Speaker 1: I wouldn't worry too much about TLEs. The reason I'm hammering you guys on LoRa is LoRa is really low data rates as you guys know. Like it's an incredibly noise resilient system but your data rates are shit. So it might be good enough to get a beacon, it might be good enough to do some commanding but if you want to get any data down you're kind of shooting yourself in the foot and I'm not sure you need to do that at that point. Okay, go on. I'll just throw in right use the information as you see fit. Obviously.

Speaker 2: Yeah, I think I was mostly.

Speaker 1: Who you launching with, do you know?

Speaker 2: Launching with Rocket Lab.

Speaker 1: So we got and you will get the same, you will get TLEs from Rocket Lab. I would just do you have a launch integrator? Like someone who does the integration for you guys?

Speaker 2: Um, yeah, I think I think we do generally. That goes through like goes through the project manager essentially. It's a little convoluted because the main payload is like some sort of classified thing that we can't really speak about.

Speaker 1: So you will have a launch integrator. These are companies that specialize on that. They talk directly to Rocket Lab in this case. So they are the main point of contact. But I'm very very certain that you will get TLEs from them. Rocket Lab will give it to them and then they will give it to you. Unless, and this is an important unless, if the sensor is classified to that degree, it might be that you're not getting TLEs. So that might be the one caveat, right?

Speaker 2: That's what we're quite worried about is that we never can get TLEs and in such can never establish contact and that's the reason we went with LoRa.

Speaker 1: Okay. The other thing is, do you guys know about SatNOGS?

Speaker 2: We have investigated SatNOGS because we're planning on LoRa so we're planning on SatNOGS but SatNOGS was our plan when we originally had GMSK.

Speaker 1: Right. SatNOGS will mainly you're gonna leverage all of these people using whatever they have in their backyard and they love picking up, you know, whatever is new and that will give you everything. They reconstruct TLEs also from there you can get SatNOGS TLEs.

Speaker 2: Yeah, because we were talking to one of the experts in, um, that we emailed and they said that SatNOGS does not upload unmodulated waveforms to the thing, it only uploads the demodulated waveforms and as such if we don't have TLEs we weren't sure that we'd be able to detect it but I guess reaching out to the community is a good idea we hadn't considered.

Speaker 1: You will even even if you have no modulation that you provide them you're gonna see when you're in contact or not. You're gonna see the passes because you're gonna get like essentially intensities as a function of time and from that alone you can that's all you need. You can see whenever you came in contact and you can see when you lose contact and that kind of bounds your like essentially the orbit right it's like plus minus 1 or 2 minutes obviously because

you don't know exactly what elevation above the ground you're gonna get contact with. But, I think Juan is about to pull it up. No. No they pick up actually use SatNOGS to get a better TLE.

Speaker 2: Yeah I think also I think with their current transceiver tech we can switch between LoRa and GMSK on demand essentially so that's so I think I was always advocating for GMSK just for data transfer reasons but I think it's good that we can like actually do it and it has decent power output as well so it's not a big deal.

Speaker 1: Yeah. So right you can kind of see in this case we have a beacon that just transmits like every whatever seconds you can see the modulation there. But like based on that you can see exactly what time you get in contact with, what time you lose contact and from there if you guys have some kind of orbit propagation you can reconstruct it but there are TLEs as part of the observations. You can get data from it if it's not encrypted or if you're happy giving them the encryption. You have here the TLEs. Have you guys there is a I forgot the name there is a really cheap CubeSat pumpkin no it's not pumpkin it's have you guys talked to the stack people the one that launched before you guys?

Speaker 2: Um no, which one?

Speaker 1: There was a CubeSat mission like two years ago or so that launched from a Berkeley CubeSat mission.

Speaker 2: Oh Berkeley oh um I don't think I've actually gotten in contact with them I should probably I should probably do that.

Speaker 1: I would reach out to them. They might have graduated. Um what were they called? The BearSat no. Oh yeah I remember I remember you talking about this. Qubiesat? Q-U-B-I-E yeah. Yeah. Q-U-B-I-E-Sat. Yeah with a Q I see right yeah yes. Um and the reason I bring this up is they there is a I forgot what the there is a open source hardware and software provider. It's I'll find it in a second I'm going to look for a few more minutes. It's a guy from the Bay Area actually who started it he did in his PhD and he has like you have all the schematics everything is and I think it includes like include the power board and whatnot and I think it also includes the radio.

Speaker 3: I think I know the one that posts videos on YouTube.

Speaker 1: Maybe. He's a CEO of a company now. Um but you have also you have also start computing space no.

Speaker 2: Okay, we'll reach out to them at the earliest possible opportunity. Um I was wondering if it's possible for us to ask any questions about our electrical subsystems if you have experience regarding the EPS and PDM?

Speaker 1: Yes, I mean you can try. I'm not an electrical engineer but I have enough exposure to electrical engineering.

Speaker 2: Yeah thank you. So basically um our main bottleneck on the electrical system is that we have a power controller that um serves two functions. First of all, um we use solar for charging our battery of course and we have to delegate solar power output so that the battery charges properly. So we have the charge controller and we also have the power controller for the entire

satellite and the power controller um has to modulate our 11.1 volt signal from our battery pack and that's just nominal it can vary um and it has to modulate that 11.1 volt nominal down to 5 volts for bus voltage and we were wondering especially given that those are integrated circuits um are there versions of them that are affordable to someone with our price constraints that are not too vulnerable to single event upsets and that kind of thing in space because a single event upset in our power system would obviously be really bad thing especially given that the search protection etc on microcontrollers is not great and we don't have really the budget to afford a proper flight computer.

Speaker 1: So, to give you an idea you have about one single event upset per year in low Earth orbit. I don't think you guys need to worry about that like that's it can happen of course but you will be unlucky for it to happen. Um there are much riskier things in low Earth orbit from like thermal cycling to like inrush currents to whatever it is. Um so what I'm hearing though is you guys want to buy one you don't want to build one right? Um buy a power controller?

Speaker 2: Yeah we have no real issue with building power controllers it's just that um yeah we we can manufacture PCBs if necessary it's not it's not an it's not that big of an issue. Um the main issue for us in that regard is just that of course we'd need to double check the schematics so satisfy our needs and everything and we're designing custom interfaces for plenty of circuitry especially with the transceiver interfacing and everything it's it's not the end of the world if you'd say it would be better for us to build it ourselves.

Speaker 1: I mean okay it all comes down to timeline if you guys want to launch in November you probably don't have the time to go through like like any kind of design you have at least an iteration cycle to learn what you need to learn before you build the final board. I don't know what speed you guys are working on. Um it is optimistic to do it it's not impossible it's optimistic to do it on that short time scale. Um I will again try to find and send you an email afterwards with the exact um model that I have in mind it's just like the components are like or the boards you can buy the fully built PCBs with like you know batteries as part of the solution and what-not. Um I will find that for you but um I wouldn't worry about single event upsets what I would worry about is essentially making sure that your voltage rails are stable and that you essentially can turn on and off everything under all different conditions that's much more risky than any kind of chance event. And same with microcontrollers right um if you have a resilient strategy in terms of your software um you have watchdog resets um I would focus focus on don't focus on building something that will not fail focus on something that can recover even after it has failed like that's kind of like the 101 on like avionics or sorry aviation right. Do not just assume shit fails can you recover from that? So as long as you keep that as your design philosophy and this is like you know if you have an upset reboot. Um you know if you have whatever OBC you are having if you have corruption on like whatever image you have do some checks make sure that your bootloader does a CRC check before you boot into it if the CRC check fails have a backup option that you can go into. So focus on resilience over essentially a design that can never fail and that way you will gain much more than like avoiding that one SEU that you there's not much you can do anyway unless you want to shield and then even that's not going to work it's it's assuming the risk of overall total radiation dose just life of the microcontrollers or something?

Speaker 1: Most COTs parts these days are rated to about 5 kilo rads and on orbit you should most likely not get more than like a few kilo rads per year if your mission life is like two-three days forget it like it's you're fine you're fine you can fly your phone and your phone will survive.

Speaker 2: Yeah ideally Ideally we're expecting about seven days but I'd like it to be at least like a month to two.

Speaker 1: Yeah you're fine you're fine. I mean they have flown an iPhone before as the main computer for a satellite. Yeah radiation is a problem but not the end of the world.

Speaker 2: And so also I think one of the main um one of the main ideas with this um flight was to use like a partially additive manufactured satellite with PPS and with other types of plastic um um some like 3D printed plastic within the satellite somewhere?

Speaker 1: What do you mean 3D printed GPS? Well okay so it's complicated basically what it is is one of our launch constraints is that we try to explore new possibilities in consumer avionics and the possibility that our project manager intends to explore is regarding the viability of additive remanufactured stuff in space so he wants at least a significant portion of our satellite to be 3D printed using PPS carbon fiber um I'm not too knowledgeable on the exact makeup of the filament but I believe it's 90% carbon fiber infill and we were very unsure the three of us about the viability of such manufacturing especially in a CubeSat system and um because he didn't um we first convinced him that it's completely unfeasible to use that for the frame for obvious reasons and after that um he's quite set dead set on having the internal components um interface or not interface rest on a sort of PPS substrate and I wasn't very comfortable with that either. Yeah um I can tell you I mean I don't have necessarily a strong opinion on this um be careful with getting sucked into like buzzwords and then them making your life difficult um I think the best argument you can use is for thermal reasons alone you want to have the highest thermal conductivity to essentially cool your components or potentially right you want to isolate them. Thermal reasons should be the main um argument so unless you have a thermal model I would be careful. And the second thing is any kind of manufacture like this um will have imperfections which make your vibe profile much more difficult. So unless right you've shown that you've printed this four-five times and vibed it four-five times and has survived it's going to be tough because let's say you do one print um you vibe it and it passes this doesn't mean that the second print will also work so you can it's very hard to basically use heritage as an argument. Um that being said right at the end of the day I would go with whatever is cheapest and fastest like if it takes three weeks to print another component versus three hours to get it in the machine shop you're losing three weeks and anything anything in an iterative cycle that takes three weeks will kill you down and then you don't have that time. So again keep it simple and move fast and if you because of it sounds like a slight vanity project if you're moving along with that you're might just slow yourself down for no apparent reason other than vanity.

Speaker 2: Yeah, I think I think we're mostly worried about like well the project manager is very adamant on like you know not even considering machining a lot of the components that we need for it's just it's not I don't I don't like the idea.

Speaker 1: Right and his argument is that there's a team that did it before and I don't think that's any sort of decent argument and that's like saying like if your friend jumps off a cliff so why don't you go jump off a cliff? Um did you guys I mean it sounds like quite some frustrations build up inside the team about this already maybe somewhat keep it at that. Um yeah build a mass model have him lead building a mass model and vibe that thing. If that fails in vibe for whatever reason that's it like you're jumping off that wagon right there and then there's no reinforcing it because it it doesn't work. If it survives vibe with all the different mass then it doesn't really matter and then you have to basically make an argument how much does it cost and how fast is it.

Speaker 2: He supervised really liked the Japanese satellite the Japanese wood yeah.

Speaker 1: I I think they were very careful when selecting the material for that satellite I think they Definitely tested it in space. Certainly they they had a special thing so that the wood becomes combustible oh wow. The other thing is outgassing. Um you have to meet outgassing requirements you're not the main payload it's going to be there's going to be a bunch of payloads if you're not meeting outgassing requirements and if there's no NASA standard for that specific material you can't fly and this is by the way why we're not flying 3D printed stuff right now because we can't meet the outgassing it is by definition right it is a process where gas is essentially right the filament has to be molten and then it it solidifies again so there is a phase transition involved which also means that like there is gas trapped in there and if you send that put that stuff in vacuum you're contaminating and if you do not you have to show um to your rocket or launch provider again you have to show a list of all the materials and what their outgassing components are. There is a beautiful NASA list that has all of this information right you can if you look it up it's called total mass loss and TML there's another term. If you look this up for the NASA standard you can find all the different materials if your specific material is not in there that means you have to qualify it yourself and if you don't do this you're gonna get you know X'd from the mission so that's another really good argument if you need another one to push back a little bit. TML and what is it? Collectible volatile condensable matter CVCM. TML total mass loss and CVCM collective volatile condensable material. That's essentially how much material becomes volatilized in vacuum and then can condense out afterwards. And there's a there is a NASA overview for all the different outgassing database that's what it is look for that and if you can't find your material in there you have to qualify it and you don't want to do that that's an insane task.

Speaker 2: Yeah, that that makes a lot more sense. I think there'll be some sort of problem with launching random random materials into space right now?

Speaker 1: I mean if you pay for it you possibly could but you're not the main the main payload. The main payload is surprisingly very chill with us doing whatever we want but I think with Rocket Lab. I'm not sure the project manager is telling us the whole story about the main payload and also I have a feeling well we can't just consider the main payload's requirements you also have to consider the launch provider's requirements because it's a bad look for the launch provider if we do something and their rocket blows up in the air so if you cause the main payload to fail you are in big trouble. So the the payload whatever the main payload is they will have interest because they spend money it's a big comms satellite I think oh definitely there's a like there is a multi hundred million dollar mission um they will have some requirement and their star tracker doesn't

want to have anything condense on their lens because that means they can't fly. So I would again I would talk to Rocket Lab and your integration provider and ask them for like your payloads normally it's called the do not harm you basically have to assure that you cannot harm any of the other payloads and mass loss and condensation slash outgassing is part of that equation. The thing I sent you um let me just um let me just pull up send them the outgassing database and I'll send you the numbers that you have to stay below because you need to basically every mission has the same number to stay below. Outgassing database okay out you won't pull find it? Yeah I believe in your abilities to find it. Yeah so just less than 1% total mass loss and less than 0.1 collectible volatile condensable matter. So it's small right so that's why most stuff yeah that does also seem very reasonable so. Yeah and you know there's most space qualified stuff is easily within that but everything that's not I would for example wood would also outgas but again that Japanese thing was super treated and they were Japanese.

Speaker 2: I don't know other companies want to go with some wood satellite there's that Swedish idea to send microcapillary tubes up to space for something and that would outgas too?

Speaker 1: No that was the there was this guy who wanted to send microcapillary tubes up to space and I think I vetoed that on the spot there's just no way.

Speaker 2: I mean they will probably break and outgas exactly I mean I've seen these things break when like you have any amount of liquid through them that's not like hauled in by capillary action there's no way these things survive actual space launch profile.

Speaker 1: I mean you can right but then you basically have to build your mechanical interface to like absorb all of the vibration profile. Can be done. But that's a whole project within our budget no probably not. Okay. Should let us go as he has another meeting and I have no knowledge. Yeah do you guys have review like design reviews?

Speaker 2: Um I mean you kind of joined pretty late I mean um we kind of joined like some months ago and Adam joined both of them around four days after I joined so most of the project has gone ahead without us and it was in a really bad shape when we joined it's not any better now so it won't be better either to be honest it's gonna be a mess.

Speaker 1: Um so that's why I'm saying like go yeah you can email us and just the the easiest way to get feedback out of um us and like essentially what we do here is like if you have like a review and this is really really important when you have a review with like people who don't have authority to stop you from going on you have to come with all of your worst problems and let them brainstorm with you. Don't try to convince them that you can fly try to convince them that you can't fly and they will come up with ways to help you out to fly right just like take advice. If they have the authority to stop you from launch then you have to be a good storyteller. If they don't be honest do nothing hiding what is not working you gain everything in showing why it is not working.

Speaker 2: Yeah I think I think yeah it was completely out of shape I don't think there was even comms before we joined so we're in a better state but I'm still pretty in a bad shape.

Speaker 1: Oh yeah of course. I mean so go go with the PiCube stuff take a look and get it to work buy it and get it to work that is a top already. Okay thank you. Cool. Okay email me I'm on the email chain as well I think I'm on some of the email addresses there. Um I'm Chris so you have the email address there. Um and another thing I'll tell you guys send follow-up emails we're all busy if we don't answer and you need an answer send a follow-up keep your questions brief but then follow-up. Of course. Thank you for taking time no problem compared to here so happy it's Friday. Adi what are you? Electrical software and power? Factor of electrical engine? Yeah I'm basically just software. Very much. Most of us are collaborating on systems because it's written in C Rust and we're just doing a lot of um work together on it because it's it's better if we all contribute if we all collaborate on it because we're we're more likely to catch stuff that the others don't have. Okay easier to get lost because everyone. At the same time yeah I get it. Okay. Okay thank you guys. Good luck. Thank you future lunch.

Speaker 2: Thank you. Thank you. Bye.

Speaker 1: Bye.