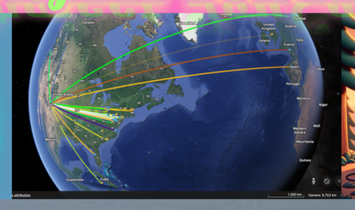
Project TouCans: Using COSMIC2, Terrestrial Ionosonde, and Real-Time Amateur Radio Propagation Data to Teach STEM, Art, History and Geography

Project TouCans



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Our Tools

Students use a variety of hardware and softwareware tools in their proejcts.

Hardware

Project TouCans

TouCans has served as the central hub for the program. It started as a pandemic point of interest to communicate with the world. TouCans is unique—even for a ham radio:

- The entire rig is mounted in its dipole antenna off the ground and is controlled remotely
- It consists of two radio kits—a transciever and a 5 Watt amplfier housed in a pineapple can with a tuna can antenna enclosure, (hence Project TouCans.)

Pico-Ws

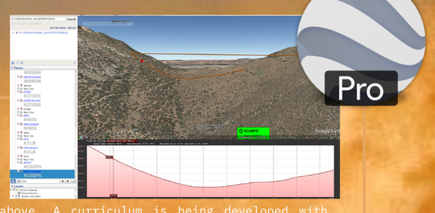
As a side project, students had started to learn how to program Pico-Ws. One of their lessons highlighted a Morse code keyer for LEDs. The keyeter control lines from Project TouCans to the ground had serious RFI issues, so we removed them using the students LED keyers as a basis for controlling the radio from the ground.

Transmitting from state and national parks means more QSOs via POTA—an organization of hams that seek radio contacts to and from parks—and that mans more data, so a part of our hardware kit is camping equipment. This has also led to spinoff nature outings and education projects.

Software

Datasette

Students use Datasette to read data from the radio's QSO log, the Reverse Beacon Network, the Lowell Digisonde network, and COSMIC2. Students frequently attend Datasette office hours with the creator of Datasette-who also co-created the Django web framework. As a side project, students are creating a Pokemon card inventory enabled by Datasette and the Gemini AI.



The launch angle of high frequency radio waves from a dipole antenna changes in relation to the slope of the terrain the antenna's suspended above. A curriculum is being developed with student input to pull elevation data from Google Earth's Elevation API to analyze the effect of terrain slope on propagation.

LDI

Students started using Lowell Digisondes to more precisely visualize radio wave skips. More recently, they've made use of the COSMIC2 constellation.

Students use Cesium Ion and the CZML JSON GIS format to visualize QSOs in comparison to the grey line and ionospheric data. Cesium allows us to animate our maps to see how radio propagation from TouCans changeds with respect to the time of day as well as ionospheric conditions.

CESIUM

Who We Are

We are a homeschooling/unschooling co-operative. Our core cohort consists of nine students. We maintain relationships with two homeschooling groups in San Francisco and the Bay Area who, combined, contain more than a 100 learners who attend our events when they find a fit with their own interests. The other major pieces of our educational structure include Bay Area institutions: NoiseBridge, an anarchist maker space organized as a Do-Ocracy, the San Francisco Museums that provide free admission for under 18 year olds—the DeYoung, the Legion of Honor, and the San Francisco Museum of Modern Art. These organizations provide learning spaces, teachers, and occasionally additional students.

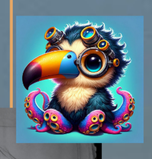
What We Do

We've developed a curriculum around Project TouCans—a 20 meter high frequency ham radio the students have built and maintain. While TouCans incorporates many STEM topics, the freedom of the students to pursue interests has spiraled off into art, video games, nature pursuits, geography and history. So far, students have learned and used:

- Both Python and MicroPython programming
- Microcontrolers (Raspberry Pi Pico-Ws)
- ChatGPT prompt engineering
- Radio engineering concepts: one student is a licensed ham radio operator; students have learned to solder and construct circuits
- Databases and SQL for analyzing radio contacts, (QSOs), along with COSMIC2 data
- Remote sensing using first the Reverse Beacon Netowrk, then the Lowell Digisondes, and now COSMIC2
- KML and CZML for visualizing QSOs with respect to the Earth and the ionosphere in Google Earth and Cesium Ion

And Why We're Here

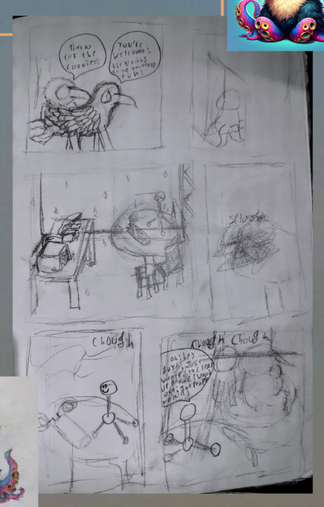
High frequency (HF) radios employ the ionoshphere for skip communications. Early on in the project this led to studying ionosphereic properties and geography. However, ground-based digisondes frequently lacked data covergae for comparison to contact paths, (QSO paths: see the map at the bottom of the poster), propagating from Project TouCans. This is where COSMIC2 entered the picture. Using the radio occultation data of the satellite constellation, students were able to make more meaningful visualizations of ionospheric skips, espeically when QSOs took place from North America to locations in the southern hemisphere like Argentina and Australia.
As we worked with COSMIC2 data, it became apparent there were other projects that could branch off, and we'd love to discuss them, (see What's Next for TouCans below.)



Freedom of Flow

Students weaving in and out of the tech track realize learning opportunities in a delightfully asynchronous manner:

- TouCans WiFi Morse Code Key sprang out of Pico-W classes
- A kid wanted to be on Twitch for video games and while doing that fooled around with singing themes. Project TouCans has a theme song now!
- Python lessons led to video games, and OLED art
- ChatGPT prompt engineering started as a way to build telnet applications and then led to the creation of the project's avatar that's sinced turned into a comic book



What's next for TouCans?

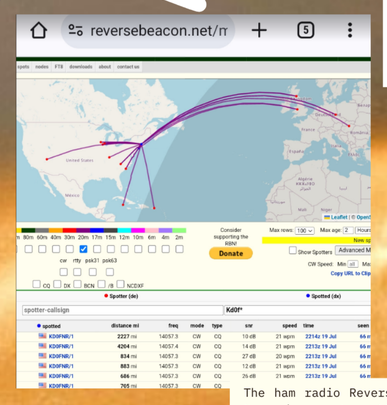
Aa, Forsythe, et. al. pointed out the need for better ionosphere imaging. Can crowdsourced data via the Reverse Beacon Network(RBN) play a part? Can the RBN be correlated with COSMIC2 ionprf data? The RBN is a network of amateur radio software defined radios (SDRs) that report detection of amateur radio callsigns, frequency, and signal to noise ratio in near real-time. Are correlations evident? Are they useful?

Can RBN data be correlated to the recently observed X patterns in the EIA? As part of these research projects, students are working with materials from the Oswald G. Villard Papers at Stanford Special Collections. Villard crowdsourced amateur radio data for an 1950s experiment to artifically ionize the Ionosphere: Operation Smoke Puff

Aa et al. Next-decade needs for 3-D ionosphere imaging

Laskar, et al. The X-Pattern Merging of the Equatorial Ionization Anomaly Crests During Geomagnetic Quiet Time

Up to the minute spot data for TouCans



The ham radio Reverse Beacon Network spots 1000s of propagation events, aka ham radio calls, per day in real-time. Can this data be used to crowd source ionospheric studies?

Places and Organizations

Students visited the UC Berkeley Amateur Radio Club, (on one of the windiest days in recent Bay history)