Explore the next sense

Parking Sensor: Obstruction Detection

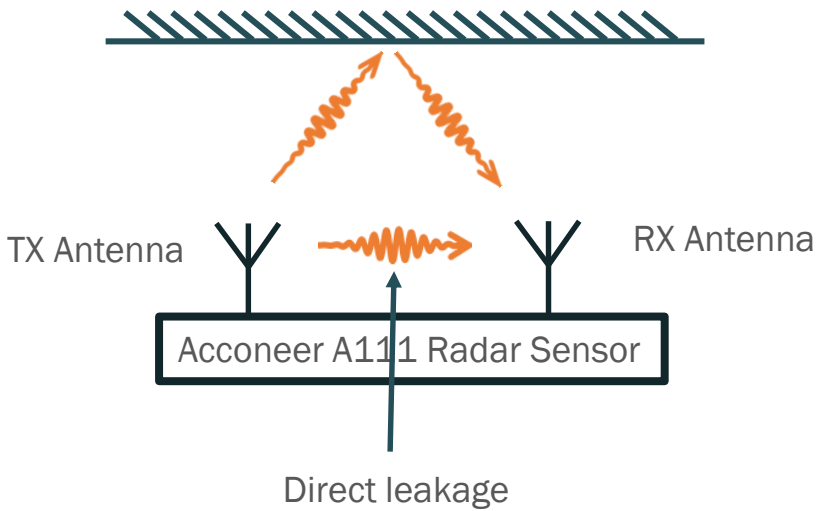
April 2019

Obstruction Detection

- More challenging than Car detection

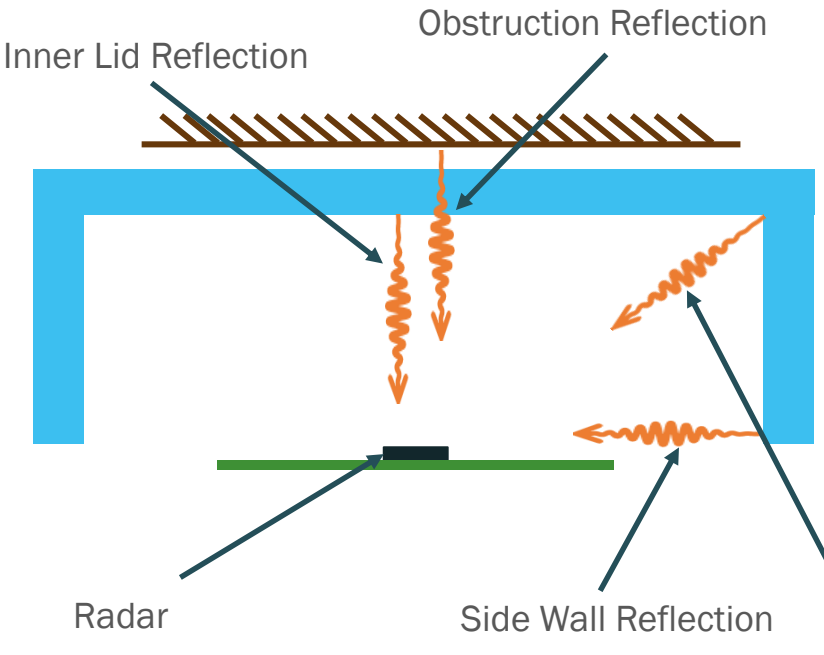
- Solution:
  - Design parking sensor lid for optimal obstruction detection
  - Calibrate Obstacle Detection algorithm for specific lid

Close In Measurements: Direct Leakage



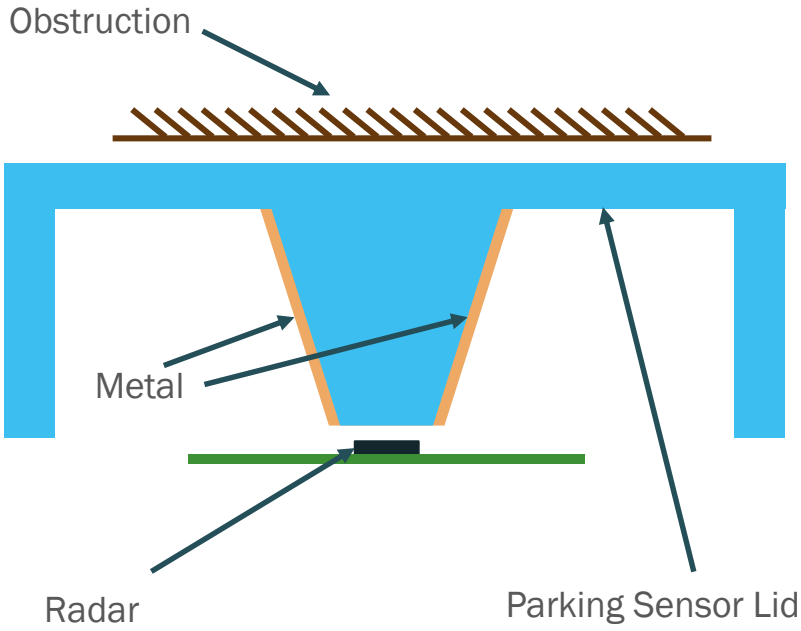
- Difficult to measure object close due to pulse transmission
- At distance r = 0 cm, the strong so-called *direct leakage* is seen
- Objects at very close distance, r < 6 cm, challenging to measure

Sensor Lid



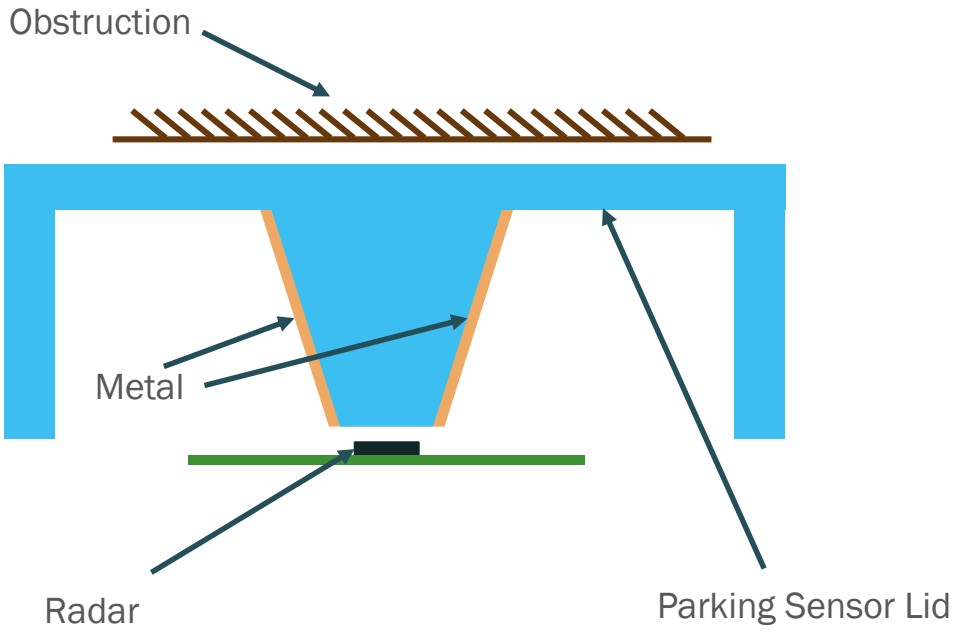
- Multiple different signals will be seen
- These can interfere both positively and negatively.
- Complicated

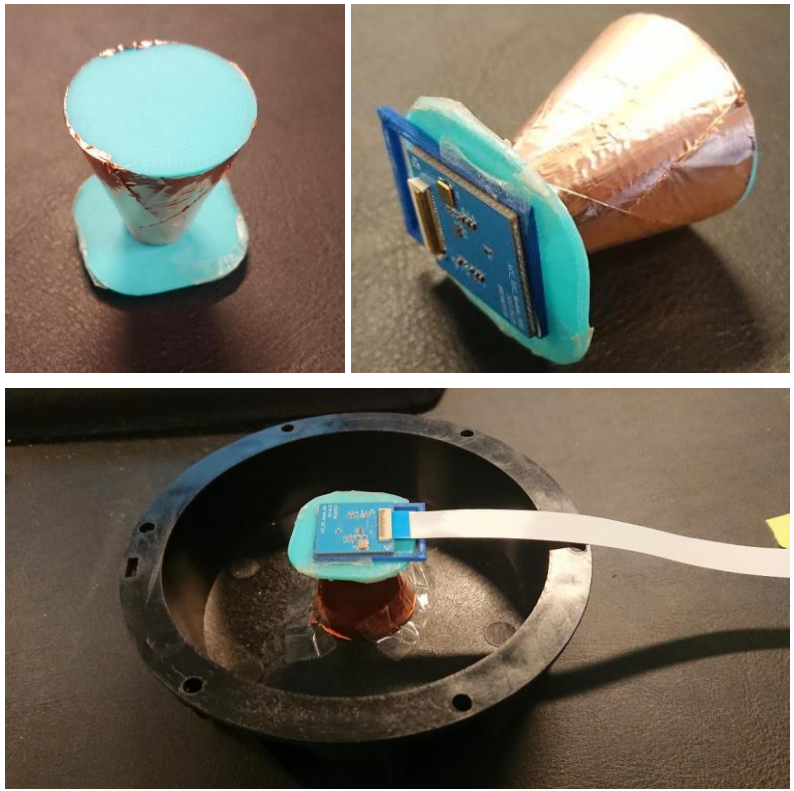
Waveguide Integrated in Sensor Lid



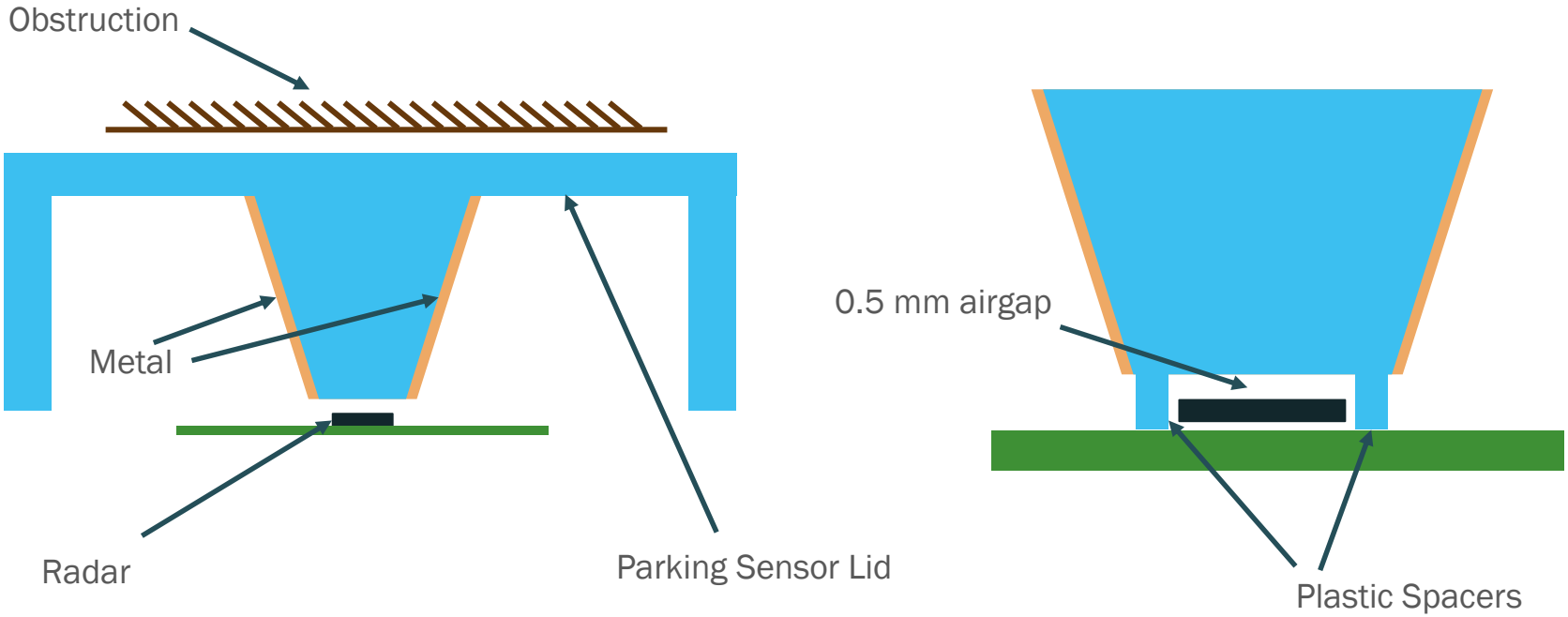
- Integrate waveguide in parking sensor lid. Ideally same plastic.
- Metallic covered plastic cone towards the sensor (e.g. metallic paint)
- Performance without metal is lower

Waveguide Integrated in Sensor Lid



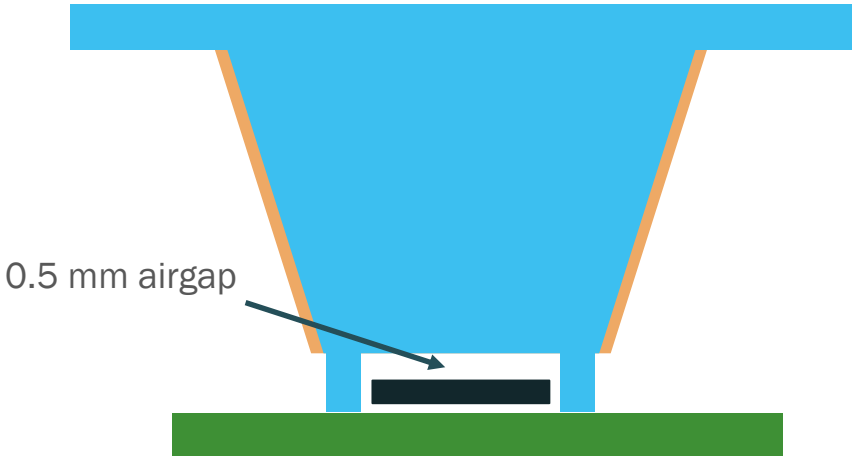


Waveguide Integrated in Sensor Lid



Optimal Lid for Obstruction Detection

- At least 3-4 cm from sensor to obstruction
- **Solid** plastic cone with metallic cover from the sensor to the obstruction
- A small non-zero air gap



Tune Obstruction Detection Algorithm

1. Using the optimized lid, collect radar sweep with Envelope API and the DIRECT_LEAKAGE profile, both with and without obstruction.
2. Inspect at what distance the obstruction is seen with a specific lid design.
3. Select a few reference distances where the obstruction is observed.

Obstruction Detection Algorithm

At sensor installation, collect a reference measurement at the reference the points and store in memory.

1. Measure the Envelope.
2. Calculate the difference squared between the measurement and the reference measurement.
3. If this number is higher than the threshold, and obstruction is detected.

Setting Threshold

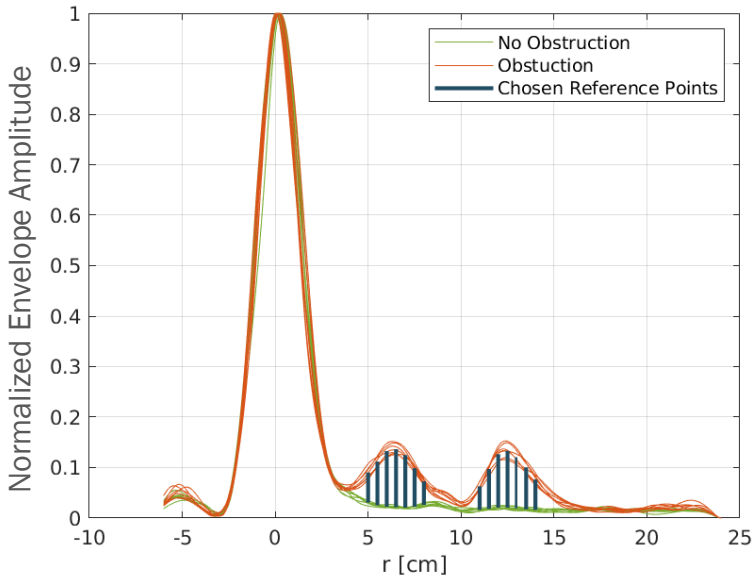
- Experiments suggest a suitable threshold around 0.001
- The parking sensor manufacturer might need to tune the threshold to their needs and parking sensor.
- Lower threshold: More false obstruction detection but less false no-obstruction detection
- Higher threshold: Less false obstruction detection but more false no-obstruction detection

Obstruction Measurements

- Strong direct leakage at r = 0 cm
- With this lid design, the obstruction is seen at 7 and 12 cm, likely reflection and double reflection
- Difference:

$$\frac{1}{N_r}\sum_i^{N_R}(Env(r_i) - Ref(r_i))^2$$

where r_i are refence points



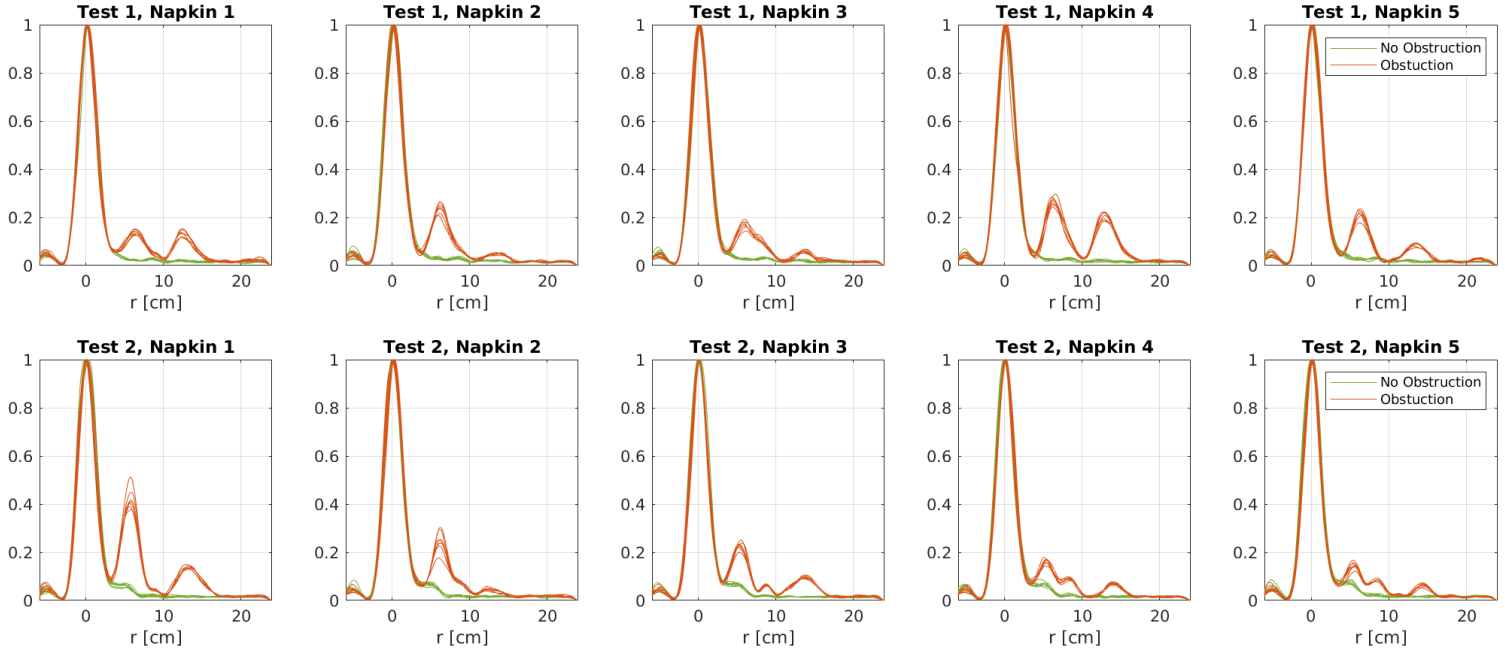
Each plotted sweep is the average of 5 sweeps from the Envelope API

Obstruction Measurements

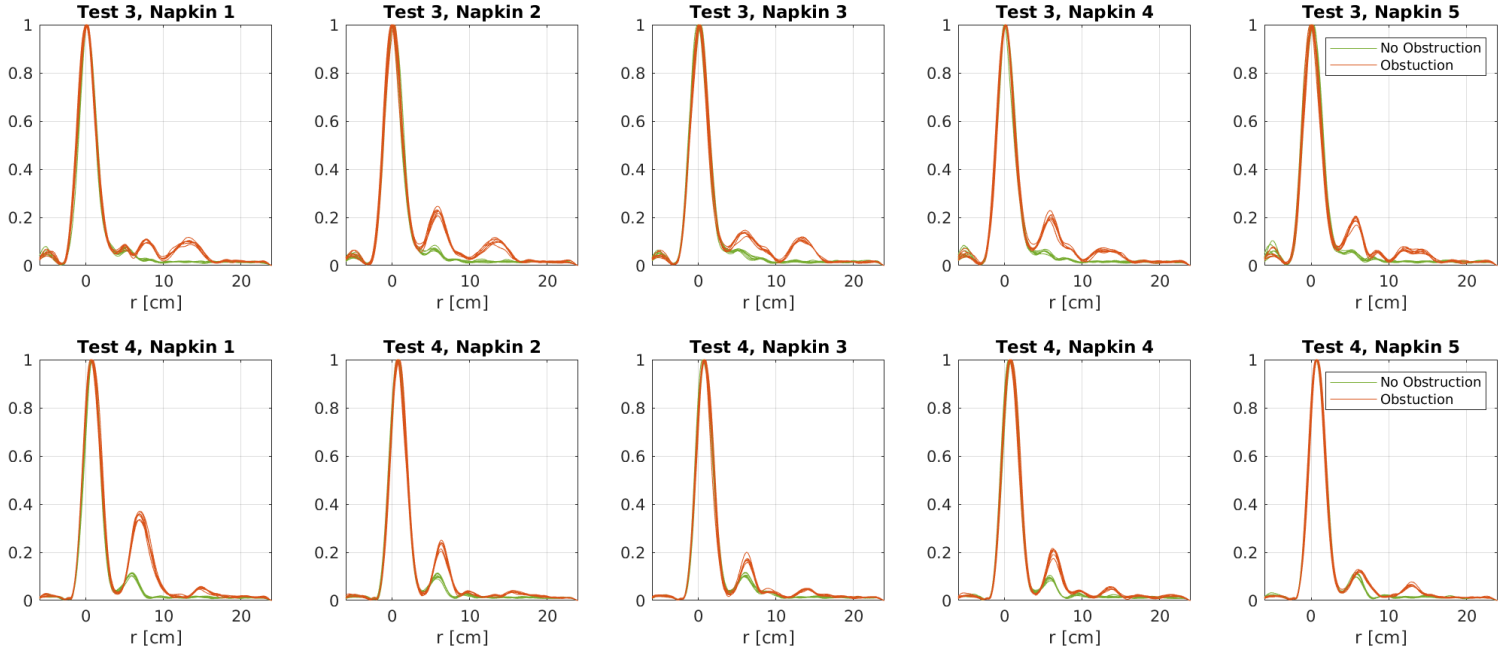
- The parking senor and lid have been de-constructed and constructed 6 times.

- Each time, a wet napkin has been placed on the sensor 5 times.

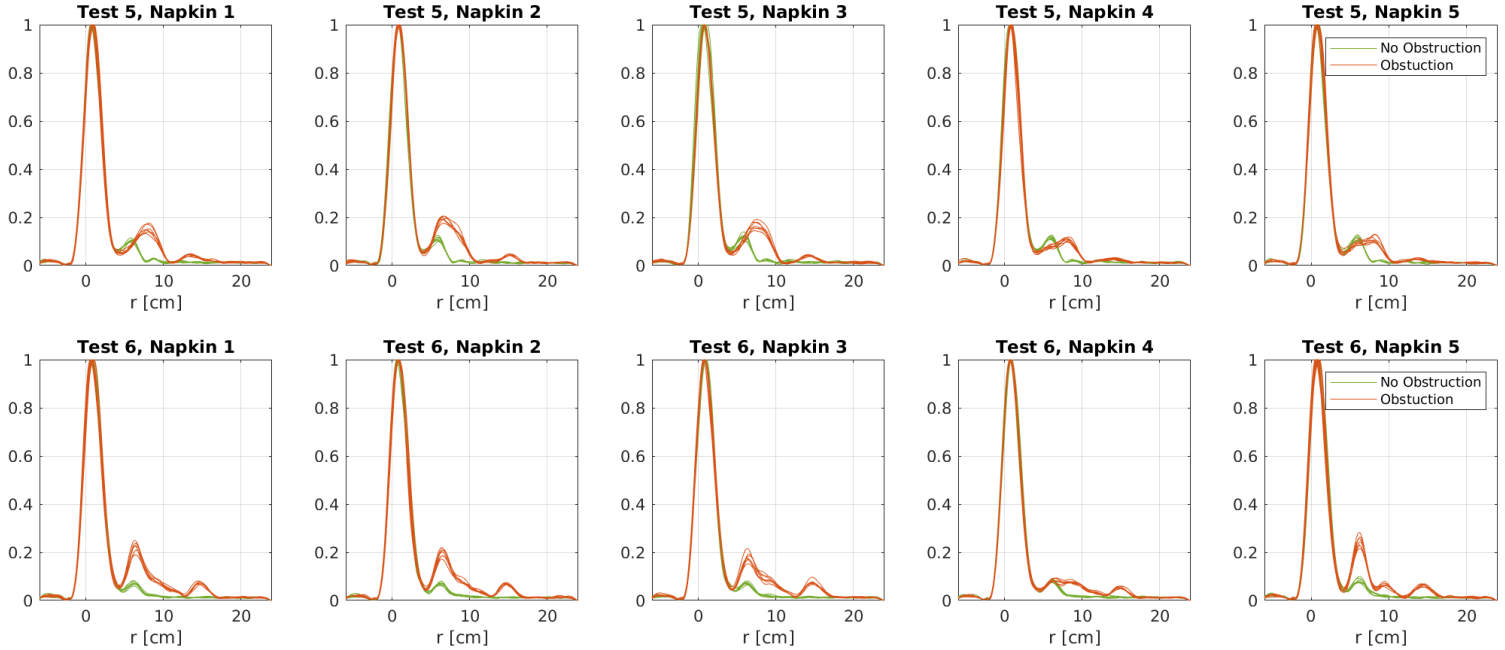
Obstruction Measurements



Obstruction Measurements

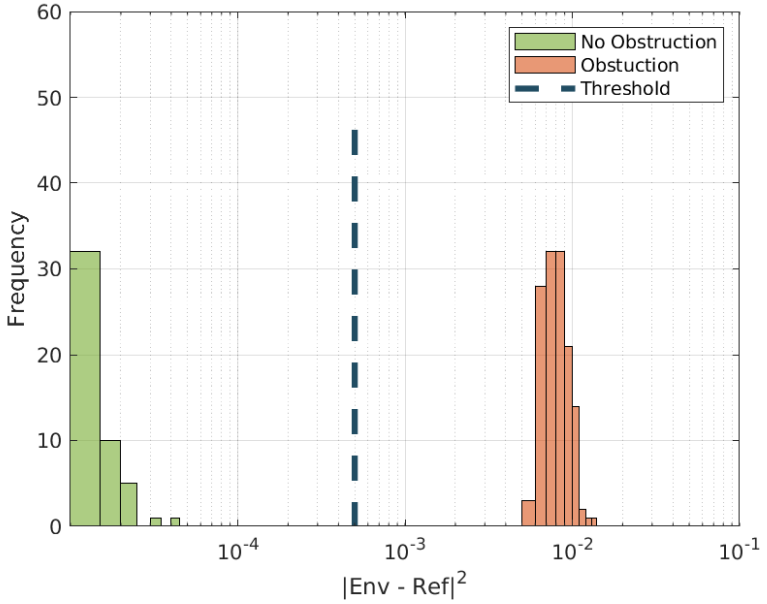


Obstruction Measurements

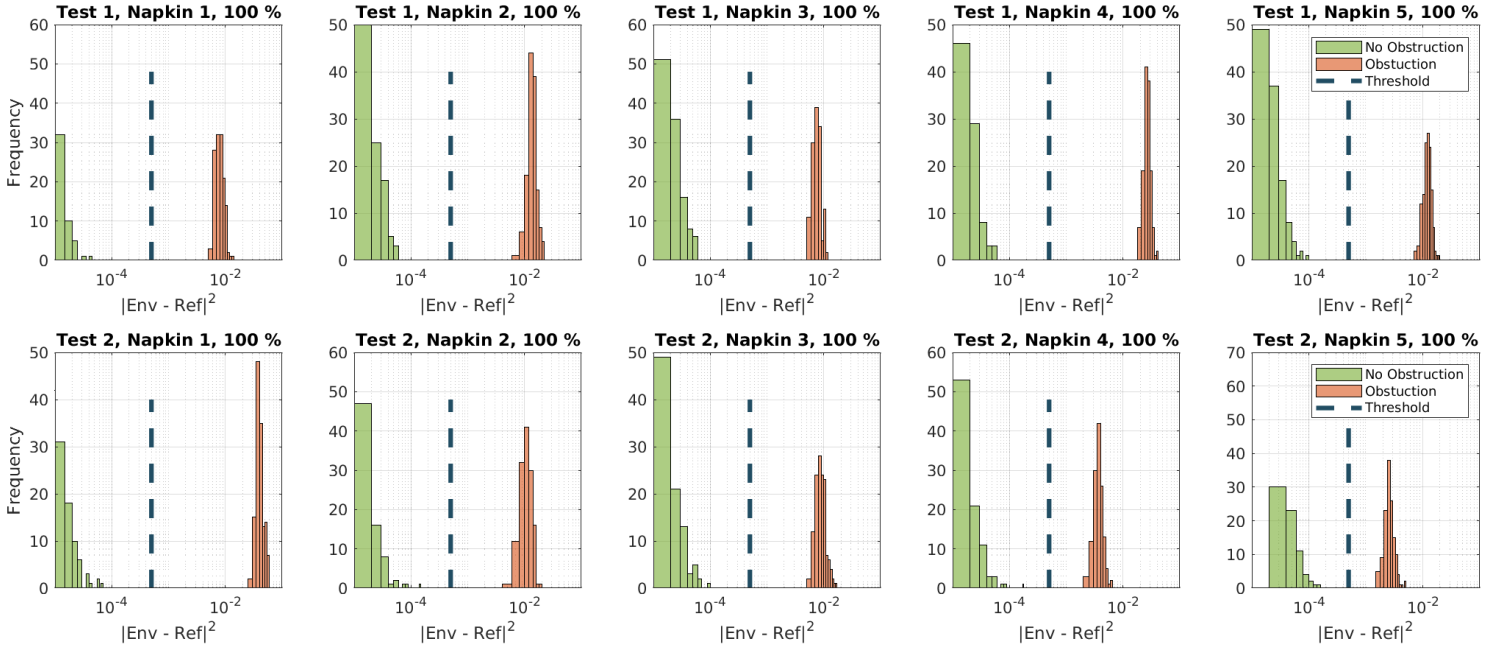


Obstruction Detection

- Before placing the napkin the first time, a reference were recorded
- Then, the difference between sweeps and the reference is calculated
- This difference is expected to be high if an obstruction is present

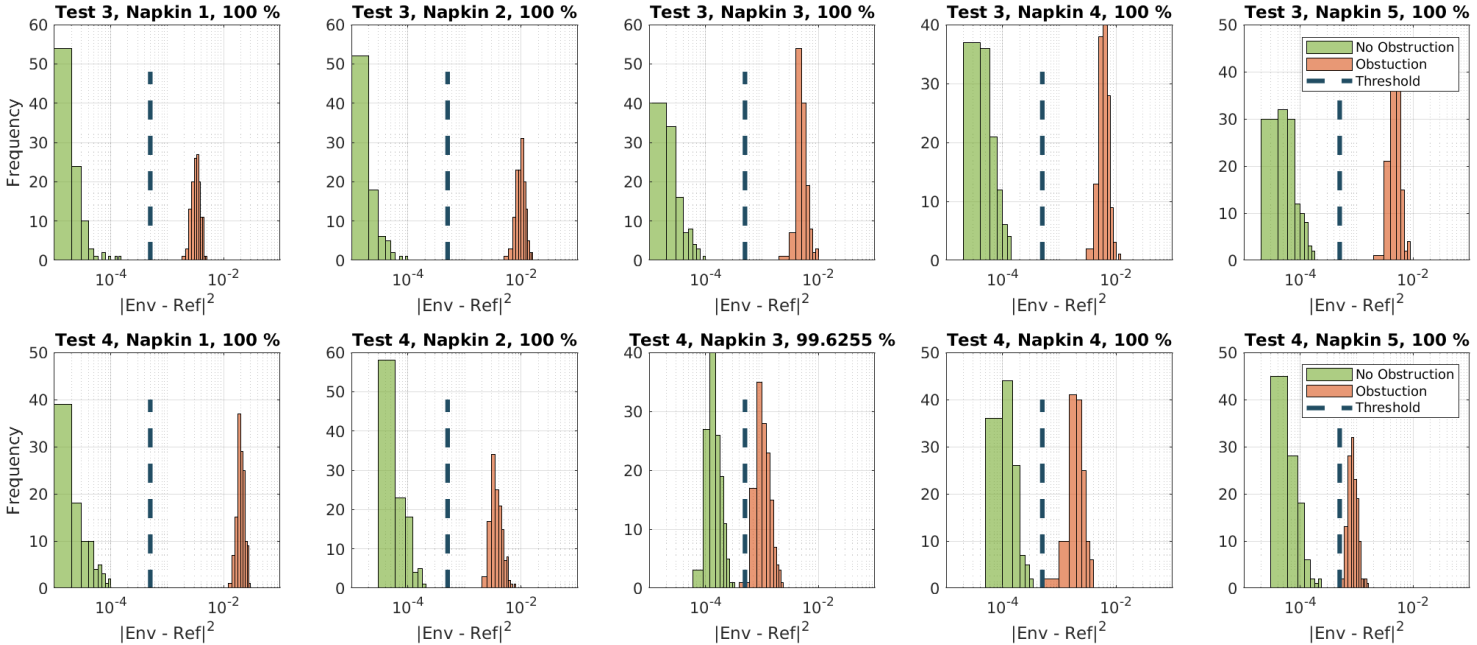


Obstruction Detection



Threshold: 0.5e-3

Obstruction Detection



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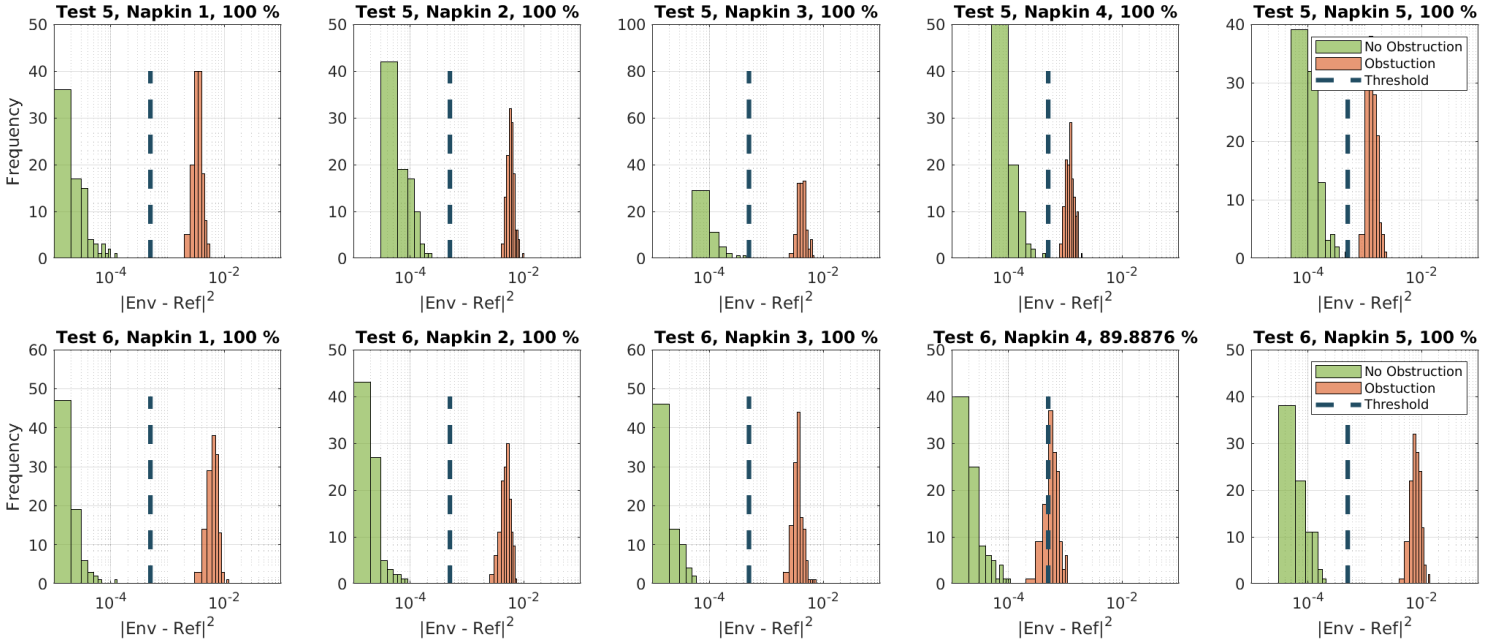
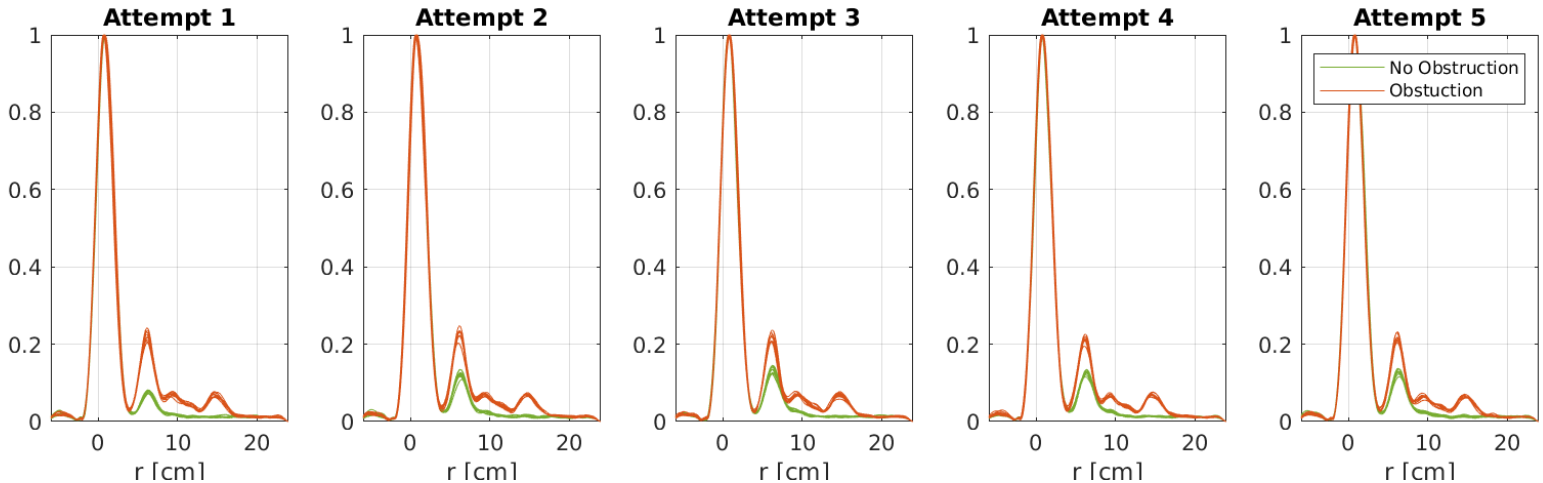
Obstruction Detection



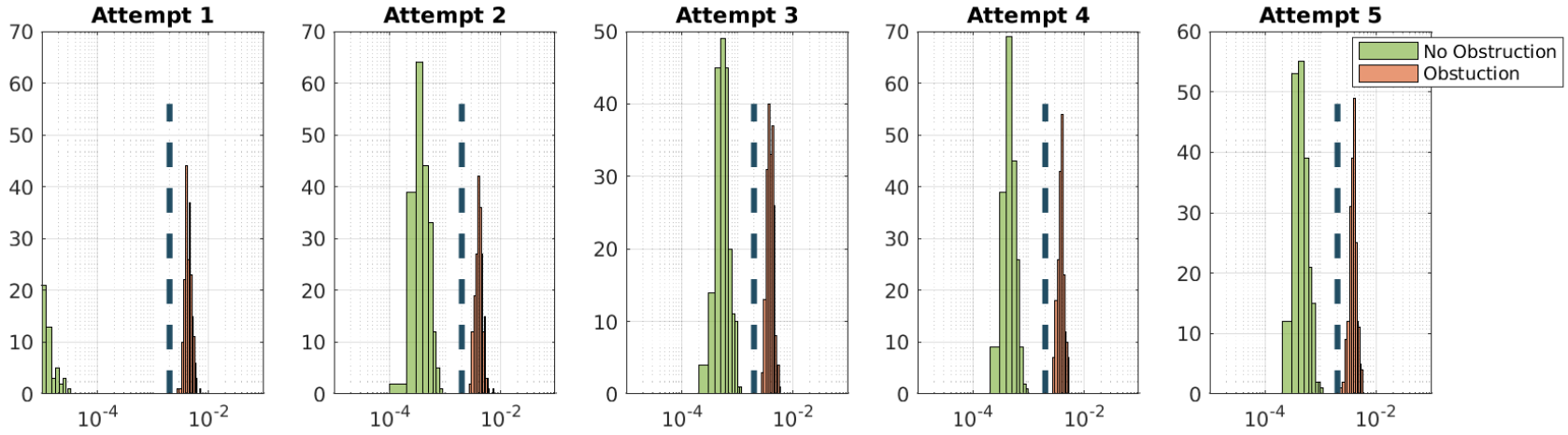
Threshold: 0.5e-3

Measure Water

Measure Water



Measure Water



Threshold: 2e-3

Conclusions and Recommendations

- With an optimal lid design, obstructions can be detected
- The algorithm is based on measuring and store in memory a reference envelope when the sensor is free from obstructions
- Then, when new measurements deviates from the reference, an obstruction is detected.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