
# Virtual Research Presentation Conference

## Hardware Prototype for Passive Sounding of the Moon and Solar System Objects

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**Program: Topic**

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Assigned Presentation # RPC-227

# Tutorial Introduction

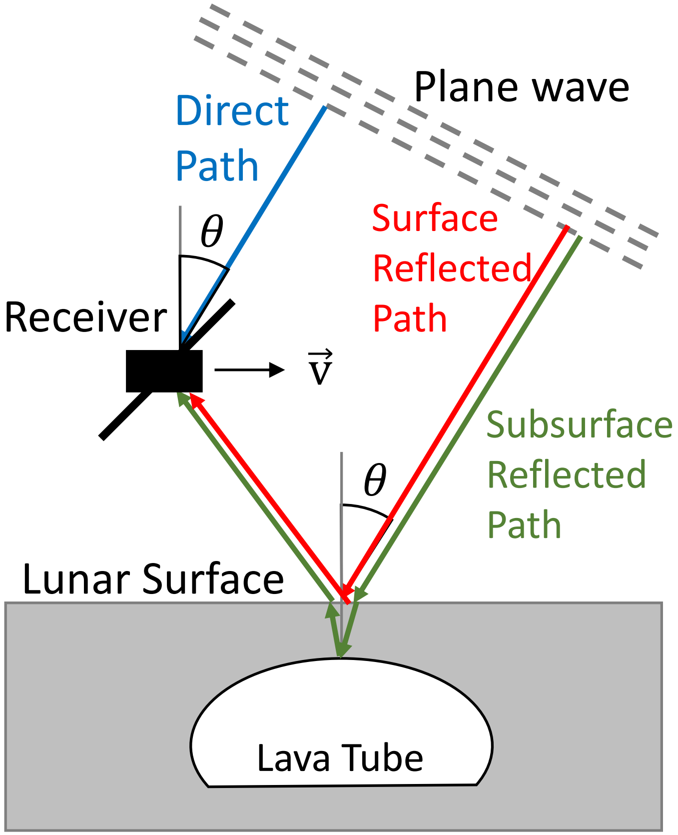

**Abstract**

Evidence suggests lunar lava tubes exist in the Moon's subsurface and could serve as potential sites for human bases.

Radar missions are currently being developed and proposed to map the subsurface of a variety of Solar System objects.

A passive sounding technique has been developed at JPL to use radio emissions from Jupiter as signals of opportunity to detect subsurface reflections from orbit or from the ground using a lander or a rover.

The inherently lower resource needs of this approach would enable low-cost smallsat or small rover missions aimed at revealing the Moon's subsurface lunar lava tubes.

# Problem Description

a) Context

- Lunar lava tubes exist in the Moon's subsurface and could serve as potential sites for human bases.
- Recent evidence from the Kaguya radar on SELENE and GRAIL gravity mapping suggests tubes with > 50 m roof heights.

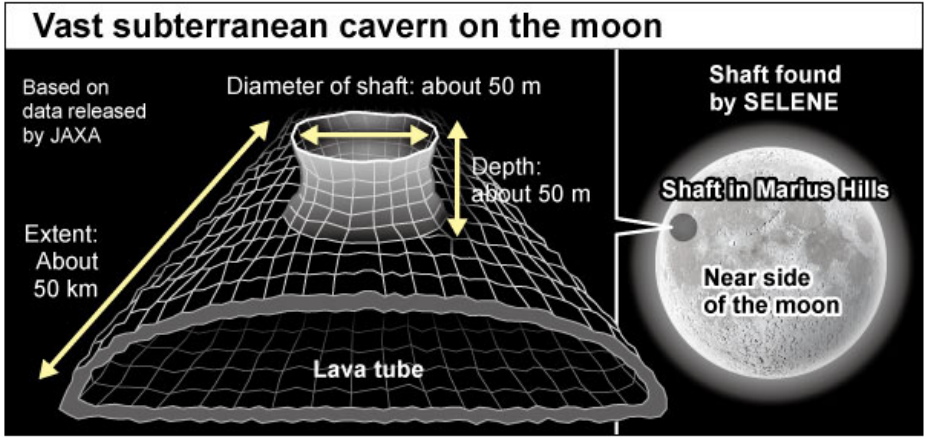



Image credit: The Asahi Shimbun

b) State of the art

- Dual frequency active radar systems (Carrer et al 2018) are capable of mapping lunar lava tubes with roof heights between one to several hundred meters.
- Although highly capable, they have stringent transmitter requirements.
- Passive sounding offers a lower resource alternative to mapping lunar lava tubes.

c) Relevance to NASA and JPL. The inherently lower resource needs of this approach could enable:

- Low-cost smallsat or small rover missions aimed at revealing the Moon's subsurface lunar lava tubes.
- Low-cost planetary sounding instruments.
- Distributed arrays for sounding Earth and solar system bodies.

# Methodology

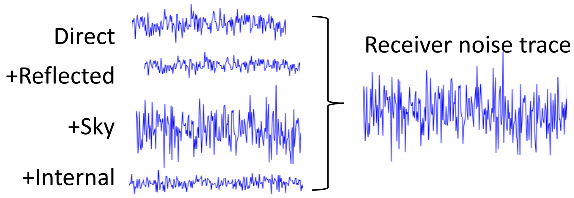
a) The objectives of the study were to:

1. Build a hardware prototype of a passive sounder that uses radio emission from Jupiter
2. Demonstrate the concept requires the low mass, power, processing available to a smallsat or rover implementation.

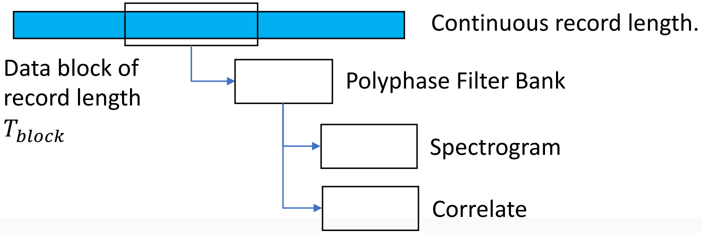
b) The study was divided into 3 milestones:

1. Develop instrument requirements.
2. Build a hardware prototype with laboratory performance measurements.
3. Field and laboratory tests of the receiver unit.

1. Acquire data continuously




2. Parse data block for autocorrelation.



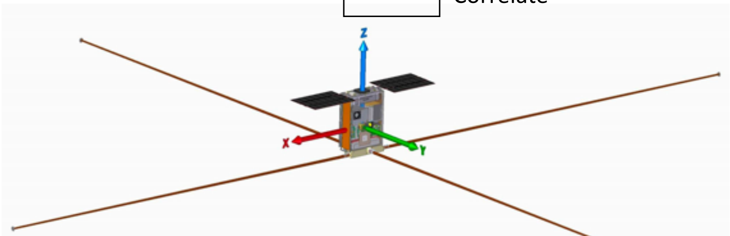
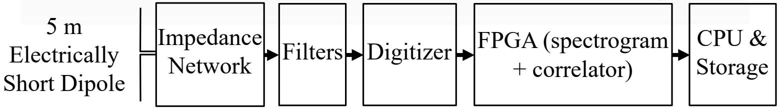




Image credit: SunRISE Concept Study Report



# Results –

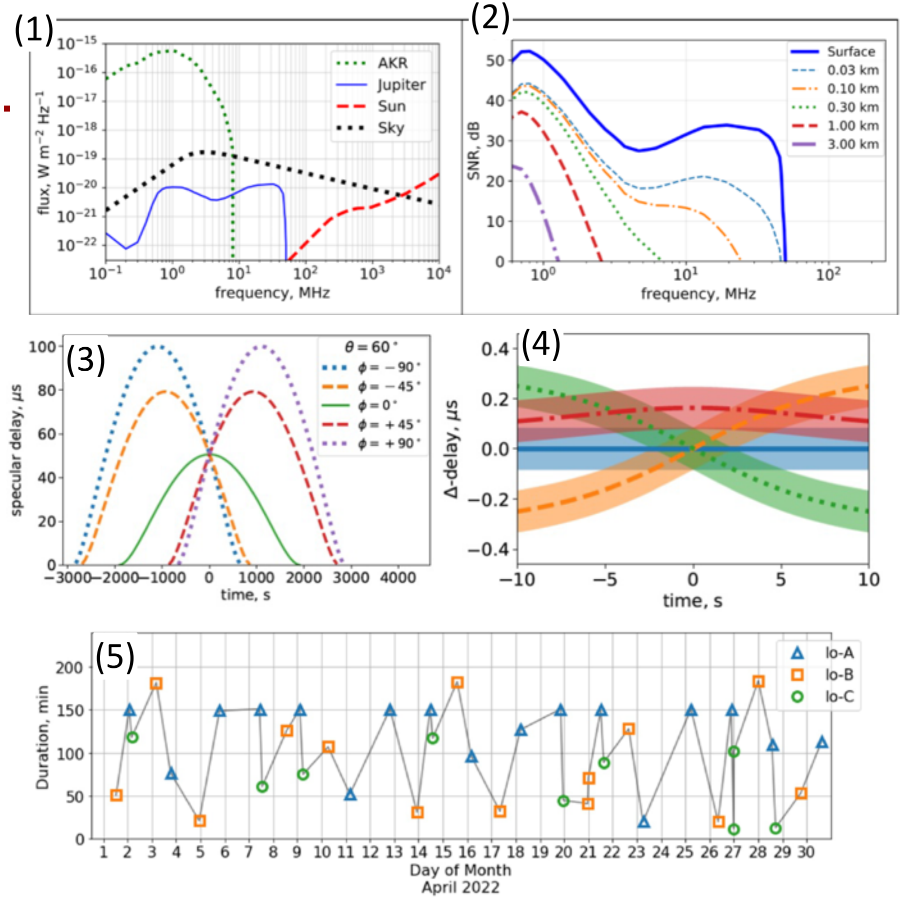
## Milestone 1: Develop instrument requirements.

a) Accomplishments:

1. Determined Jovian bursts is the only source suitable for lunar sounding from orbit and the Sun could be used from a rover.
2. Determined that Jovian bursts have ~km scale penetration depths at the lowest frequencies.
3. Mapped out expected specular delays for passive sounding, needed for operation.
4. Determined <100 m along-track resolution using delay mapping (SAR) techniques.
5. Identified Jovian burst opportunities occur ~1/day with > 2 hour duration (~orbit period of low lunar orbit)

b) Significance: understanding of requirements and constraints enable mission concept design.

c) Next steps: publication of findings.

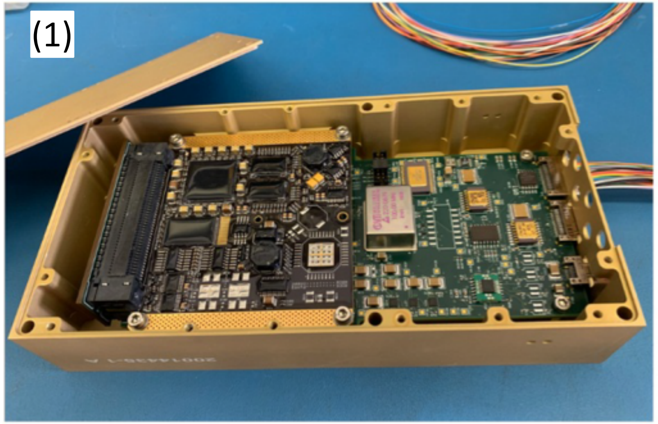


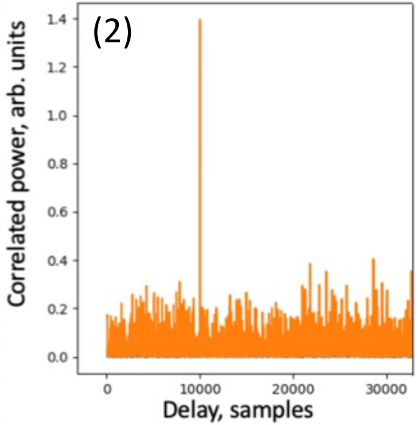
# Results –

## Milestone 2: Hardware prototype.

a) Accomplishments:

1. Built passive lunar sounder prototype board from the SunRISE design with minor modifications.
2. Injected simulated Jovian burst-like signals with reflections into the board and verified the reflection could be extracted via autocorrelation.




b) Significance:

- We have a prototype board in hand that has been tested with simulated signals.
- When a proposal opportunity arises, the team will be able to use this data to strengthen the case for achieving TRL 6.

c) Next steps: identify funding opportunities for passive sounding of the Moon or other Solar System bodies.

# Results –

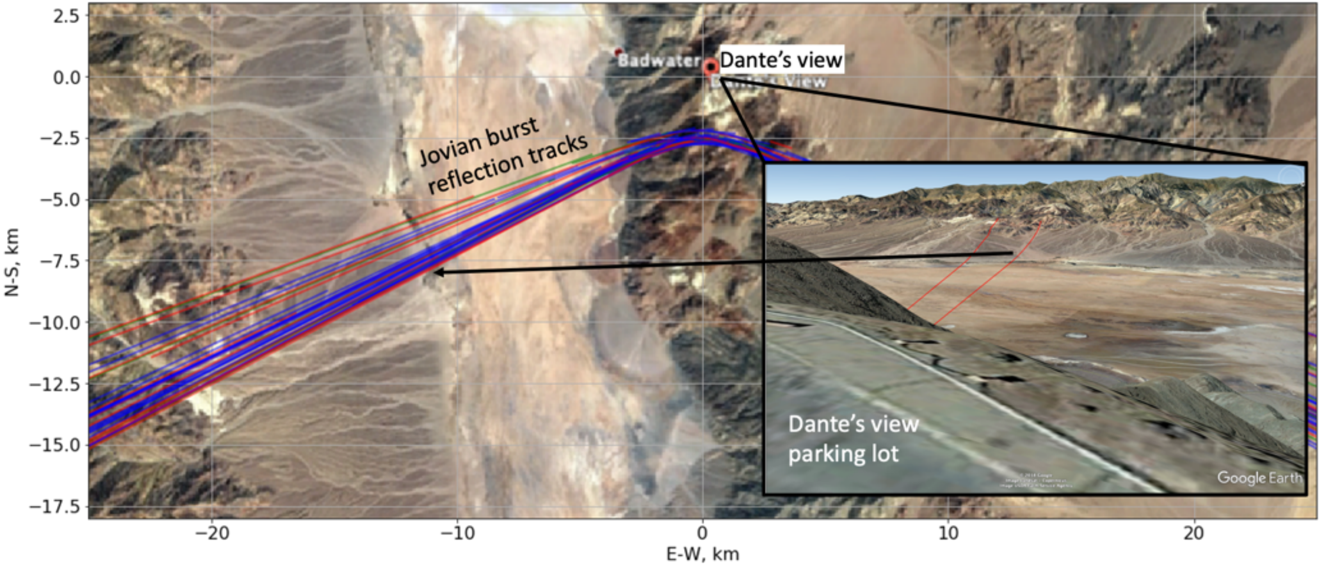
## Milestone 3: Field tests.

a) Accomplishments:

1. Worked out the logistics for a field test in Death Valley (Dante's view).
2. COVID-19 prevented its execution.

b) Significance: field tests are ready to be executed as soon as it becomes safe.

c) Next steps: identify funding opportunities to execute the field test and publish the findings.



# Publications and References

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