Satellite

Notes

2xHC-12

ATTINY 85

Solar Panel

if it hears any other one it id’s itself then msg’s can be routed through it

Cardsat

Pcb motor for reactionary wheels

Balloon drop vech

https://asciinema.org/

Links

https://news.stanford.edu/2019/06/03/chip-size-satellites-orbit-earth/

file:///Users/masonwright/Downloads/05_soc.pdf

https://www.nasa.gov/sites/default/files/atoms/files/nasa_csli_cubesat_101_508.pdf

https://science.howstuffworks.com/how-is-gps-used-in-spaceflight.htm#:~:text=Flying in low-Earth orbit,only transmit down%2C not up.

https://www.insidegnss.com/auto/IGM_julaug14-Hauschild.pdf

https://www.alibaba.com/product-detail/Factory-price-dtp-656294-dtp-606090_62388867133.html?spm=a2700.wholesale.0.0.699d57ca713EbF https://www.alibaba.com/product-detail/Solar-5v-Cell-DIY-Solar-Panel_1600452911686.html?spm=a2700.galleryofferlist.normal_offer.d_title.39cf7ce3Z6PQJm&s=p

adafruit.com/product/1904?gclid=CjwKCAjw77WVBhBuEiwAJ-YoJI8eYMwJekDv0qo1jWvYrH070xRpqgKUs3IqZth4h-8DB4Ic8EiIAhoCnjMQAvD_BwE

https://www.planet.com/pulse/planet-openlst-radio-solution-for-cubesats/

http://www.ernstc.dk/arduino/tinycom.html

Write up

“Satellite on a chip” refers to a single PCB that can perform all the functions of a satellite without any other supporting systems. The “Satellite on a chip” or SOC, as I will be referring to it from now on, we will be trying to build will be a communications relay that is capable of intelligent routing messages to other SOCs in the network.

The inspiration for this project is the **SWARM M138 MODEM.** Swarm’s services allow a device to send 750 packets (up to 192 bytes per packet) a month with a subscription for $60/year plus the hardware cost. This seems like a good (although low bandwidth) alternative to using a service like particle.io which is a cheaper and faster service that uses LTE, not a dedicated satellite network.

The design parameters I am going to shoot for are:

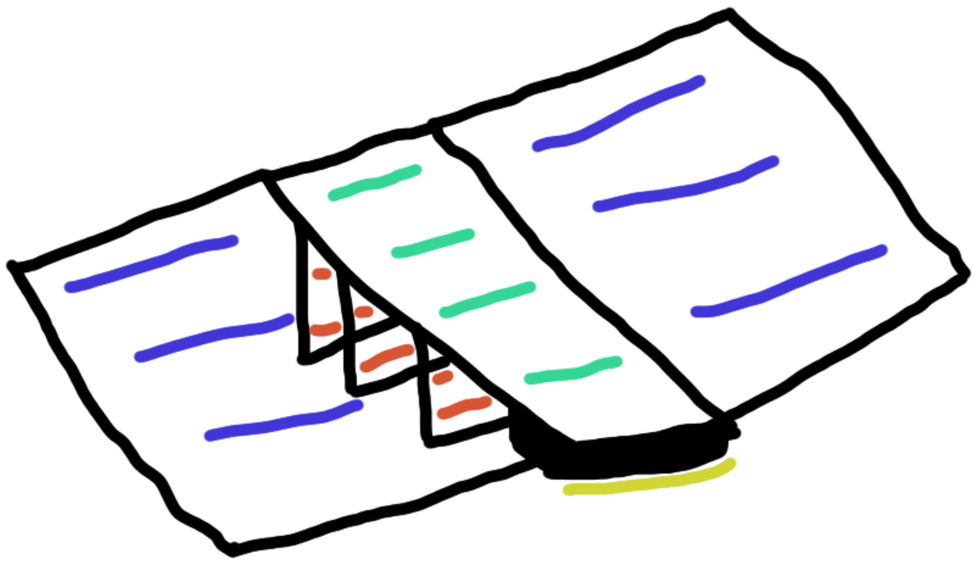
- Solar panels that can self-orient towards the sun.
- Minimum of two radio transceivers
- The SOC needs to know when it will de-orbit

- In the storage position, it needs to be no thicker than 10mm

When setting up a project like this you will need some way to make money to pay to put the network up and maintain it throughout its life. For this article, I will be setting up a small startup and working through the economics of starting this service. I am going to be targeting the same hobbyist/small business customer base as SWARM and Particle.io. For a domain name, I am thinking **chipset.co**

Chip design

Below I’ve sketched out an idealized design for a satellite that would be able to accomplish the mission, however, it doesn’t fit the design parameters so I need to adapt it to fit, but first, let's go through the design to see what we can take from it.



The components of the satellite are color-coded as below:

- Blue - Solar Panels
- Green - PCB
- Yellow - Battery
- Red - Transceiver

Design Break down

Pros

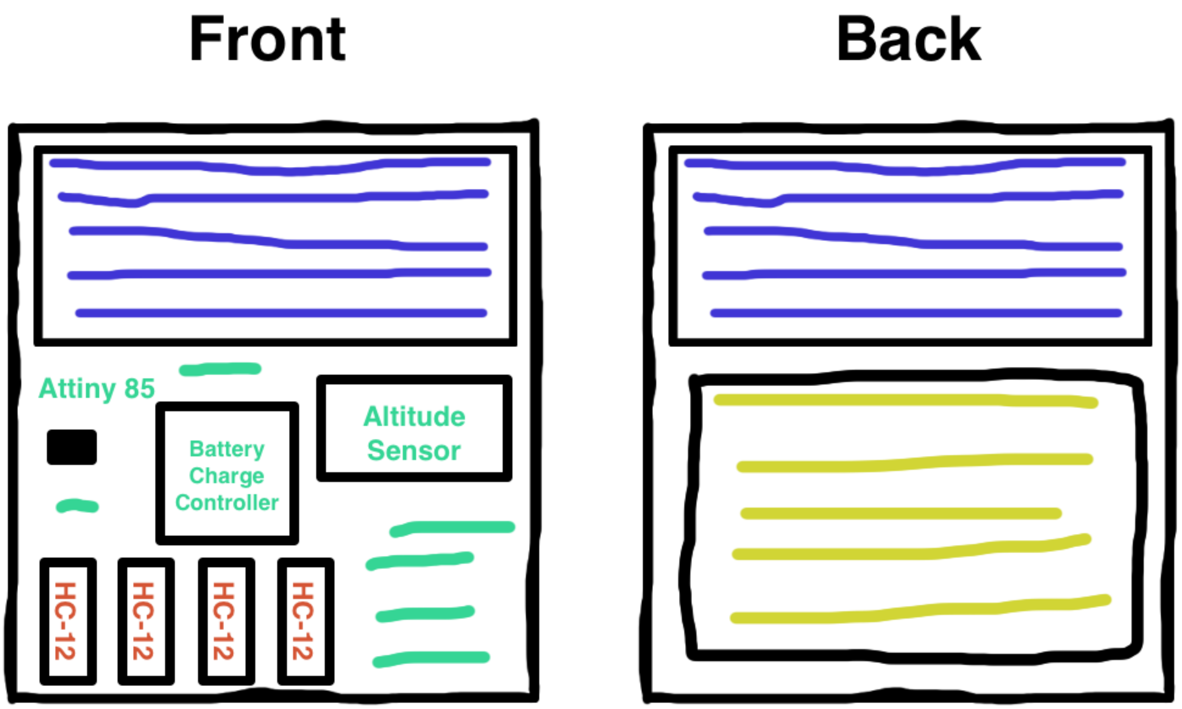
- Larger design that can hold a lot of electronics
- Large solar panels that can power it

Cons

- Larger designs cost more to put into space
- Needs reaction wheels to align the solar panels with the sun

Adapted design

The below design covers most of the pitfalls of the idealized design and fits it into the design parameters. Currently, this is just a rough prototype, and will we edit it much more when we make the board. The design is made up of a single dual-sided PCB with solar panels on each face, allowing it to collect power no matter the orientation. A large but thin battery is shielded with an aluminum backing plate on one side and the rest of the electronics on the other. We will use four HC-12s as the radio transceivers to transmit and receive two-channel simultaneously, those will be wired into the ATTiny85 which will be used to process the signal relay requests from other chips. There is also a BCC (Battery Charge Controller) and an altitude sensor on the front.

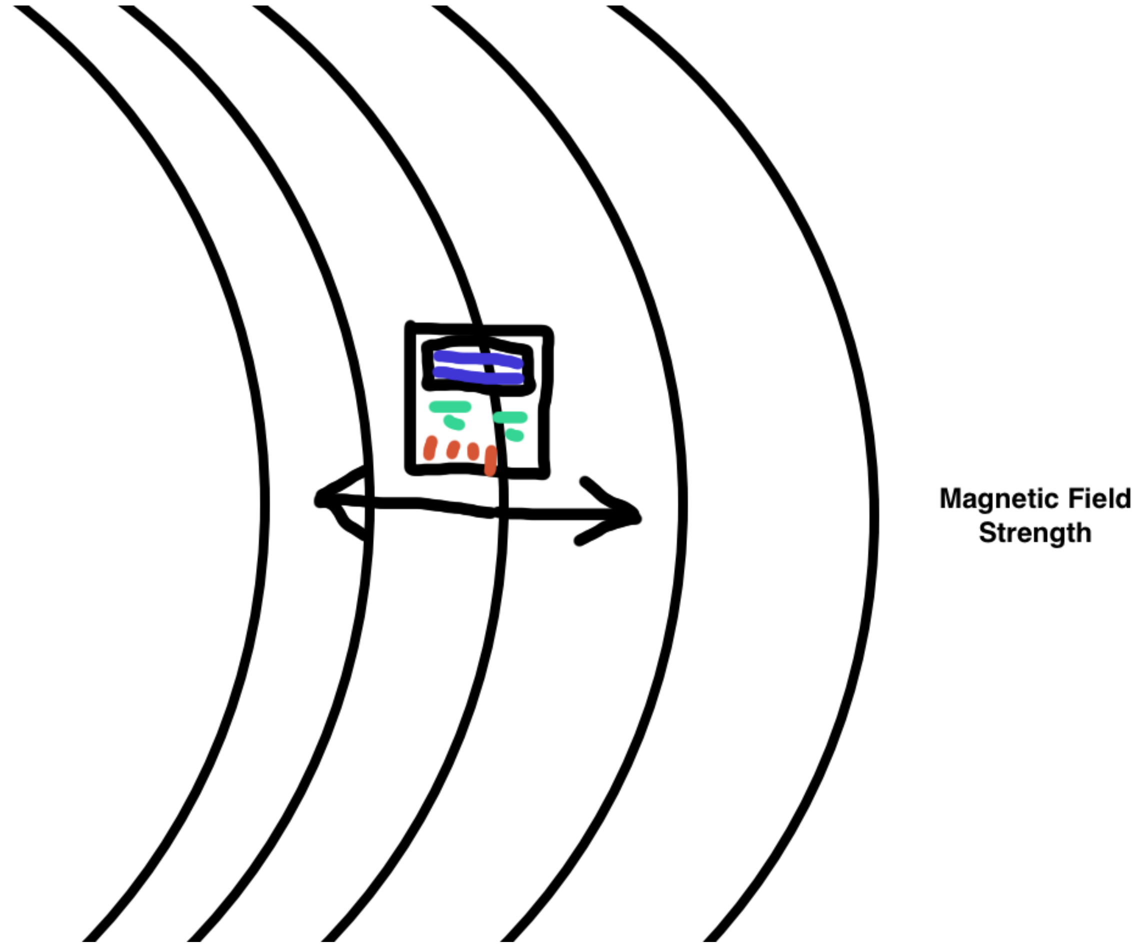


Altitude sensor

How do you measure altitude from space when there isn't any atmosphere to measure barometric pressure? I'm not sure but I do have a couple of ideas I am going to look into.

- Using the strength of the magnetic field of the earth
- Ground base measurement using a service like leolabs
- GPS

Magnetic Field Strength Detection



The Earth's magnetic field is generated by electric currents due to the motion of convection currents of a mixture of molten iron and nickel in Earth's outer core (Wikipedia). So with some simple logic the farther away you get from the Earth the weaker the detectable magnetic field is. If we use this we should be able to estimate our altitude and it gives us a magnetometer on board that we can use to calculate our attitude using TRIAD.

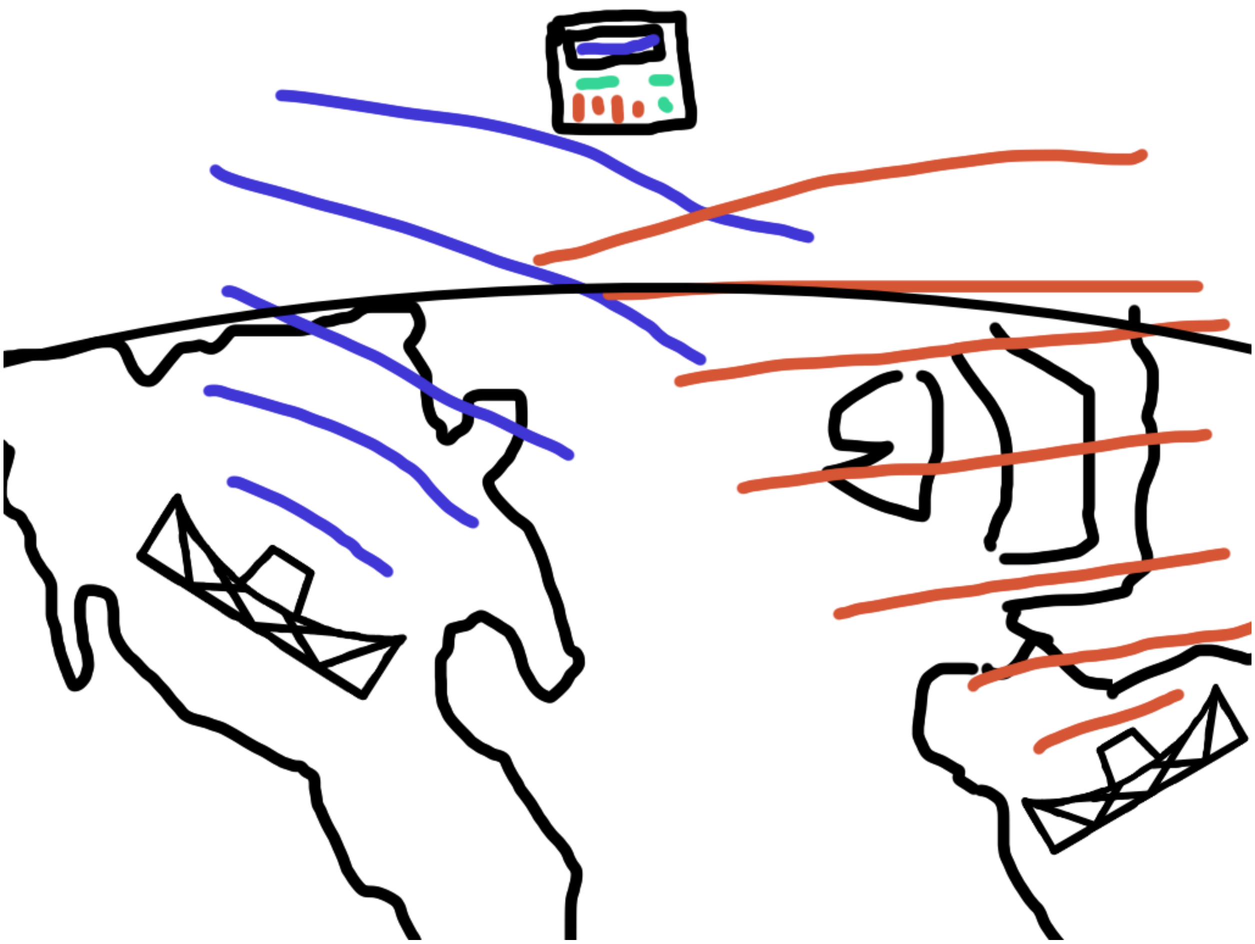
Pros

- Cheap and lightweight
- Allows us to also calculate the attitude

Cons

- Unknown if it works and would need a test flight to find the rate of decay of the magnetic field

Ground-Based Altitude Measurement



Using a ground-based satellite tracking system is possible and is probably the safest way to guarantee you are getting good altitude and position tracking. We could use a company to track the satellites like leolabs which from their website, “provides automated satellite and space debris tracking services are in real-time, over the internet, from a network of trusted radars.”. The challenge with this approach is that the SOC won't know its location unless we uplink it to it. If we are uplinking the position information we should have a gyroscope and an accelerometer so we can just use the ground track data to update the calculated position on board the SOC.

Pros

- Reliable

Cons

- Only get tracking information once per orbit
- Still need components on board the SOC
- Needs to uplink the location to each SOC blocking incoming traffic

GPS

According to a paper published by the team behind the german satellite “Technologie - Erprobungs-Trager 1” or TET-1 team, it is possible to calculate orbit trajectory and altitude with a consumer off-the-shelf GPS. The TET-1 satellite was part of an OOV (On-Orbit-Verification) program dedicated to testing and qualifying new technologies in space. During its flight, they were able to receive 8 to 12 satellites most of the time providing sufficient redundancy. The receiver would track four or more satellites 99.99 percent of the time on C/A-code and 99.73 on P(y)-code with meter-level accuracy. This experiment proves we will be able to use GPS to track the SOC.

Pros

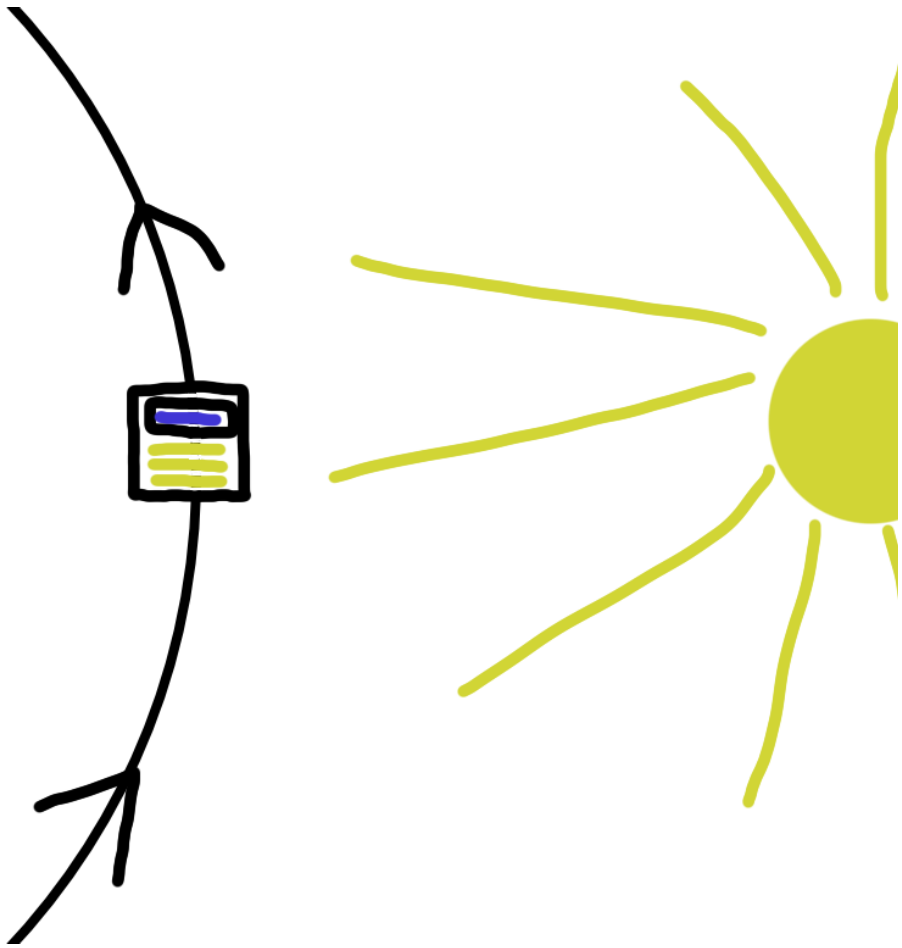
- Meter level course measurement
- Altitude measurement

Cons

- Higher current draw on the chip

Battery and Battery Charging

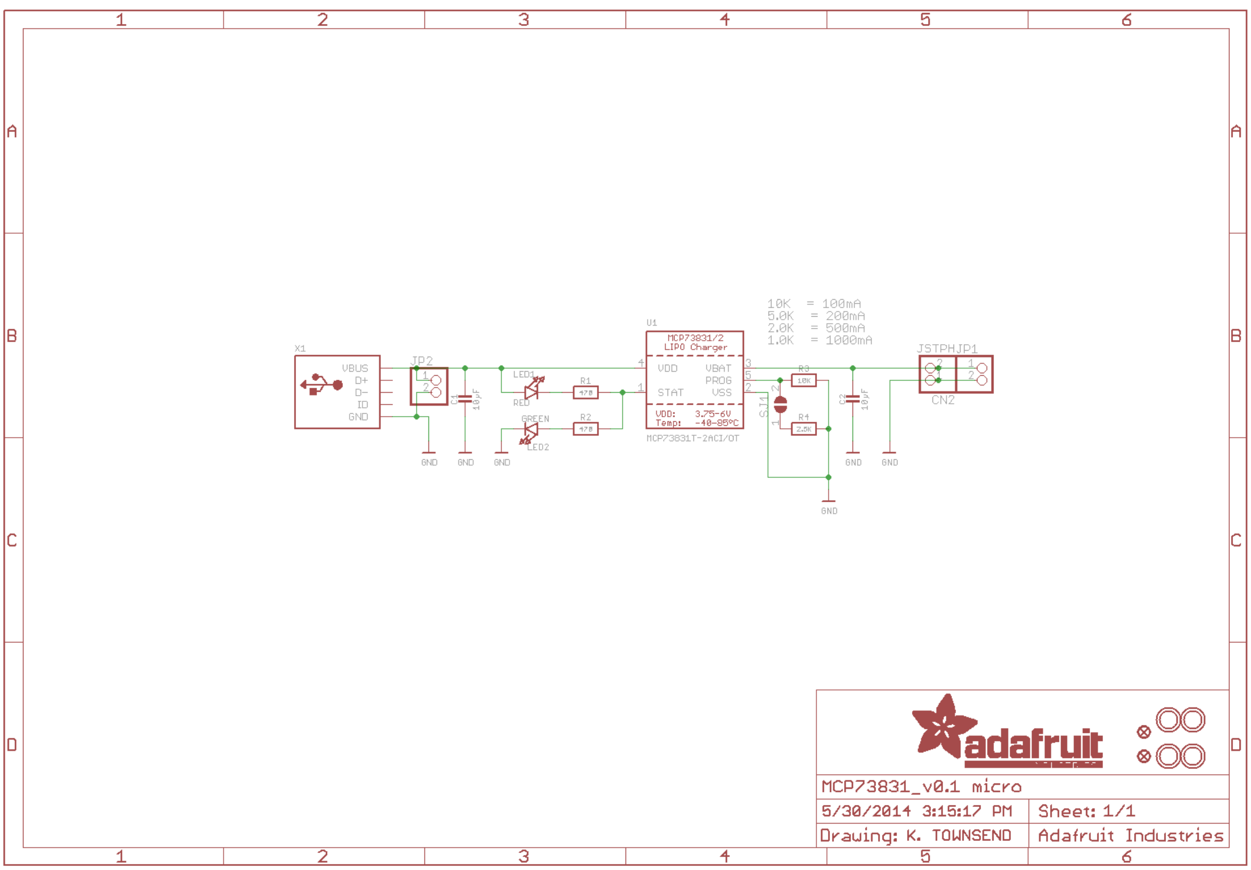
Providing ample power to our SOC will be one of the biggest issues we will face as only half the orbit we will have power. We will need to keep the current draw to a minimum so we can charge the onboard battery during our sun-facing portion of the flight while still running all the onboard systems.



For the battery, we need to go as safe as possible to prevent any mishaps during the initial launch of the satellite and during the lifetime of the mission. To do this we will go with a Lithium Polymer battery which is a solid battery that will not explode if punctured that provides the same power carrying capacity as a Liquid Lithium battery. Thanks to the mass use of LiPo batteries in electronics we are able to very easily source a battery that fits within our 10mm thickness requirement for very cheap. After some research online I found a LiPo that has the dimensions of 94x62x6.5 mm with 4000mah that outputs 3.7 volts. These dimensions along with the output voltage will help shape the size and voltage requirements for our board.

Battery Charger

The battery charger specifications will be based on this ADA Fruit micro LiPo USB Charger that charges off of a 5v input and outputs a 3.7v current at 100mah but can be hacked to charge at 500mA.



With the charger running at 500mA and the battery capacity being 4000mah it should take 9.6 hours with a 20% efficiency loss. Our orbit in LEO should take 128 minutes, giving us 64 minutes of sunlight per orbit and 11.25 orbits per day. Let’s do the math on our charging system to see if it works.

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Charge time to 100% = 576 minutes (9.6 hours * 60)
576/64 minutes of sun light = 9 orbits to 100% charged

11.25 orbits - 9 charging orbits = 2.25 orbits
2.25 obits & 64 minutes of sunlight = 144 minutes of extra charging

144 minutes of sunlight = 2.4 hours * 500mA = 1200mah of extra current
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Solar Panels

Our SOC will be solar-powered as that's the easiest way to power something in space, we can use a single solar cell that can be sourced from many online retailers. Here is one that is 110x69mm with an output of 5v at 1.1w. We will use two of these, one on each side.

Communications and Payload

What would our satellite be without a payload and some way to talk to the ground station, as I mentioned before we will be copying and improving swarm.space’s business model.

What is swarm?

Swarm

Swarm provides the world’s lowest-cost, global connectivity for IoT devices. They provide low-bandwidth satellite connectivity for only $5/month using ultra-small satellites in a low orbit. Swarm satellites cover every point on Earth, enabling IoT devices to affordably operate in any location.

For our payload, we will need a transceiver and/or multiple transceivers to allow us to be able to talk to ground-based devices. Ideally, we should pick something that can be bought off the shelf cheaply so our customers don't have to buy a custom transceiver from us to use our service. If we did want to use a custom and cheap radio we could go with the planet.com OpenLST. OpenLST is a low cost Low-Speed Transceiver (LST) for UHF telemetry, command, and control. It was designed by the engineers at Planet for their Dove satellites and is the telemetry and C2 transceiver they are using today. They have provided full documentation and all the files you need to build it and it can be built for ~$50 per unit.

However, we will not be using the OpenLST we will be using the HC-12 radio. The HC-12