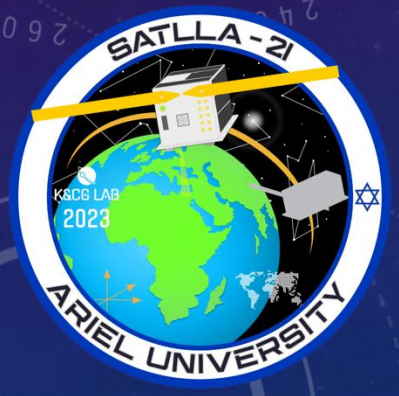


SATLLA-PROJECT

STEPS INTO SPACE, VIA COTS & OPEN-SOURCE

Boaz Ben-Moshe & Rony Ronen
School of Computer Science, Ariel University
March 2025

www.ariel-asc.com

ARIEL UNIVERSITY

AGENDA

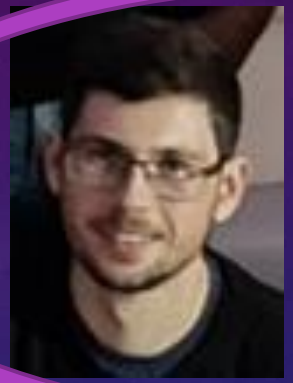
- SATLLA Project 101
- Laser Communication
- Tiny GS: IoT optimization
- AI (Edge) in space
- Few open problems

SATLLA Project: Core TEAM

Boaz Ben-Moshe

Rony Ronen

Ph.D. Student



Michael Britvin

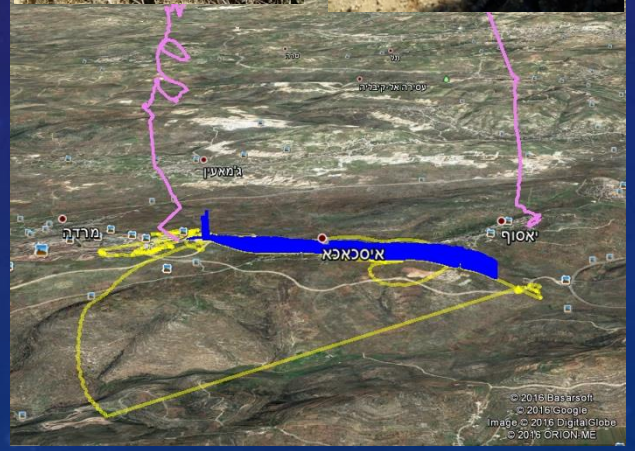
M.Sc (Eng)

Rifath Shaarook

Ph.D. Student

SATLLA0 Project – the Fun part (aka Educational)

- We love toys and drones
- Lots of High Attitude Balloons Experiments
- WiFi Hacking
- Long Range WiFi: 100m → 30 km

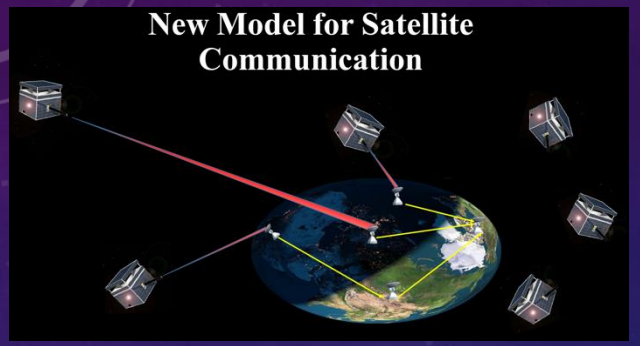


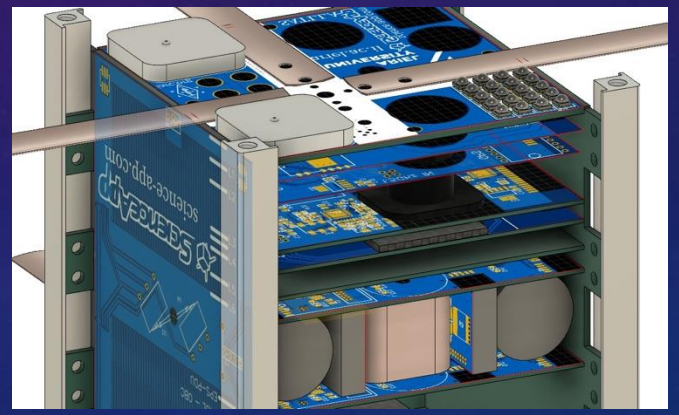
Long Range WiFi Link 10km → 100Km

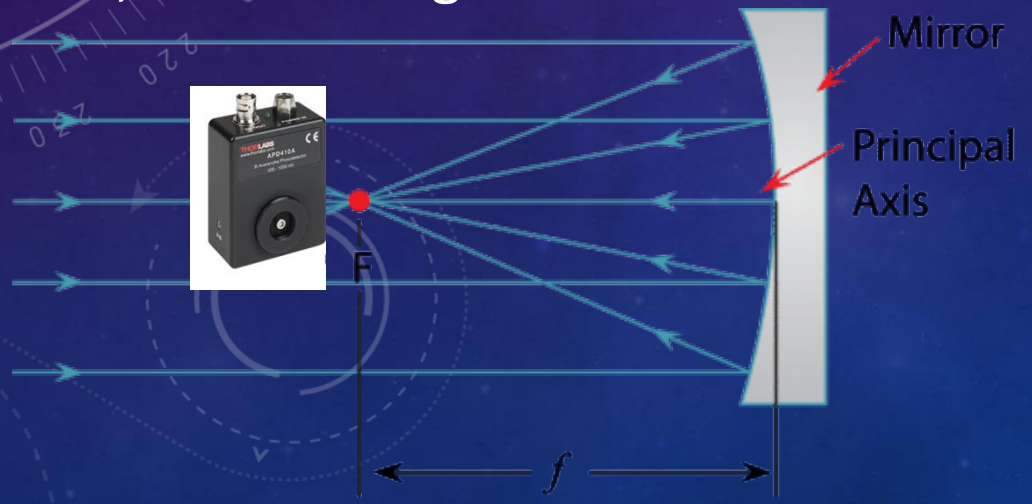
- 10 km is “easy” using COTS FCC Drones: e.g., DJI’s air3, Evo max 4
- 10X factor with Directional(~20dBi) Antenna (~24dBi) 100 km.
- Doable using WiFi Hacking & FEC

SATLLA: Project Goal & Vision

- LaserCom Link from NanoSatellite:
- Benefits: Secure, Fast, No license band required → lots of ground stations.
- Requires: GNSS, ACDS, sub-1-mili-radian dynamic tracing & pointing. LaserCom Ground Station (robotic telescope).
- LaserCom: 3 stages Tracking: LED, Ground Laser, Sar-Pointing.

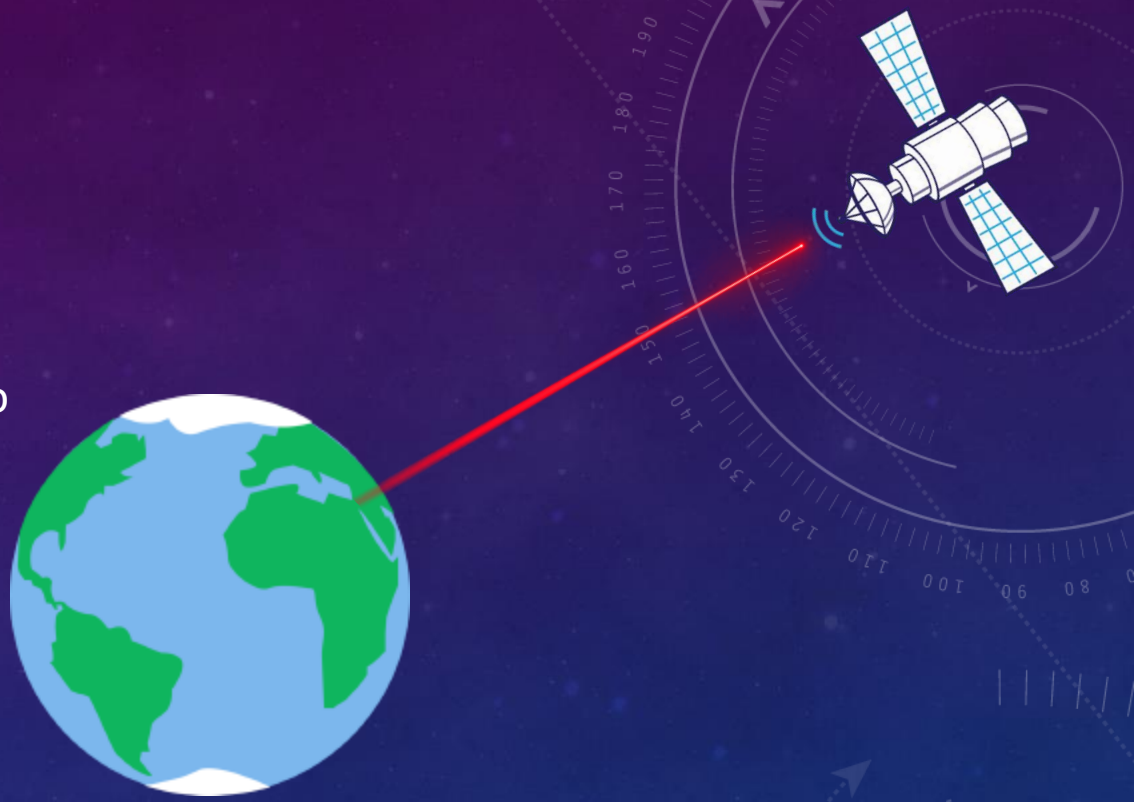






SATELLITE OPTICAL ALIGNMENT

- To enable *satellite-to-ground* laser communication we need to align the satellite to the ground station
- The ground station will flash a strobe light at the satellite at a constant frequency.
- The satellite will search for a blinking light at the agreed upon frequency and align accordingly
- Due to computing power limitations, the satellite could not run FFT on the image, but instead sampled images at twice the frequency (Nyquist–Shannon sampling theorem)



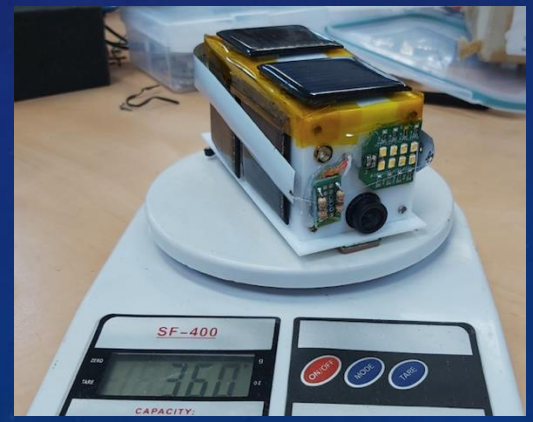
The device used for the alignment system (RasPi-Zero)

https://github.com/ifryed/SatAlign

SATLLA: Project 101: New Space

- Student based projects:
- LaserCom Link from NanoSatellite:
- RF: (ISM): LoRa, WiFi (2.4, 5 GHz).
- Multi Ground Station concept.

- SATLLA-1 (1U): LED + LoRa + Pi-camera (RIP)
- SATLLA-2B (2P): IoT + LED Tracking
- SATLLA-2I: Improved version of 2B (RIP)
- SATLLA-0: Go Open Source – classroom sat
- SATLLA-3 (1U): AI, IoT server, Laser (Q1 25)



SATLLA-1: 101 (RiP)

Student SOLELY project:

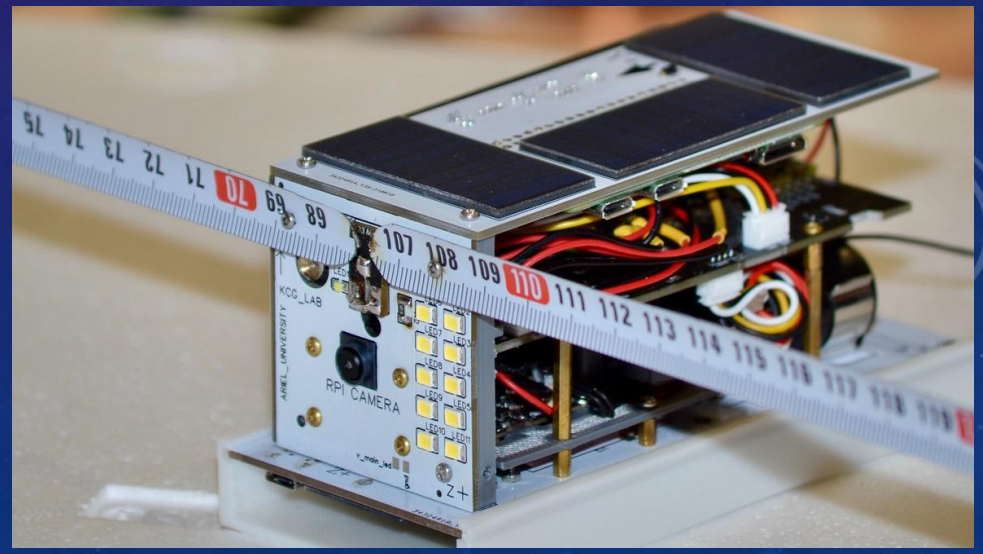
- 1U, launched: Nov 2020
- LoRa 433 (UHF), LoRa 2.4GHz (SBAND)
- Single reaction wheel
- 2x Pi zero, each with 8MP camera, running OpenCV & Python
- LED array – should be visible via 14” telescope
- GPS, IMU, ToF Ranging
- Can perform software updates via python!
- Seems to ha ve an antenna malfunction.

MISSION (SATLLA-2)

Just work (send a few beacons)

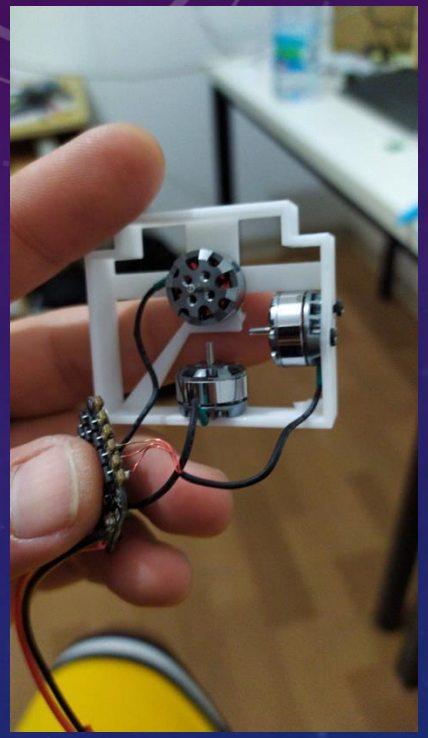
Become a cost-effective platform for pico sats

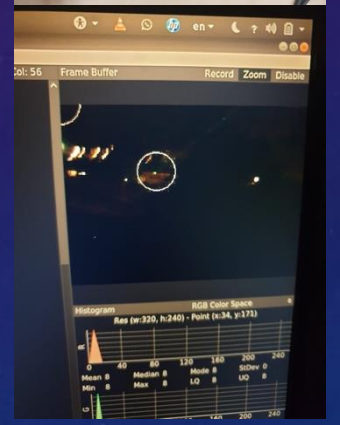
- IoT: from space
- IoT: between satellites
- Star Tracking (Ground Tracking)
- LaserCom (FSO) from space

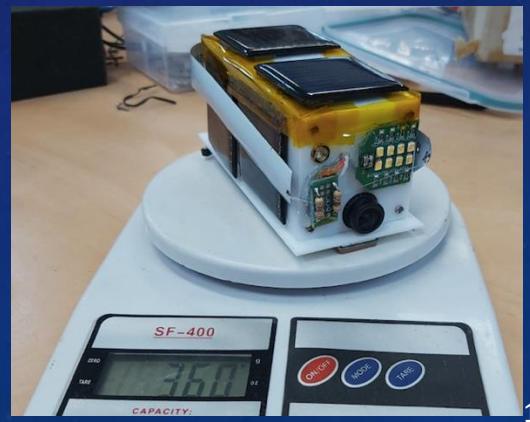


SATLLA-2 + SATLLA-2b: 101

- Student SOLELY project:
- Pair of pico-sats – inter-sat communication
- 2P, currently in manufacturing.
- LoRa 433 (UHF), LoRa 2.4GHz (SBAND)
- 3 reaction wheels
- Embedded Linux & Camera: OpenCV & python.
- Laser tracking and aiming.



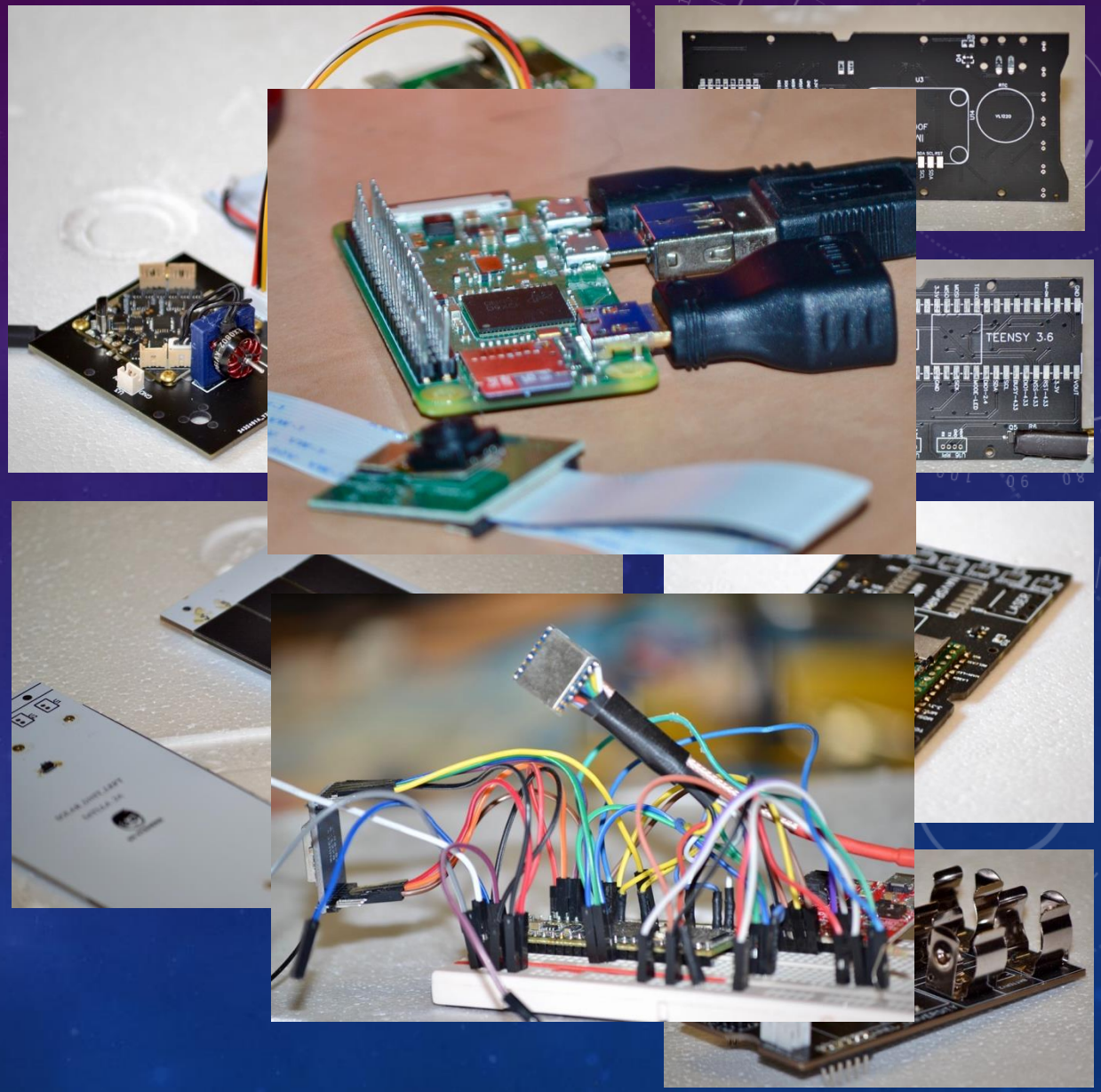




SUBSYSTEMS

- Payload: say: LaserCom,
- ACDS: Aim the laser accurately
- GPS (redundant in most cases)
- Main (always on) controller + IMU, Sensors
- Communication (RF) – LoRa 433
- Energy: Battery, Charger, BMS, Solar panels
- Structure: Boards, kill switches

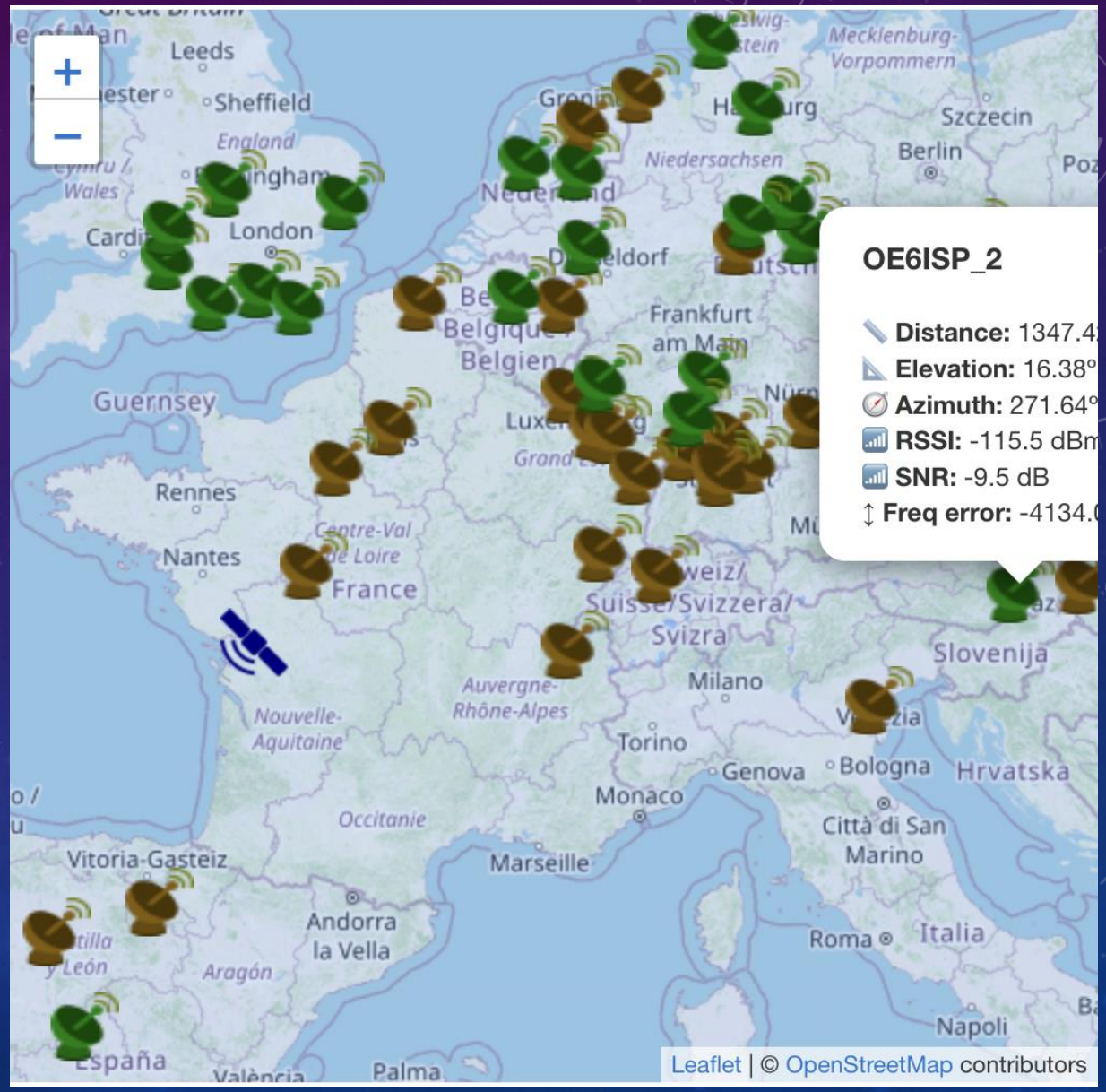
- No Ground-Station – TinyGS rocks!!!



IN FLIGHT RESULTS

1. It was working for 21 months (Oct 23)
2. Several components were “Space qualified"
3. The concept of SATLLA-2 works
4. TinyGS → Rocks!

https://tinygs.com/satellite/SATLLA-2B
https://www.ariel-asc.com/blog
https://in-the-sky.org/satpasseschart.php?utc1=1657826782&utc3=1657827230&satid=51014

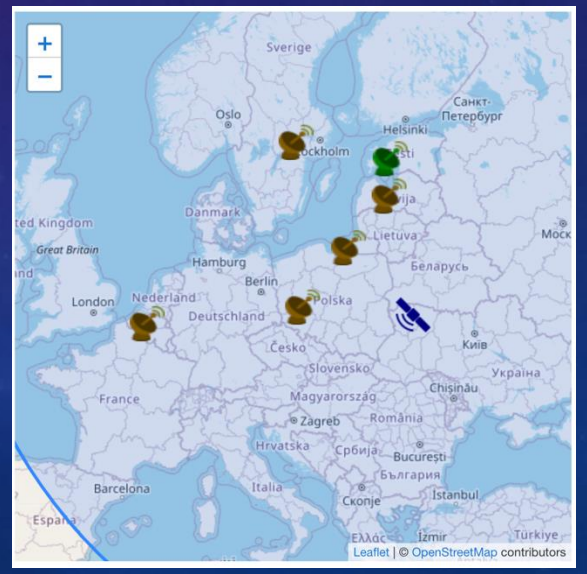


GROUND STATION OPTIMIZATION

Maximizing the Throughput of Nanosatellites via Ad-hoc Multi Ground Stations:

Given a set (S) of n satellites, each of which transmits a unique message on a unique frequency, and a set (R) of k receivers, each of which can listen to only a single frequency. The objective is to maximize the expectation (E) of the total unique messages received by all the k receivers.

https://tinygs.com/satellite/SATLLA-2B



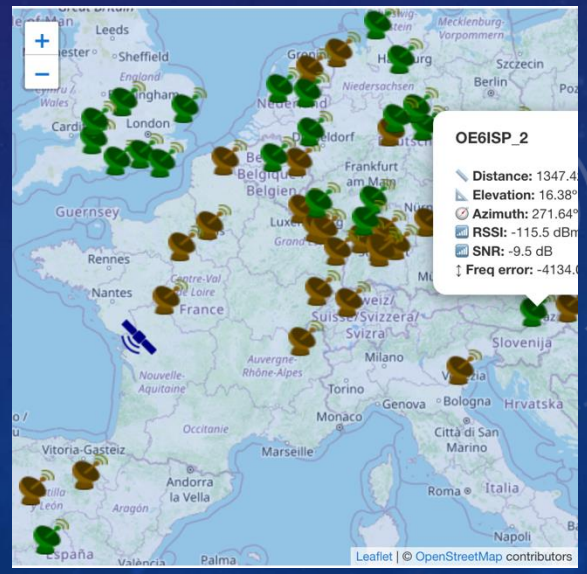
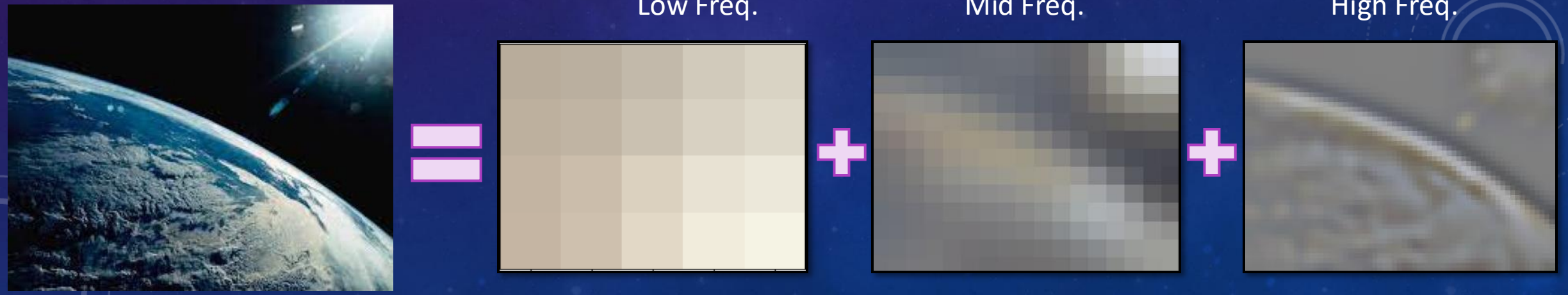


IMAGE TRANSFER OVER LORA

- A typical 640x480 image takes about 10-50 KB $\approx +100$ packets
- We used Laplacian Pyramids to separate the frequencies of the image and compress each frequency separately to achieve an improved compression rate (up to 10X)
- Star- image $\approx 50 - 100$ Bytes – required for StarTracker ML.
- EdgeAI can help to prioritize the optimal image for transmission
- Given an image (onboard) – locate it (image based positioning)

https://github.com/ifryed/SatImageTransfer



OPEN CHALLANGES – Q&A

- SATLLA 0: https://github.com/kcglab/satllazero
- HAB: Long lasting (around the world in 21 Days).
- Toys: aka IoT, Long Range WiFi.
- AI In Space (Edge): classify the best and most interesting images (in Space).
- StarTracker & EarthTracker
- Image-based positioning
- SATLLA3.0

- Laser Communication – we are looking for cooperation

SATLLA

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SATLLA Project - YouTube