FocalPoint

Supercorrelation: A Software Upgrade to Toughen GNSS Receivers

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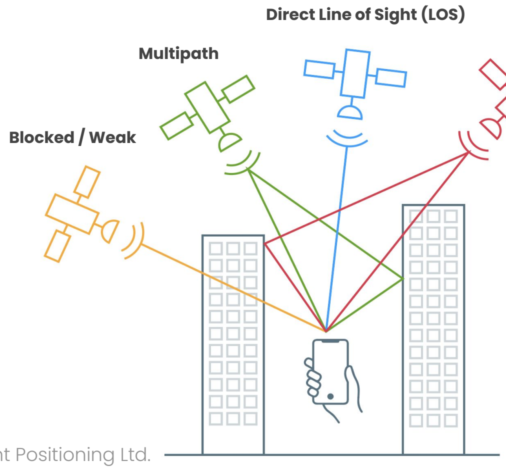
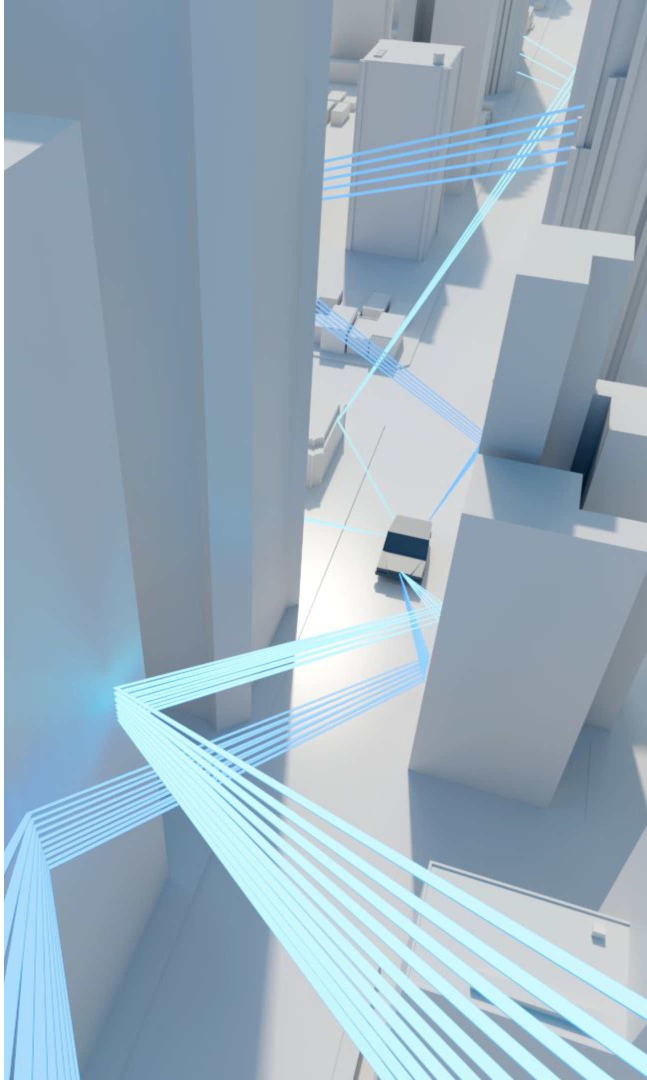
Founder, President and CTO

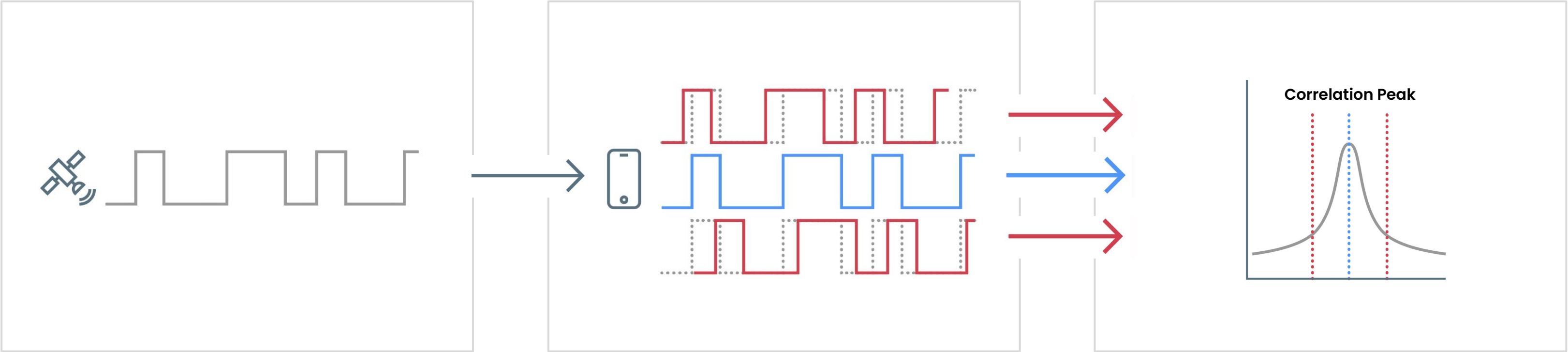
There is a big, structural problem with GNSS in cities.

- GNSS performs poorly in cities because signals are blocked or reflected from buildings
- The reflected signals dominate or interfere with the true line-of-sight (LOS) signals
- Receivers cannot rely on power level to distinguish between LOS and NLOS (e.g. weak LOS penetrating a canopy, versus lossless reflections from metal)





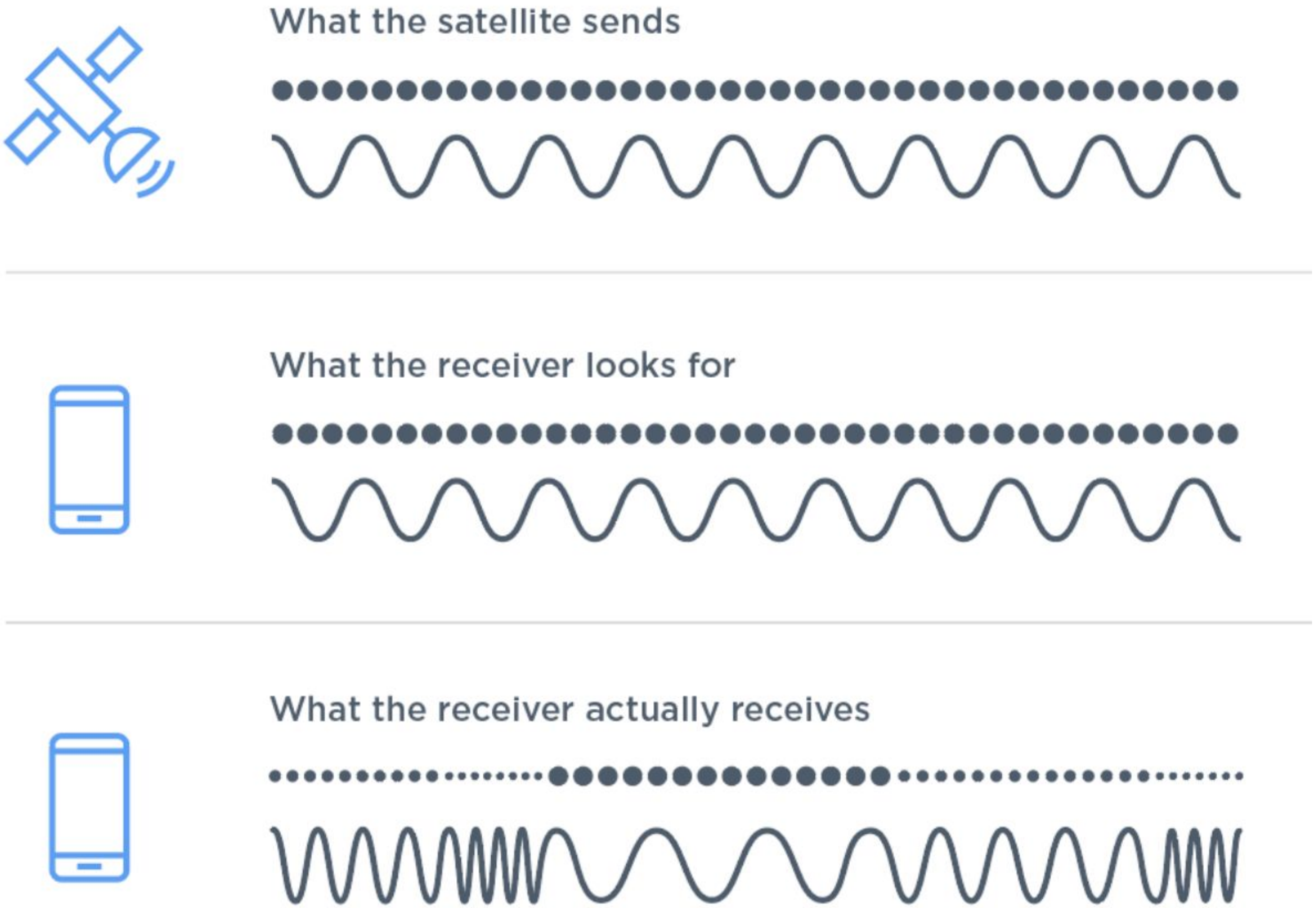
Correlation is at the core of the problem - and the solution

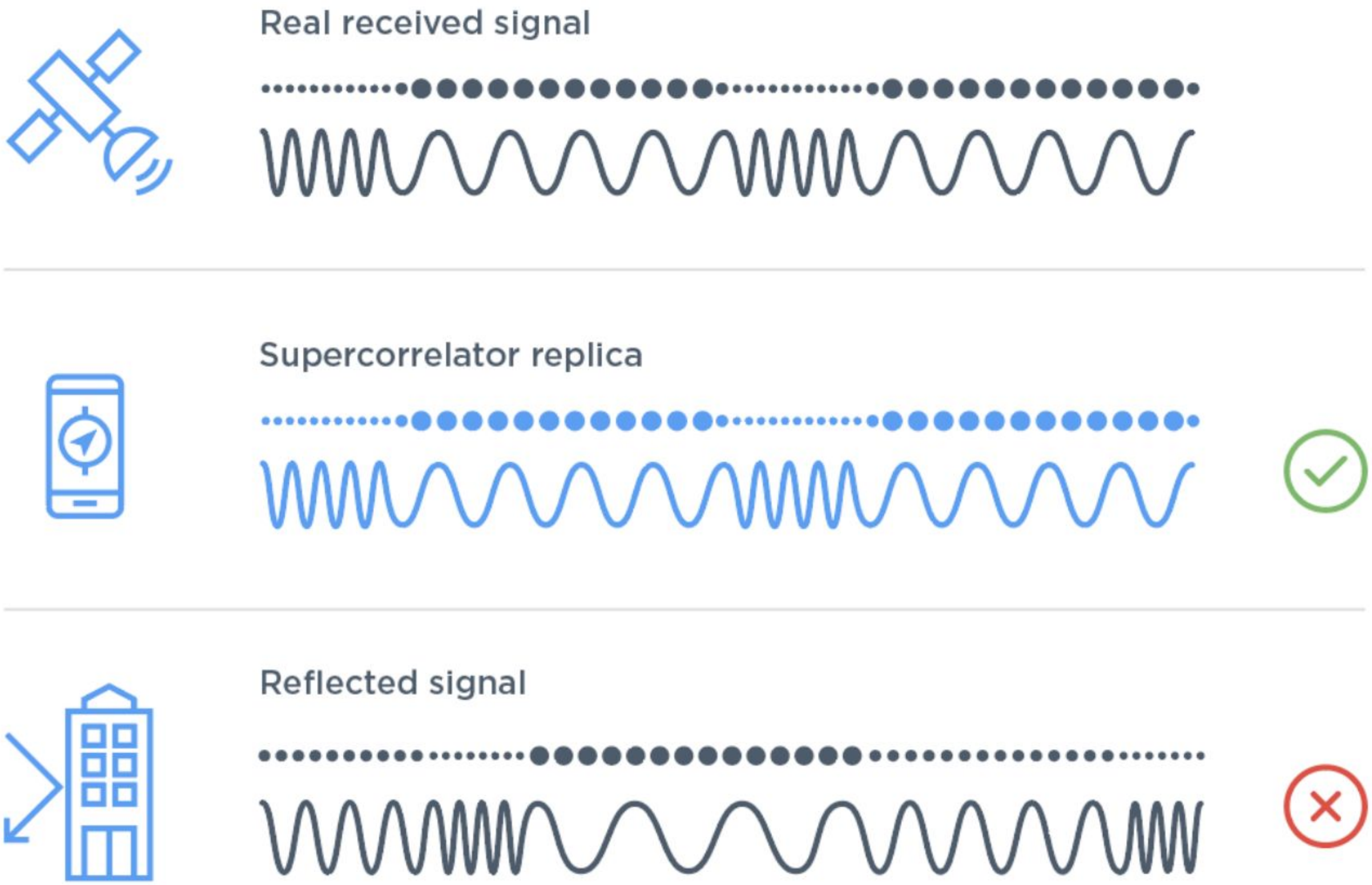


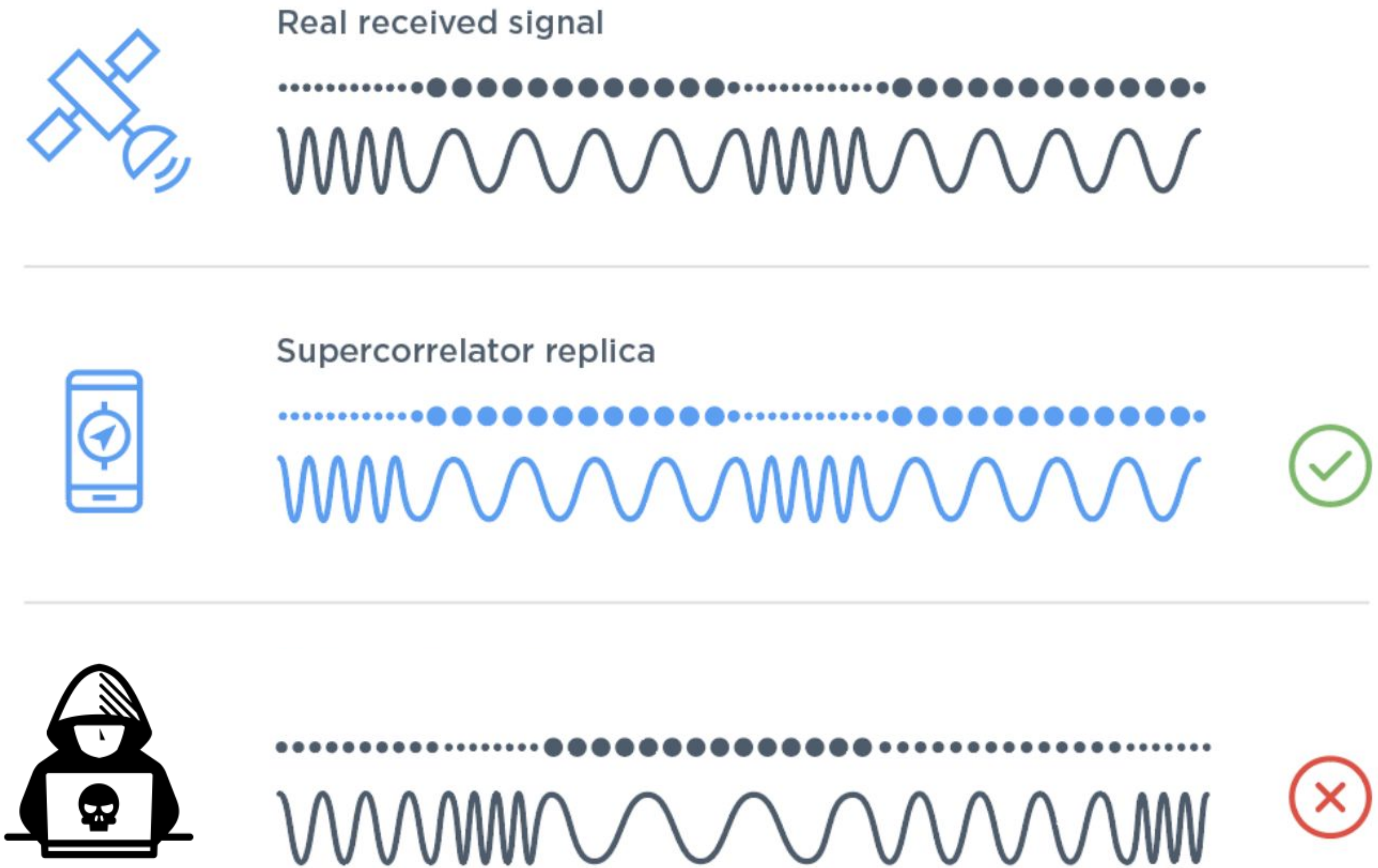
Step 1
Satellite sends out unique coded signal

Step 2
Device matches received signal with internal replicas with varying time delays

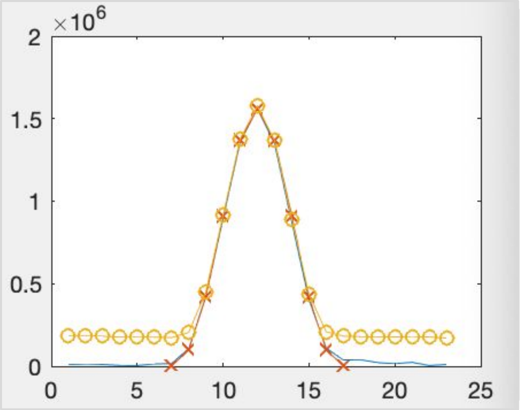
Step 3
The correct time delay replica gives the strongest correlation, allowing the device to estimate the distance to each satellite, and thus the device's position


What the satellite sends
What the receiver looks for
What the receiver actually receives

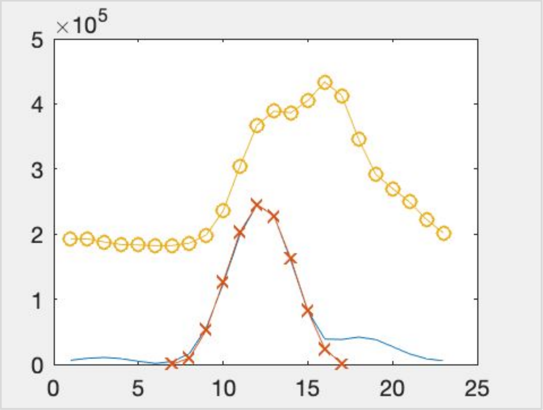

Real received signal
Supercorrelator replica
Reflected signal


Real received signal
Supercorrelator replica

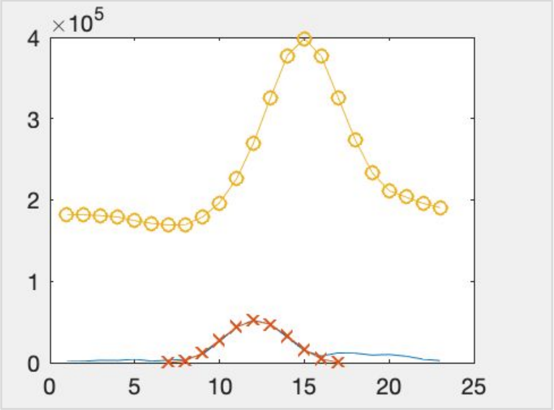
Actual correlation peaks - GPS L1



Clean signal



Multipath interference

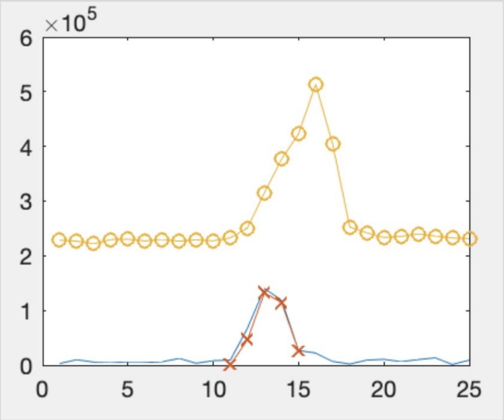


Non-line-of-sight signal overpowering the LOS (e.g spoofing)

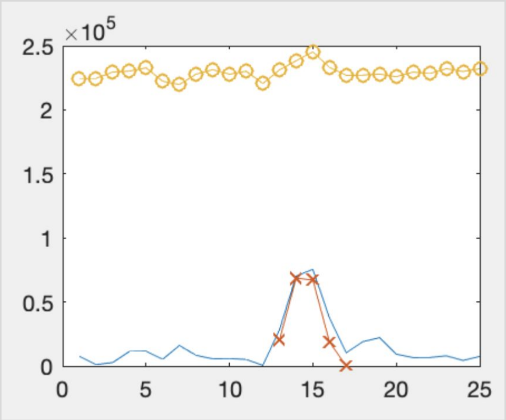
Yellow = incoherent integration
Blue = supercorrelation
Red = a clean (multipath-free) template correlation peak

Actual correlation peaks - GPS L5

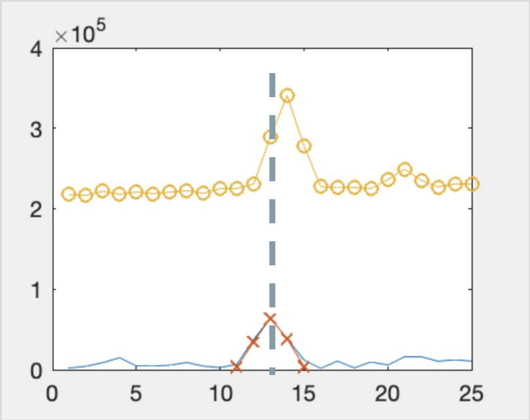
L5 coherence length is 10x shorter than L1, but the correlation peaks can still be distorted and displaced



Multipath interference



Sensitivity boost
(helps with the L5 antenna problem)



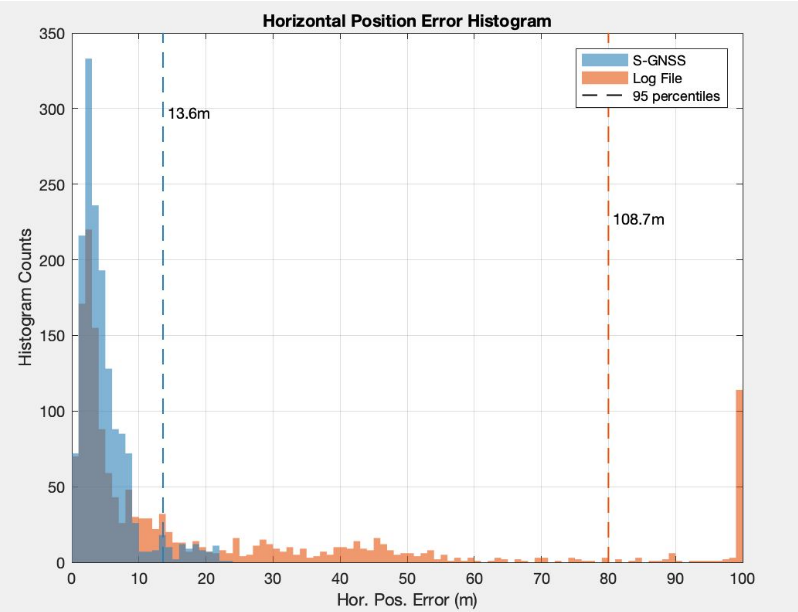
NLOS overpowering the LOS

Yellow = incoherent integration

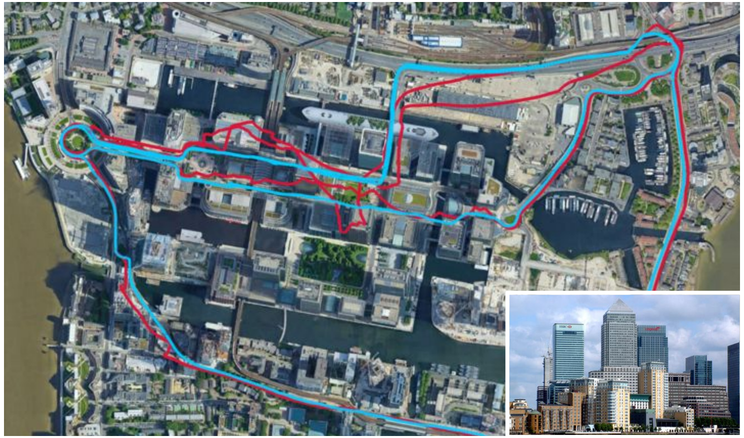
Blue = supercorrelation

Red = a clean (multipath-free) template correlation peak

Trials in Canary Wharf, London, UK using GPS L1



Canary Wharf, London undocked drive test with and without Supercorrelation



Supercorrelation vs standard GPS chipset

- Smartphone GPS chipset
- FocalPoint S-GNSS (GPS L1 only)

Driving test in Canary Wharf, London with undocked smartphone (not using strapdown inertials)

Typical improvements

Sensitivity boost of 5-10 dB depending on settings chosen

Accuracy improvements of 2x to 12x across pseudoranges and Doppler depending on environment

Integrity improvements of 3x to 10x depending on environment

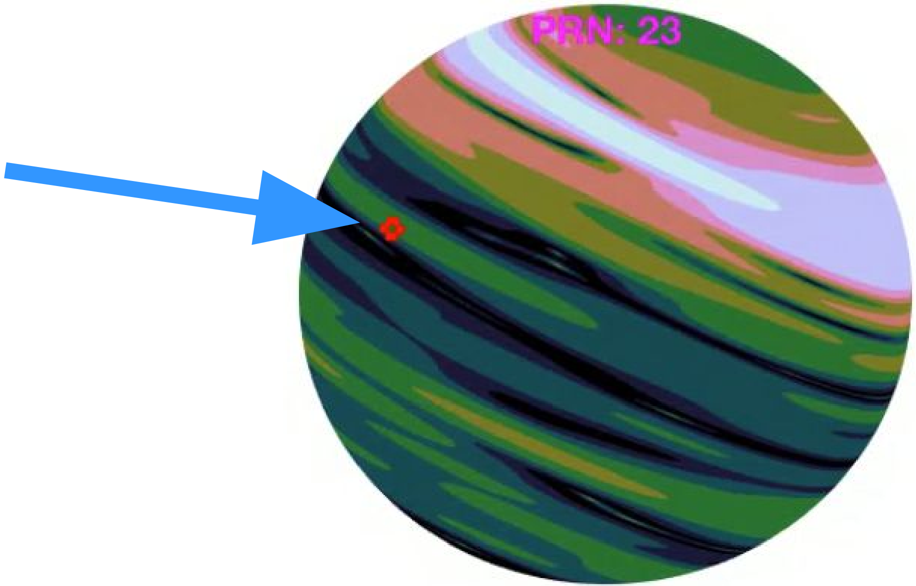
BOM savings on XO, antenna, L5 requirements, silicon area, power consumption, etc

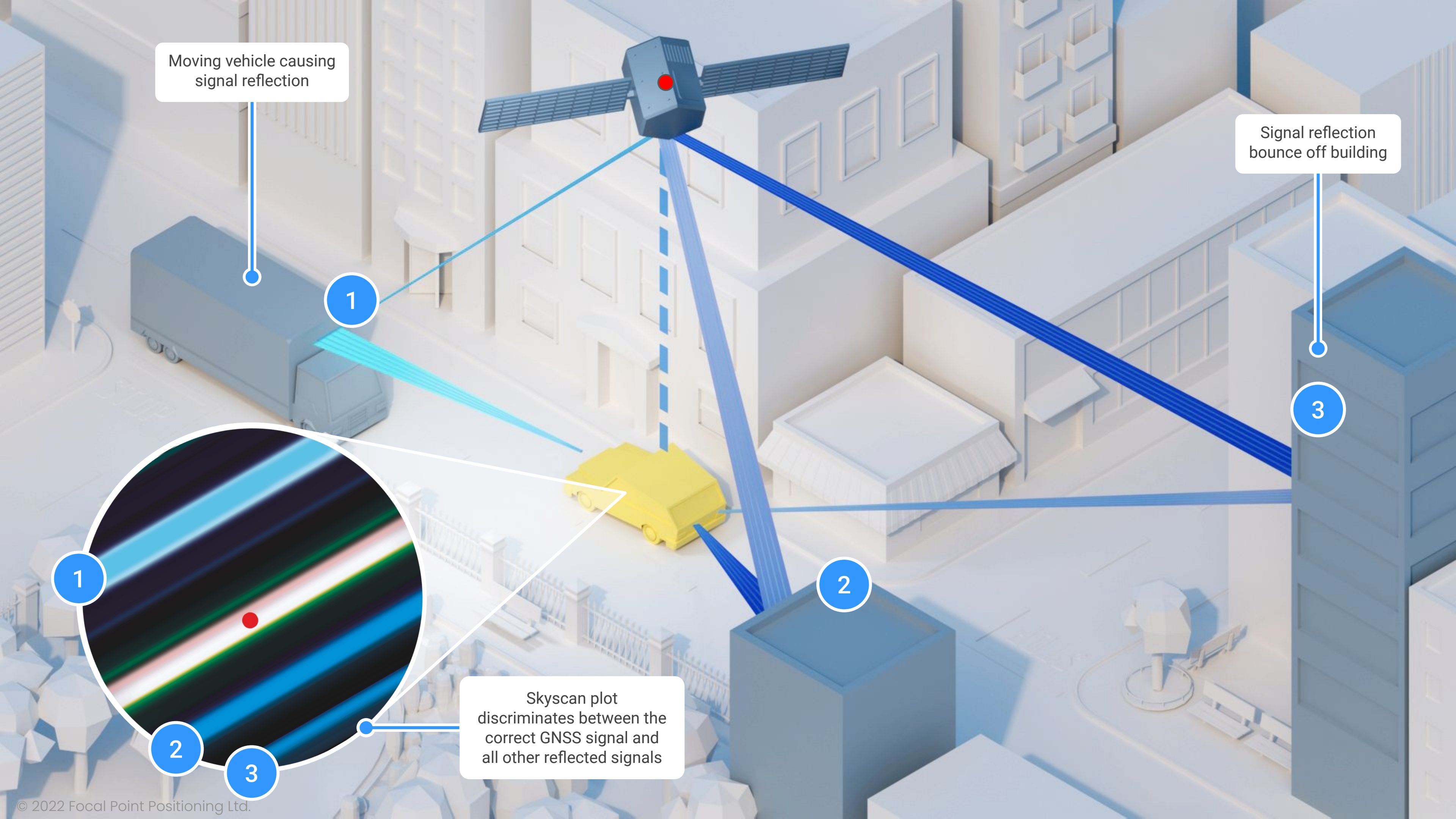
Anatomy of a Skyscan

A skyscan plot is a representation of the incoming power from a given satellite for all azimuth and elevations

The red mark is the true satellite location in the sky

The colours show the power detected from each arrival angle

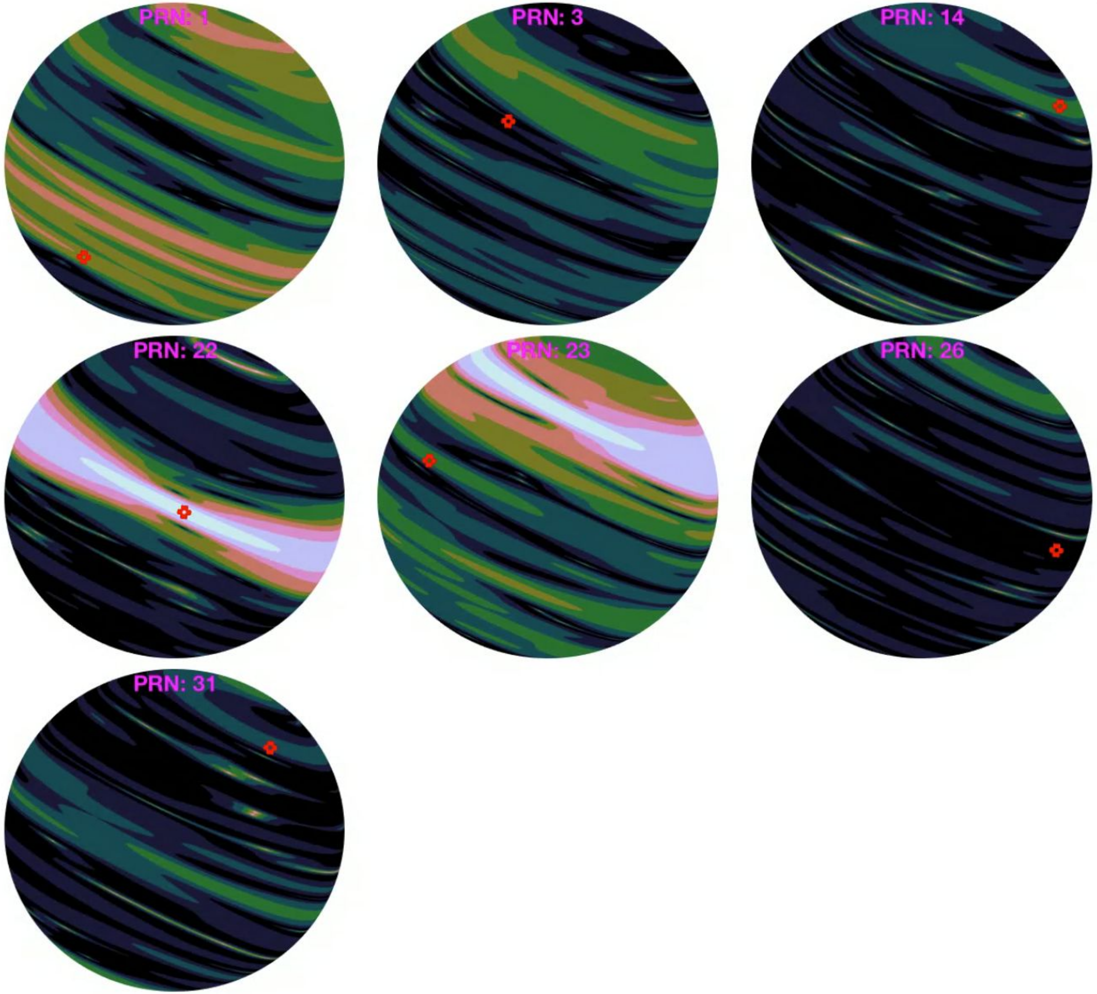




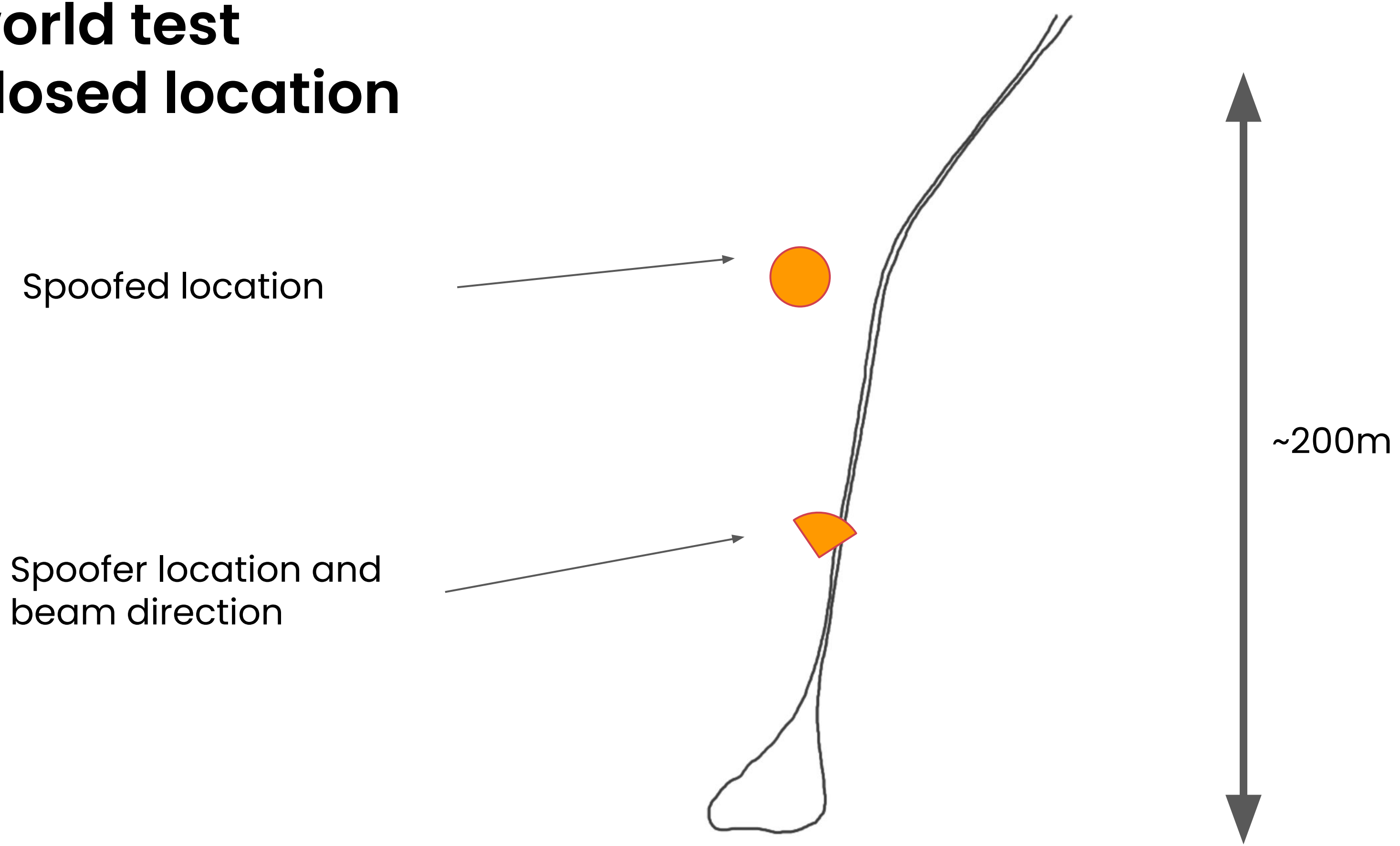
Moving vehicle causing signal reflection
Signal reflection bounce off building
1
2
3
1
2
3
Skyscan plot discriminates between the correct GNSS signal and all other reflected signals

Skyscan

Reveals signals that match the satellite broadcast but are coming from the wrong directions to be the line-of-sight component

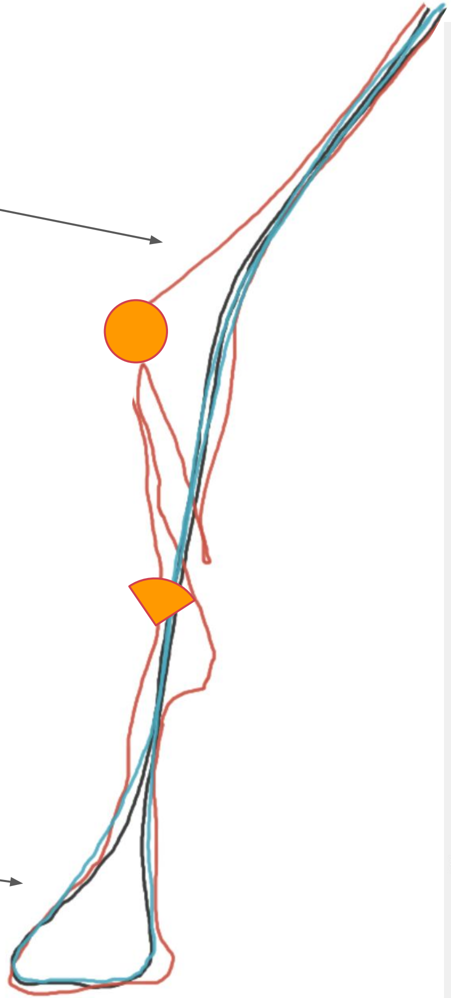


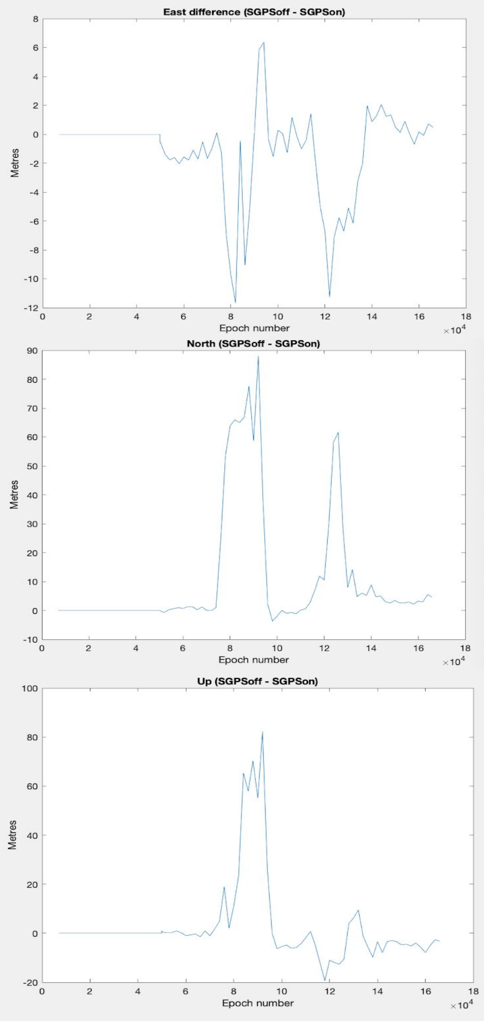
Real-world test
Undisclosed location

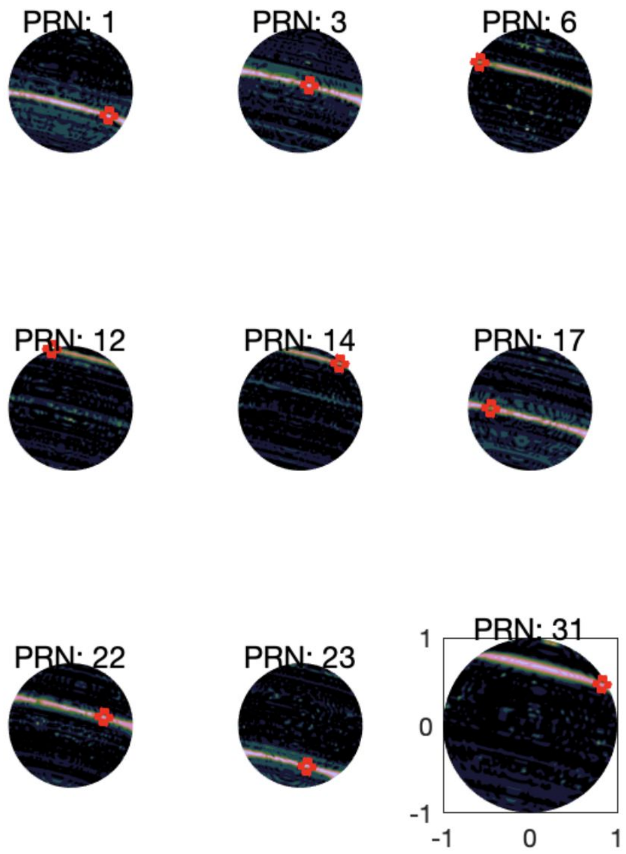


Red line = standard GNSS positioning

Blue line = Supercorrelation position fixes



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PRN: 3
PRN: 6
PRN: 9
PRN: 11
PRN: 12
PRN: 14
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PRN: 23
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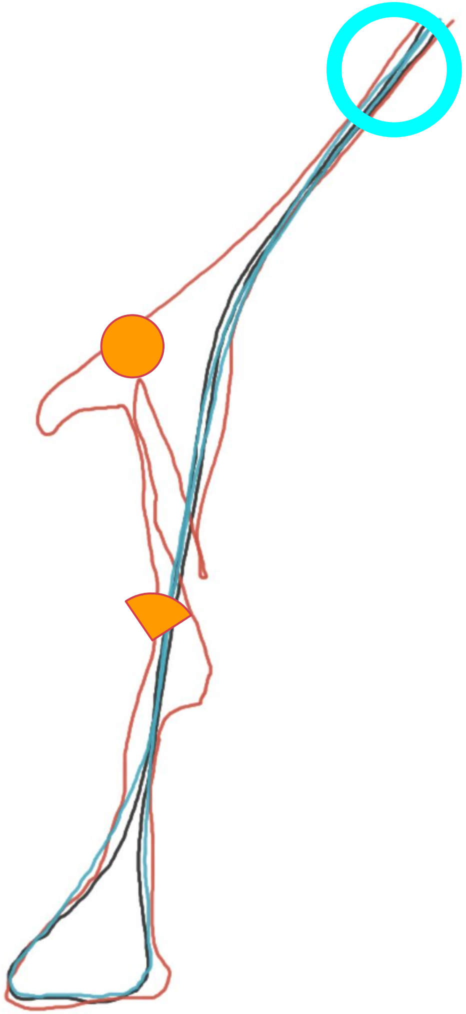

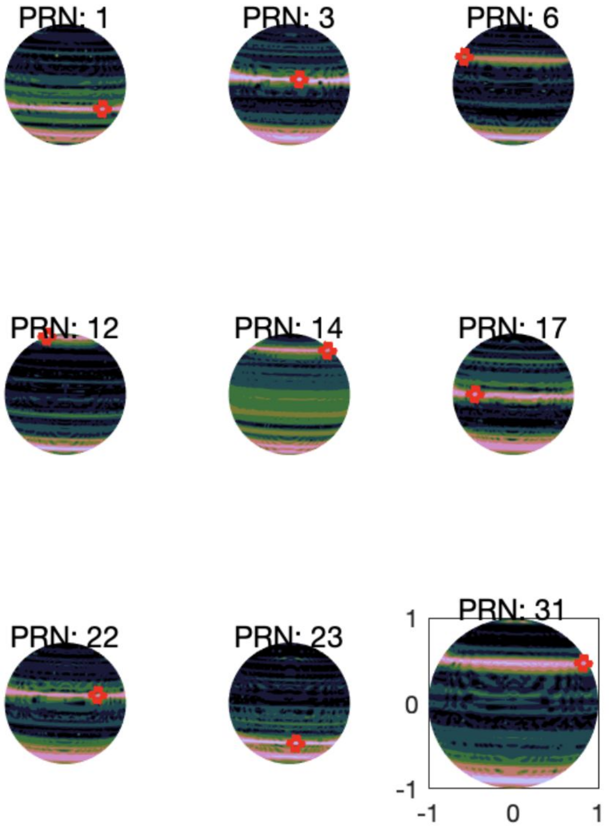
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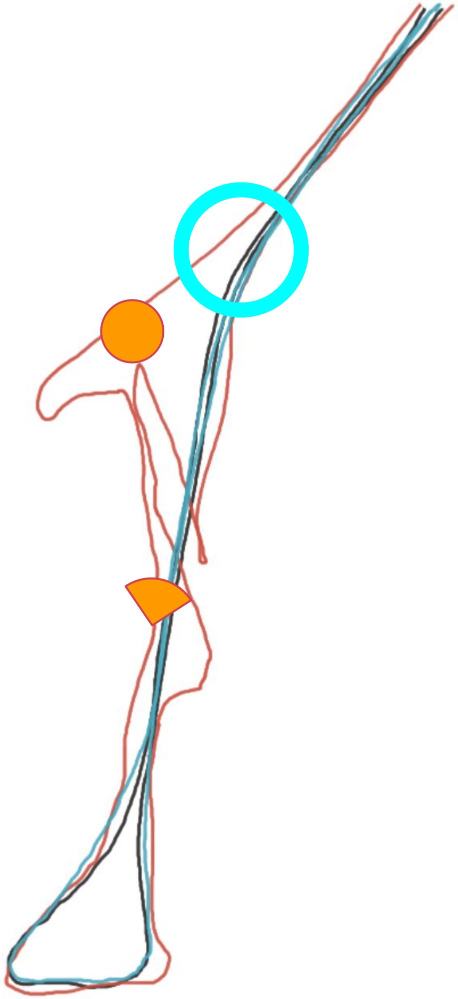

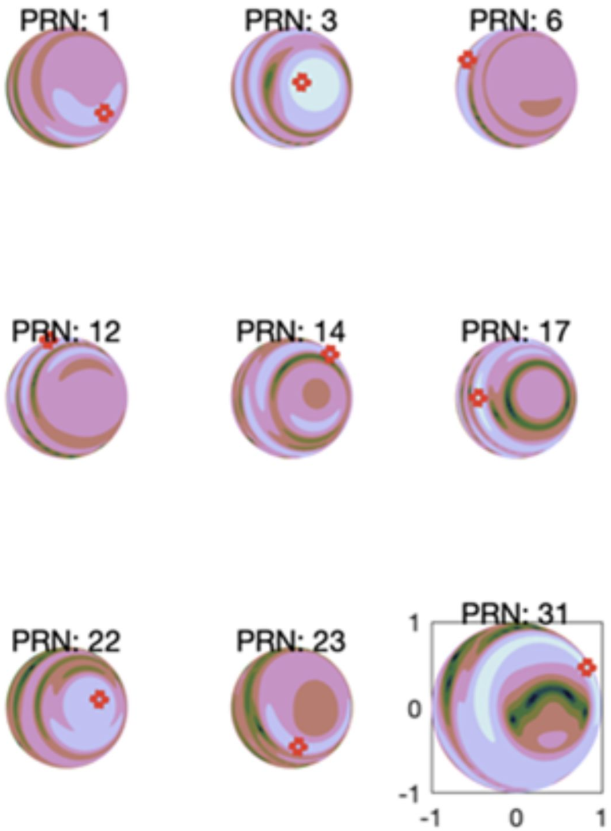
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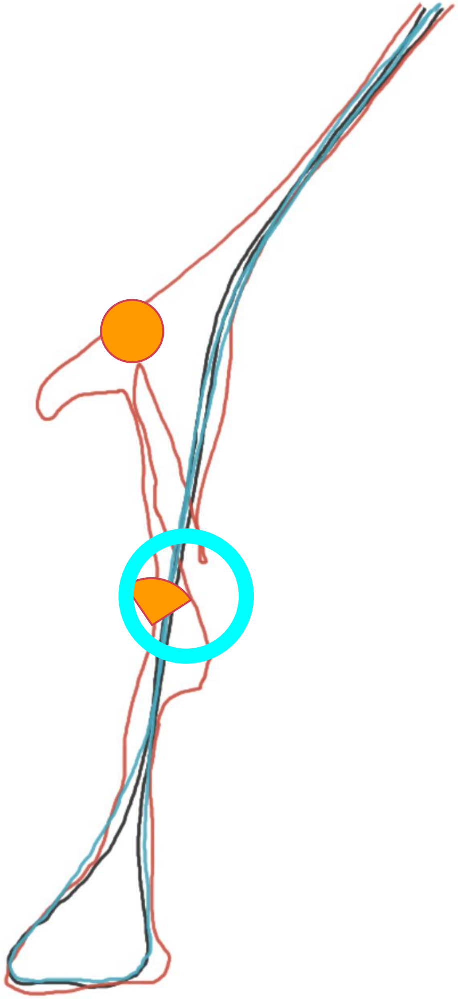

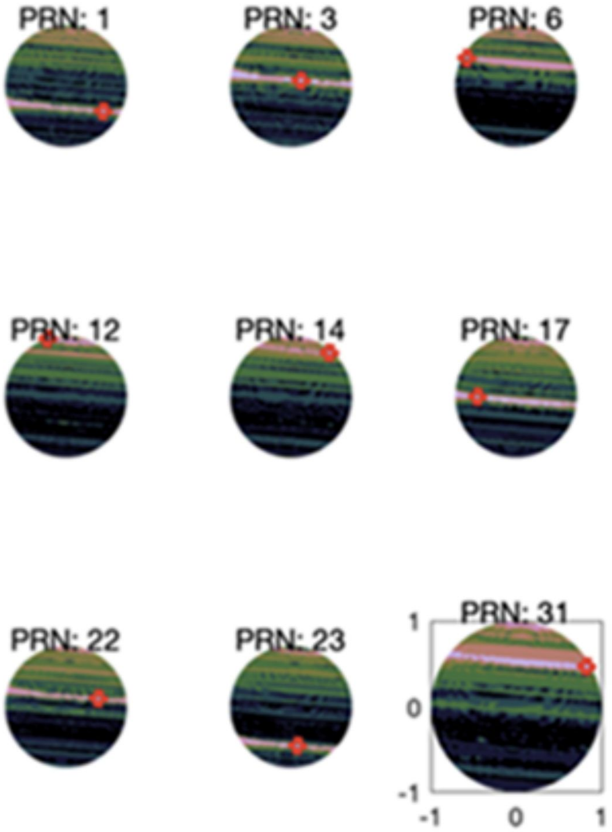
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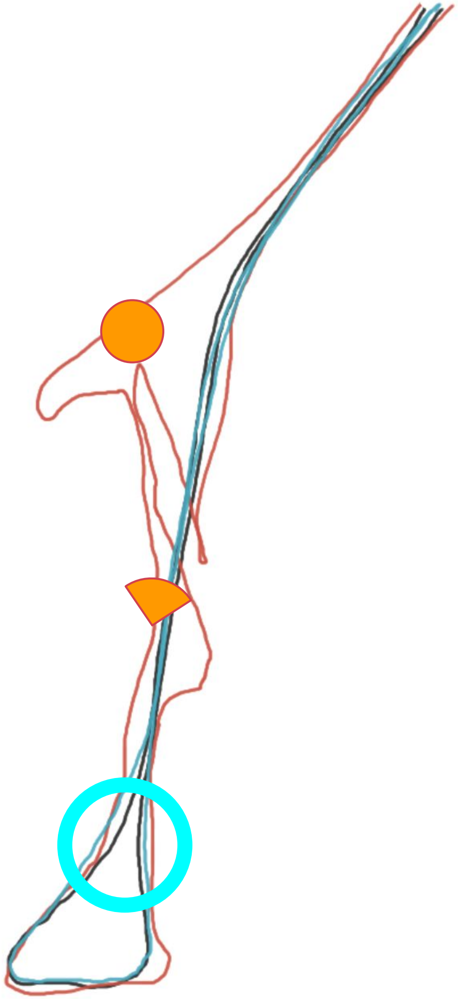
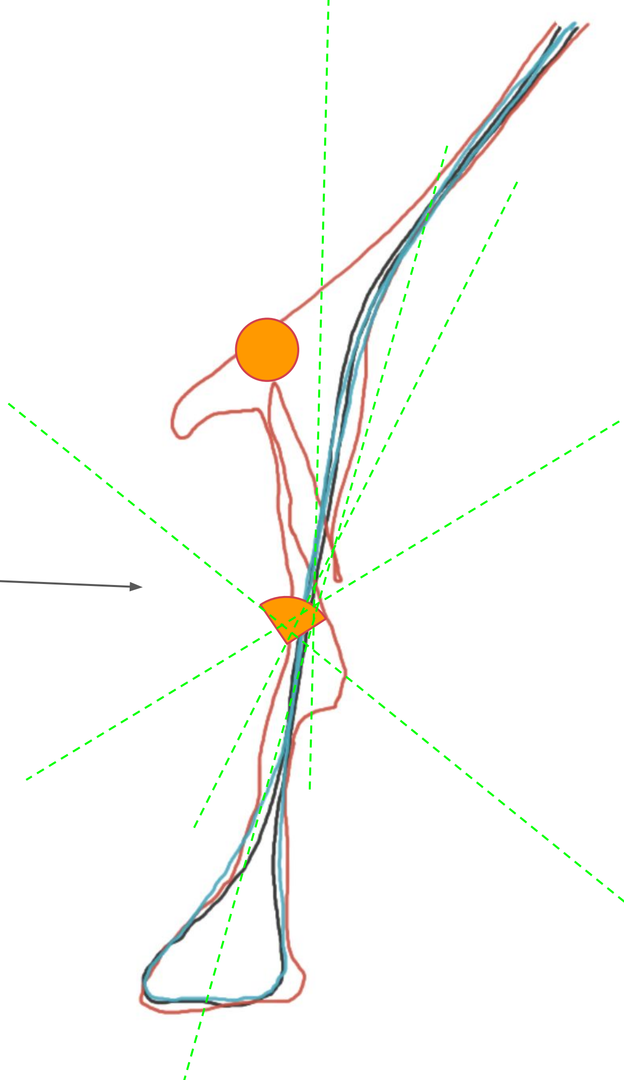


Monitoring azimuths over time as the receiver moves allows the spoofer location to be determined



Summary

Supercorrelation is motion-compensated, very long (>1 second) coherent integration

Supercorrelation provides angular dependant sensitivity boosts/nulls similar to a CRPA but entirely in software

We focus on smartphone and smartwatch grade devices

Supercorrelation can provide all GNSS receivers with greater resilience against jamming and spoofing attacks without any changes to the hardware

The angle of arrival sensing not only allows spoofers to be ignored, but it allows them to be located too

FocalPoint

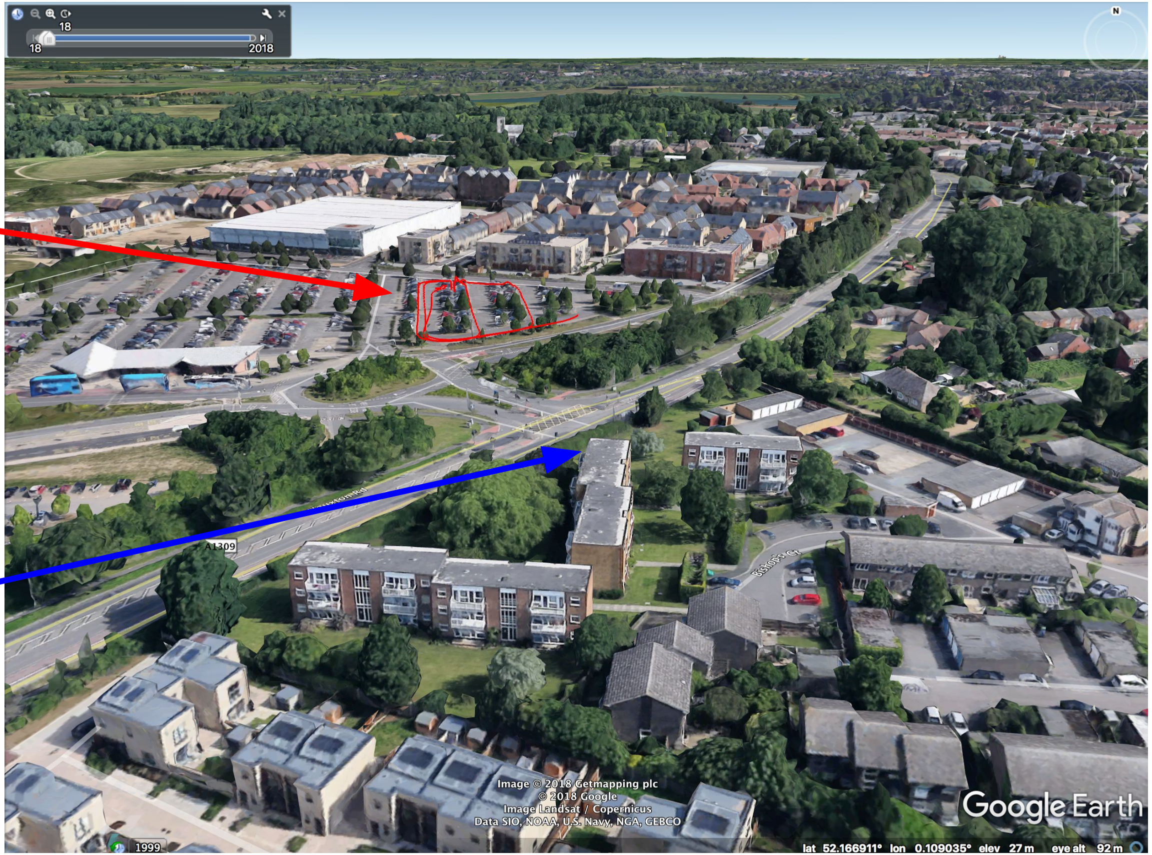
Founder, President and CTO

Dr Ramsey Faragher

Anti-spoofing capabilities - interference injected in playback (offline attack)

Driving experiment in car park

Simulated meaconing rebroadcaster here

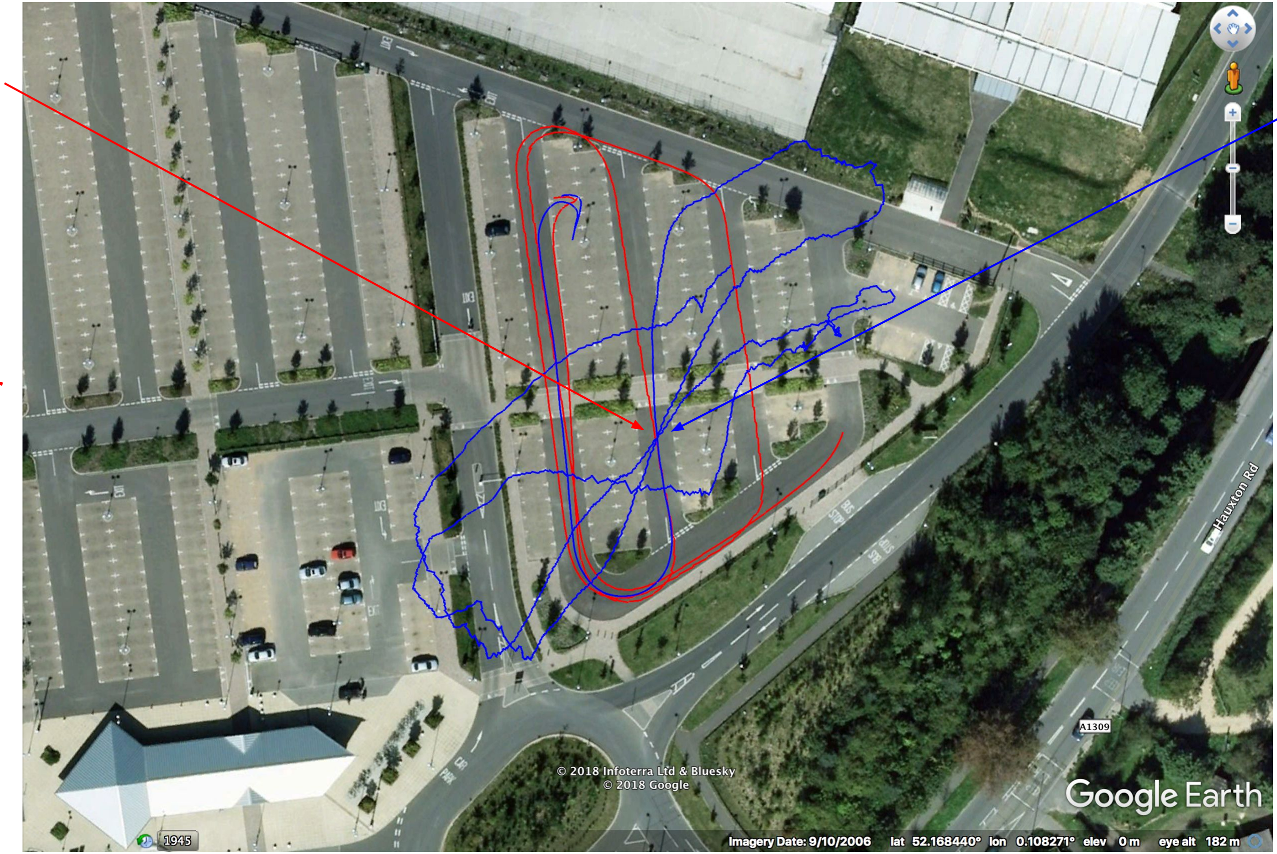


Anti-spoofing capabilities - interference injected in playback (offline attack)

Red line:

S-GPS

Resilient against the meaconer



Blue line:

Standard tracker

Disrupted by the meaconing attack

Anti-spoofing capabilities - interference injected in playback (offline attack)