mahle milage rates of 2.5WH/Km (4Wh/mi) I should get about 240Km (150mi) from the system. That high mileage doesn't seem realistic.



latching switch & voltage monitor

Gearing/ Compatibility

I learned the hard lesson that the 3 classes of bicycles; road, gravel, mountain bikes components are not interchangeable. I learned that a gravel flat bar trigger shifter (GRX) isn't compatible with an XT mountain bike rear derailleur because the pull ratios inside the shifter mechanism are different, therefore not compatible. Shimano XT shifter has a pull ratio of 1.7mm/mm. The GRX flat bar shifter which is compactable with road derailleurs has a pull ratio of 1.1mm/mm for 11 speed shifting systems. Shifter pull ratios differ between mountain bikes (MTB) and road bikes primarily due to design constraints, intended terrain, and component evolution. The MTB shifters often pulling more cable per click for wider gear ranges and stronger shifts over rough terrain (like 1.7:1 or more), while road shifters have compact lever bodies limiting cable pull (like 1.1:1 or 1.4:1) for smoother, faster, closer-ratio changes on pavement. These different pull ratios create distinct families that generally don't mix without adapters.

I carefully selected the derailleurs front and rear based on the gearing I thought I could use, 50/34 teeth front chain ring and 11-42 teeth rear cassette, 11 speed. The rear derailleur capacities of XT derailleurs for the long cage has the capacities of 47t chain wrap and 46t maximum big chainring for a 1x. I am a few teeth over chain wrap specification with the 46/28 and 11/42 cassette at 49t, but it seems to be working ok. The rear derailleur worked with the 50/34 and 11-42 at a chain wrap of 47t, with the maximum ring at 50t. I think the derailleur capacities are more of a guide line than a go/no go gauge. There's a handy chain length calculator here that showed for the dura ace 50/34 and the 11/42 cassette I needed a nonstandard long chain of 122 links versus the standard of 118 links. I use an Ultegra front derailleur with a capacity of 16t (50-34=16). When I switched the front crankset gearing to 46/28 it created a capacity of 18t, which exceeded the recommended capacity of the Ultra derailleur, but it is working, but kind of touchy to adjust and shifting can be a bit slow at times. Another option would be a Shimano Tourney FD-A073 Front Derailleur with a capacity of 20t, which is really cheap as a backup in case the Ultegra starts to get unmanageable. The front derailleurs are also complicated to select beyond just the capacities specs, with all the mounting and cable pull options.

The incompatibility gets even worst when you're looking at cranksets and chain rings. The front chain rings selection and compatibility with the BCD (bolt circle diameters) is very confusing. Seldon Brown has a good page explaining some of the engineering background around symmetric and asymmetric BCD. It would seem that the engineering gain between these small BCD differences on the inner ring BCD of 90, 80, 74 and 64 and likewise the larger ring BCD of 130,110, and 104 wouldn't be that great. I ended up buying and building up 5 cranksets before I got one that met my needs.

I have a steep rocky trail (the secret road) I use to gauge my lower gear selection, it's maybe a 20% grade, but I see it as the worst-case climb I would want to encounter on a ride. Anything steeper and rockier than that and it's a hike a bike climb. The crankset comparison table represents all the combinations I tested or consider for the build. The evaluation started off with the Dura Ace crankset with a 50/34, and climbing with the 34 tooth small chainring really stressed out the hub motor to the point that internal planetary gears were skipping and grinning. I soon learned that the hub motor does not like slow speed with high torque situations.

11 speed crankset comparison

make	model	weight	axal	Q factor	# bolts	pattern	chain rings	BCD outer/inner	available chainringns
shimano	Dura Ace	685	24d x110	148	4	asymetric	double	110	53/39
shimano	GRX	710	24dx 110	151	4	asymetric	double/ single	110/80	48/31 46/30
shimano	vinage XT	860	24d x120	180	5	n/a	triple	110/74	46/36/24 44/32/22
shimano	XT	774	24d x120	176	4	asymetric	triple	104/64	46/36/24 44/32/22
shimano	XT direct mnt	710	24d x120	172	4	asymetric	single/ double	104	spider adpater 52-32
Raceworks	XT	814	24d x120	175	4	symetrical	single/ double	104/64	52-32 / 32-22

Figuring out how to setup the Keyde hub was an experiment as well, as the instructions didn't cover how the thing actually functions. The hub has a torque sensor in it and I assumed at higher torque situations (climbing) the power output would increase, but it actually was the opposite. On flat terrain the hub would give you a huge boost of power maybe 350 watts, and on a steep climb it would put out about 100 watts. I later turned off the torque sensor mode and just set the power manually to the setting of 1-5, where 1 was about 100 to 50 watts of boost. 5 was the maximum at 350 watts. You could also set the maximum boost to 500 watts, but I felt that was a bit much. Most of the time I would keep the hub on the 1 power setting with a maximum of 250 watts. The power setting of 1 felt more natural and like riding with a tail wind pushing you along. On steeper climbs I would bump the power up to 2 or 3 and spin the crank, the hub motor skipped less in that mode. There seems to be a threshold of some slow speed and torque when the motor skips: it's very ignoring. To stop the grinding noise/skipping you have to back pedal about ¼ turn and it stops, typically you lose all your momentum.

I decided that the correct low gearing for this bike would be a situation where I had to shut the hub motor off to eliminate the skipping and just pedal under my own power. This e-bike is about 10-12 pounds heavier than the non-motorized version of this bike, which means the gearing had to be lower than usual.

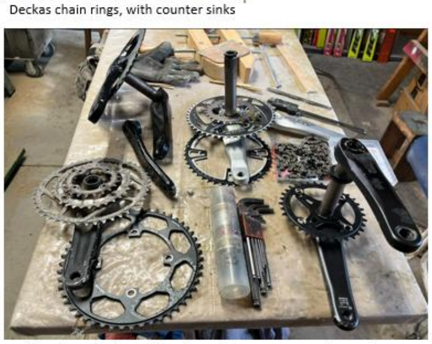
After searching the internet for smaller dura ace chainring and not finding any, I switched to the GRX (46/30) crankset because it had a 30t ring and a 110 BCD for the larger ring, which I could install a new 50t ring. I purchased a 50t x 110bcd from Deckas for the GRX, but I had to machine a counter sunk hole to recess the bolt head so the chain wouldn't hit it. The 30t ring almost worked, but decide I needed a 28t or 26t small ring. How about that; you can't get those smaller chainrings in a 80 BCD. I found that there is a pretty big variety of chain rings in the 104 BCD and the 64 BCD from Deckas.

Then I searched the internet for more crankset options with the 104/64 BCD patterns; I found a couple and when with the Racework XT one as it was only $50 and hollow tech 24mm diameter x 120 axal. It's weird the Racework axal was 120mm, but the retaining nut wouldn't go deep enough into the axal to retain the left crank arm, so I machined 2 mm off the shaft, and fixed it.


Deckas chain rings, with counter sinks


machining counter sinks holes


old9 speed XT hollow tech triple setup as a double


variety of cranksets consider to meet lower gear requirements.

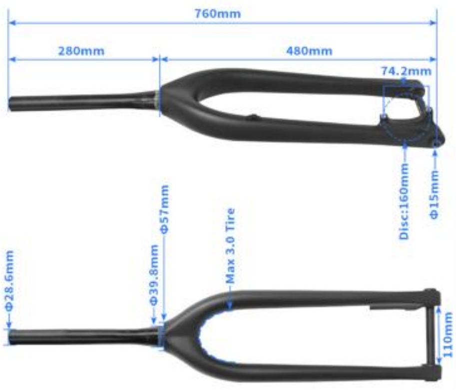

Shimano GRX crank set


Raceworks XT crank set


final crankset selection , raceworks XT with 46/28 t, Utrera front derailleur

The last modification to the bike was to change out the straight rigid carbon fork to one that has 45mm of rake to it.   The handling characteristics of the bike was kind of twitchy, more like a road criterium bike. The additional rake made an immediate improvement in the handling characteristics. I am sure having the big 3” 29er tire and the increased moment of inertia on the front has something to do with the handling characteristics. The other thing I feel when riding the bike on trails is the lower center of gravity from the additional 12 pounds under neat, but after a bunch of rides you get used to it.

The 3” front tire does smooth out rough trails a bit, and rolls over fist size rocks with ease. The cornering grip is outstanding and riding in soft sand or dirt is no problem at all, it tends to float over it. I haven’t had a front flat tire in 5 years using the 3” tire, but in an emergency a regular 29er tube will probably get you home.



1st fork, no rake


2nd fork 45mm rake

Conclusion

finished e-bike

It took a big effort to build this e-bike, but I have exactly what I want and it works. I didn’t meet my original weight goal of under 30 pounds (13.6 Kg) and came in about 35 pounds (15.9Kg), which is not too bad considering it was kind of an ad hoc build and modification to an existing frame. For an e-bike with this milage range; the 35 pounds is still pretty good. It's not a race bike, it's a bike that can go anywhere, paved or dirt roads, to rough rocky trails. It's a full rigid hard tail, so your rocky trail descending speed is limited due to bouncing around, which is good it makes you ride a bit slower on the descends.

On a good note, I have had a number of email communications with Keyde about the motor performance. My first impression was that because the company is in China, I'd be on my own with no response to my emails. They assured me that "the planetary gears are made of aerospace grade materials", but didn't say they were metal, so that could mean anything. I did ask if they had a planetary gear replacement kit for when these finally strip out completely, that request got no response. They did say that they are aware of the problems and are currently doing development work to improve the hub motor's robustness and slow speed/ high torque performance. So maybe the next version will be better.

With the inherent limitations of the hub motor do I regret spending all these hours building a bike around a hub motor concept? No. I think the mid-drive DIY market is probably more restrictive and locked up by the OMEs similar the Mahle company. In only a short time the Scott gravel e-bikes have gone from a hub design to the mid-drive design, probably for all the short comings with the hub motors I have sighted previously. The proprietary nature of the mid-drive motor designed e-bike is pretty extensive, from the availability of a motor to the public, motor mount geometry, electronic controls, special cranksets, bottom bracket design, torque sensors, controllers and bicycle frame design. Would I build another one? Probably, not, but it would be a lot easier the 2nd time around. I will probably just maintain this one for the next few years till I can't ride it any more. I hope that by publishing this, that it will help someone build their dream bike. Good luck and be safe.