

Exploring Time-series Telemetry from CubeSats

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Introduction



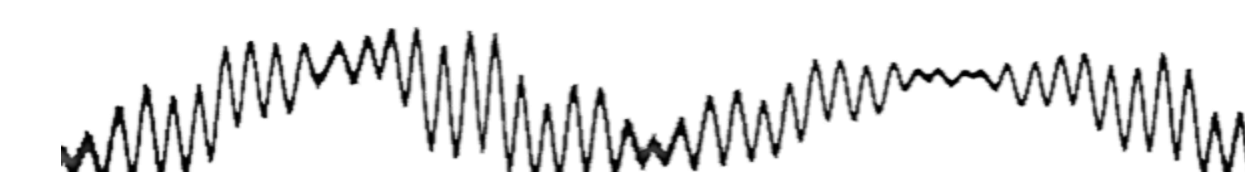
CubeSats: Sensors in Space

- Size: $10 \times 10 \times 10 \text{ cm}^3$
- Weight: 1 kg
- Low Earth Orbit (LEO)
- Cheap & Low-power
- Application: Research, Education, By hobbyists...

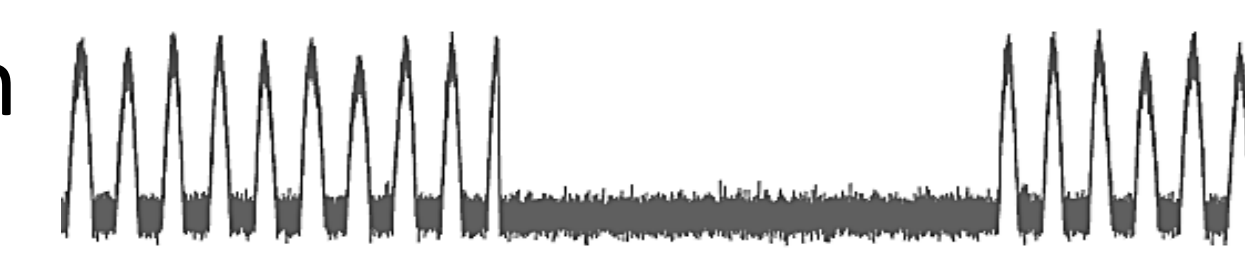
Telemetry Data

Time series measurements from different sensors

Magnetometers



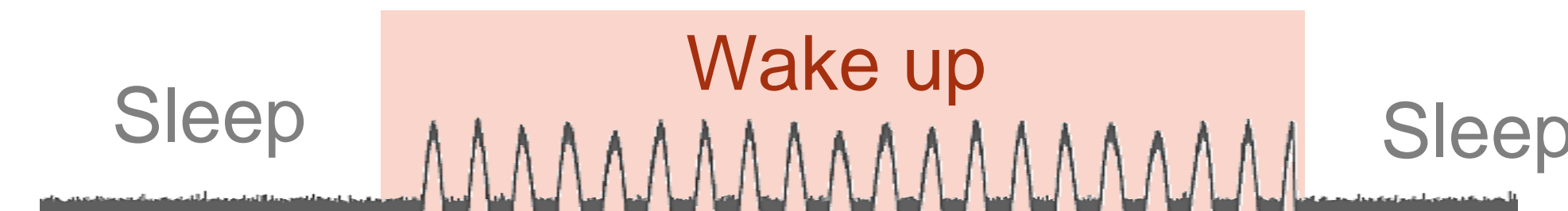
Power generation at sonar panels



If the end users at the ground can obtain this information...

- **Anomaly Detection & Debugging:** identify and correct what is going wrong
"A recent launch of CubeSats by CMU-team in collaboration with NASA and found that three of them were consuming much more power than expected"

- **Time-aware Computing**



Current Limitations of CubeSat Telemetry

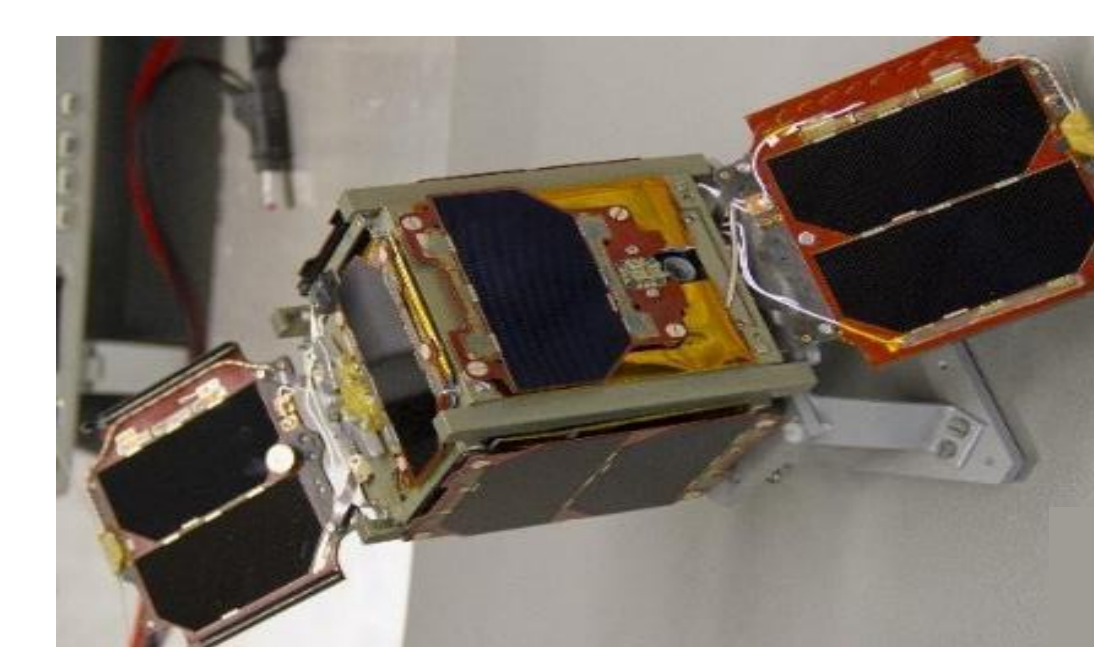
① Sparse ground station coverage



Available ground station in SatNOGS Network

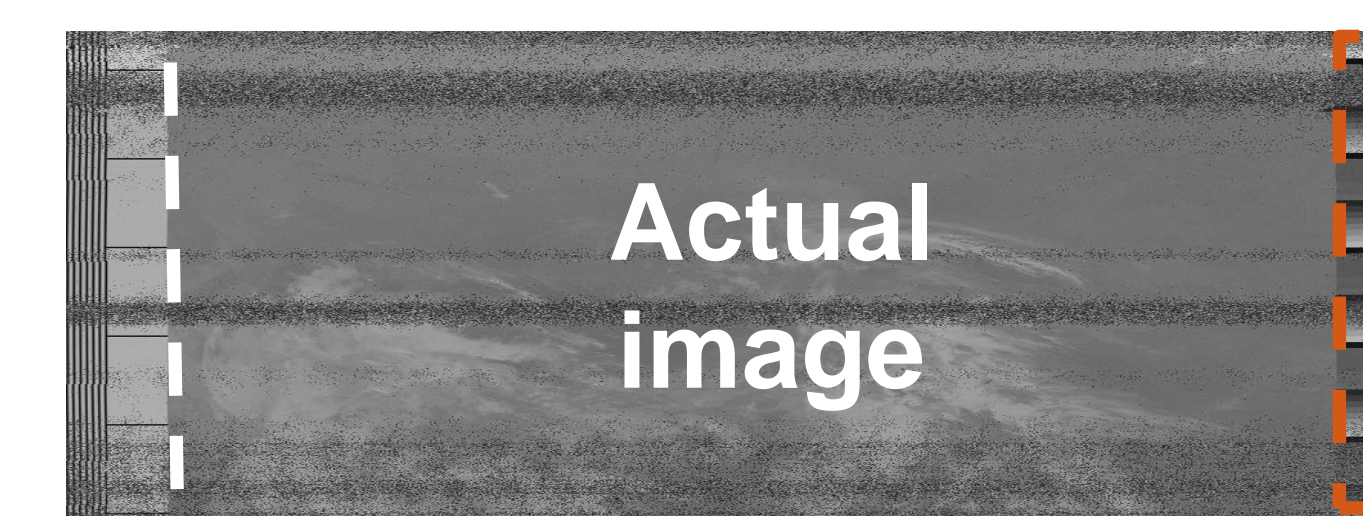
② Limited communication bandwidth

- Constrained power by small sonar panel
- Narrowband communication technology: LoRa (~kbps)
- Much of the downlink payload are reserved for actual data



LoRa™

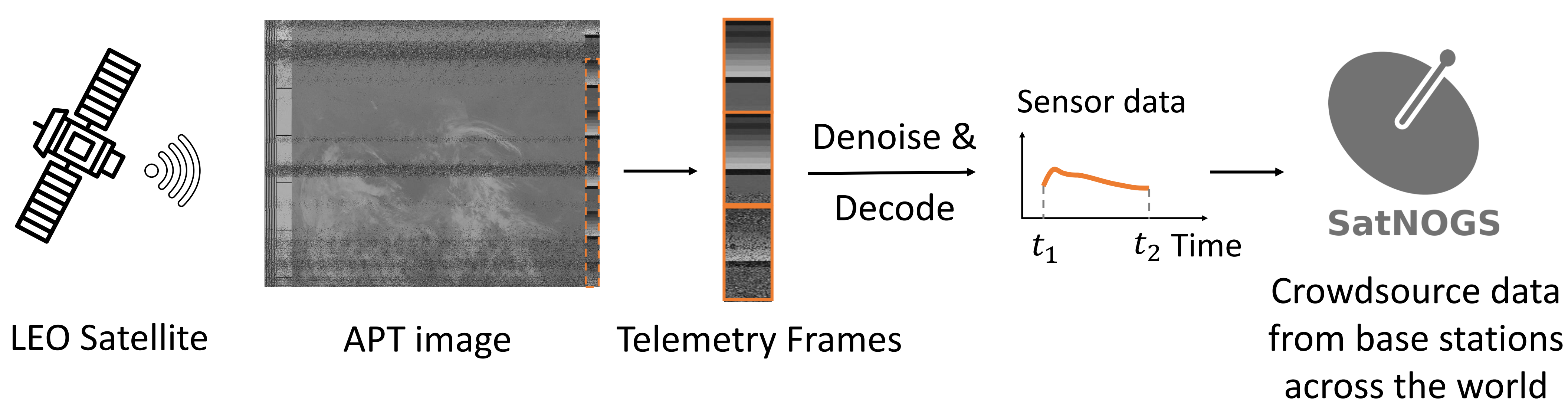
Telemetry data



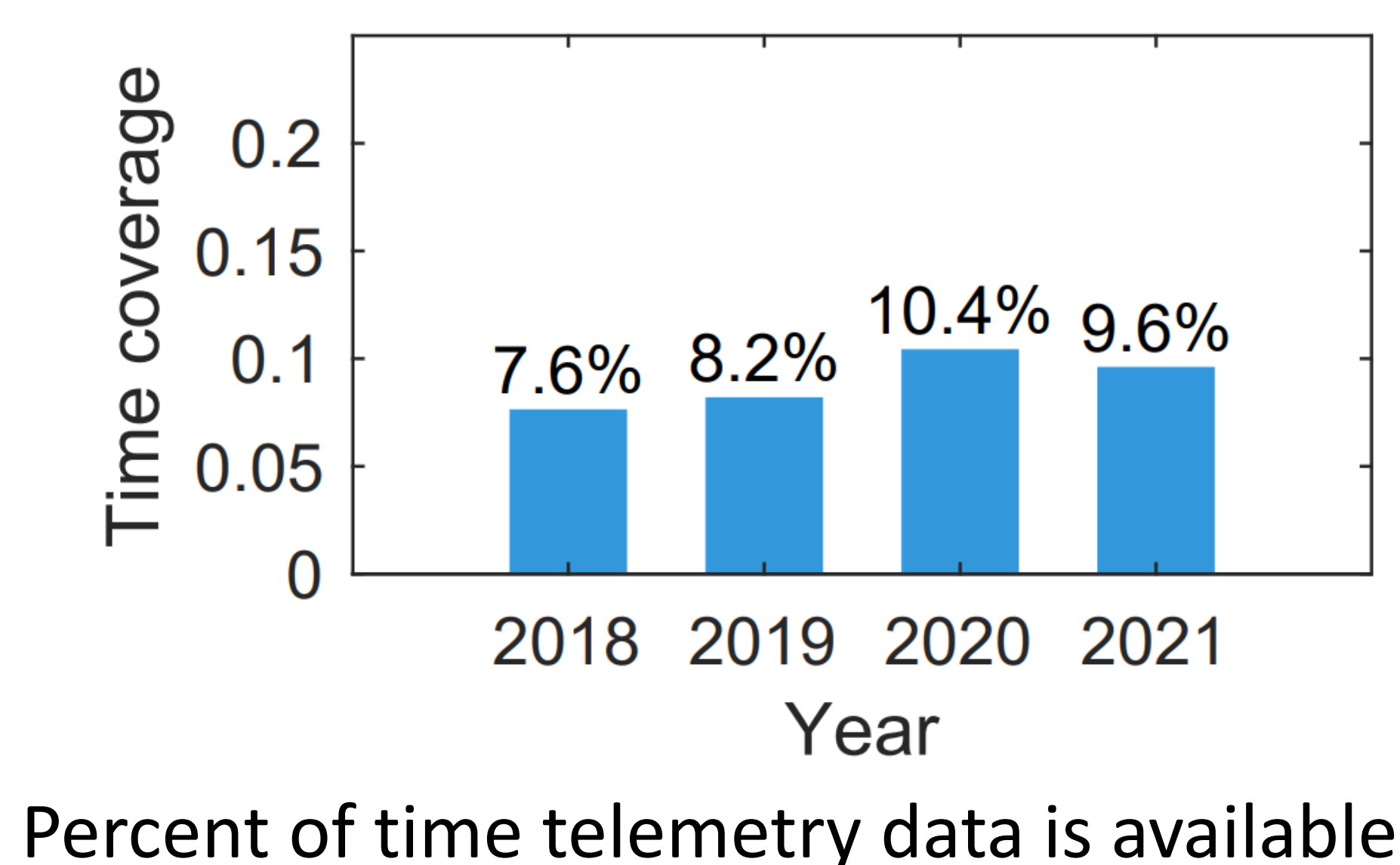
Question: Can we provide the benefits of time-series telemetry that big satellites enjoy to CubeSats?

Motivation Study

A software pipeline to retrieve telemetry data from LEO satellites:



Demonstrate on NOAA-19 US weather satellite:



- Ground station number was increased in last two years
- **10% time coverage remains too little for real-time telemetry applications**

Need to develop better approach for telemetry from CubeSats!

Design Space and Challenges

