Novel Multipath Vibration SAR Phenomena of Concealed Targets

INTRODUCTION

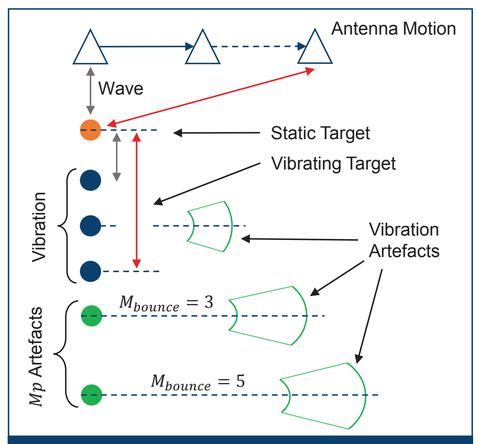
- Remotely gathering information on activities within buildings is an area of great interest for defence and public sectors.
- Through-wall Synthetic Aperture Radar (SAR) phenomenology of complex vibrating targets within a building is the focal point of this investigation.

Multipath and Vibration Artefacts

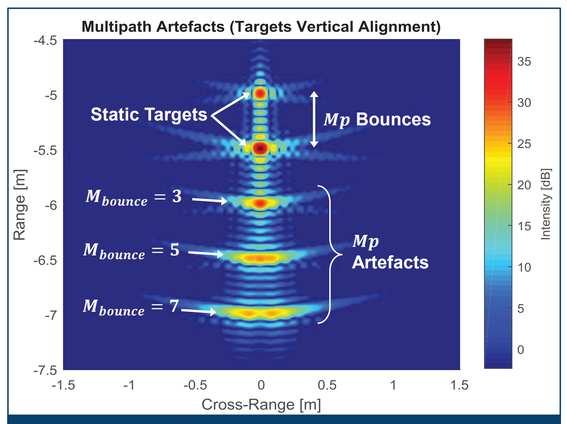
- Multipath is the effect of electromagnetic waves interacting with multiple surfaces before returning to antenna.
- The wave ***bounces*** between surfaces create artefacts in SAR imagery, providing information about the scene.
- When a vibrating target is imaged with SAR, it gives rise to echoes either side of main target.

Discovery of new Artefacts

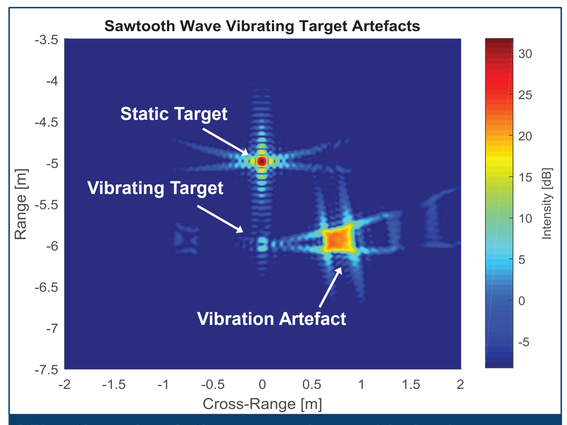
- A **Novel one sided echo** has been found, produced from particular types of vibration.
- A **Novel multipath vibration** artefact and mechanism has been found.
- The new phenomena have been combined in a **Through-Wall Wall-Multipath** scenario.
- Detection of these effects would provide improved information on building interiors.



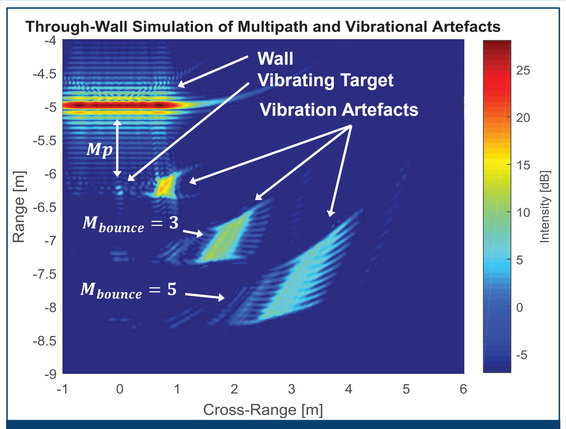
Simulated scene set-up



Multipath simulation – two static targets located vertically inline, undergoing multipath.

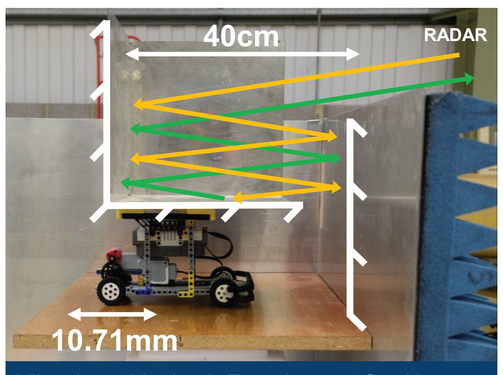


Vibrating simulation – novel one-sided echo, produced from particular types of vibration.

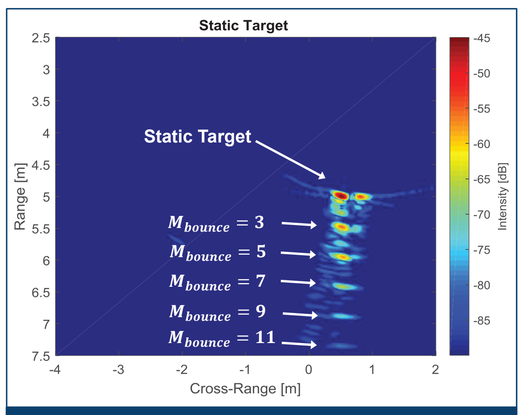


Through-wall simulation - novel combined multipath and vibration artefacts

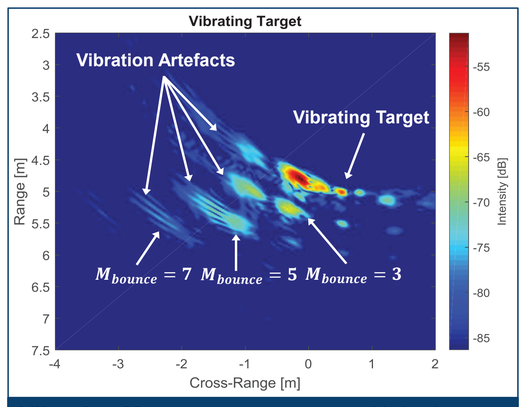
MEASURING MULTIPATH & VIBRATION ARTEFACTS IN SAR IMAGERY



Vibrational Multipath Experimental Set-Up



Multipath Measurement – Static target with multipath artefacts.



Vibration Measurement – target with both vibration and multipath artefacts.

- To validate the predictions a novel experiment that exposes concealed vibrating targets was setup using a **remote control vehicle**. Its motion is **synchronised** with Cranfield's **AGBSAR** radar system.
- The scenario here could represent an **air-conditioning unit** on a building.

Experimental Parameters

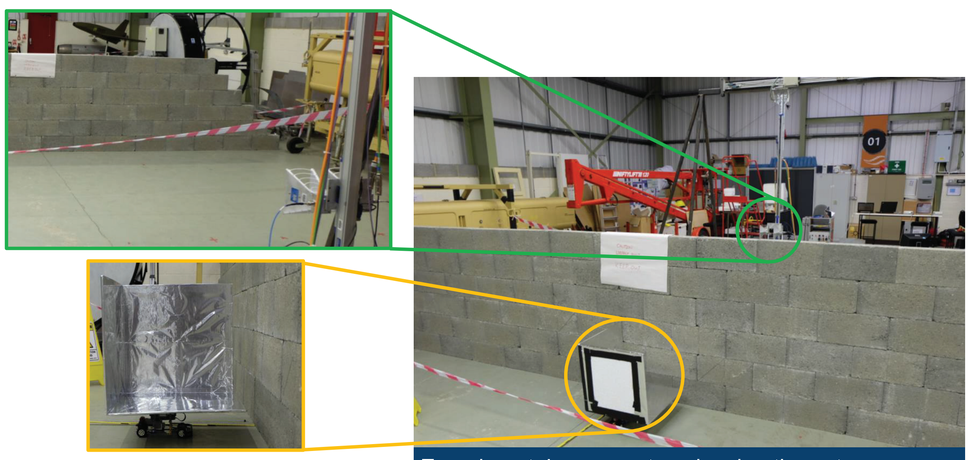
Radar	Vibration
Bandwidth: 4 [GHz]	Amplitude: 10.71 [mm]
Centre Frequency: 6 [GHz]	Frequency: 10 [Hz]
Aperture: 2 [m]	Effective Antenna Velocity: 2 [m/s]

MEASURING MULTIPATH & VIBRATION ARTEFACTS IN THROUGH-WALL SAR IMAGERY

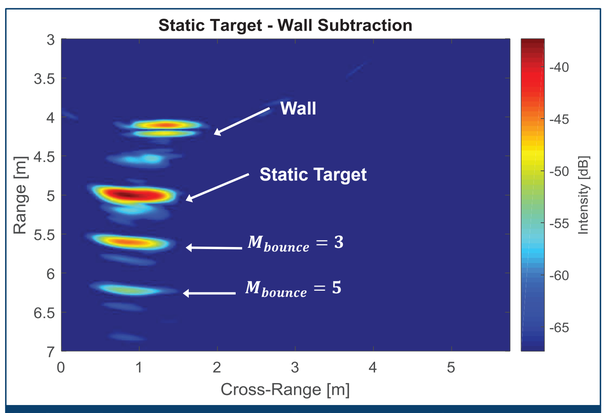
- Entirely concealing the remote control vehicle behind a wall mimics scenarios with, for example, an engine or other equipment **running concealed inside a building**.
- Experimental results **match predictions closely**, validating the understanding of newly identified SAR phenomena.

Experimental Parameters

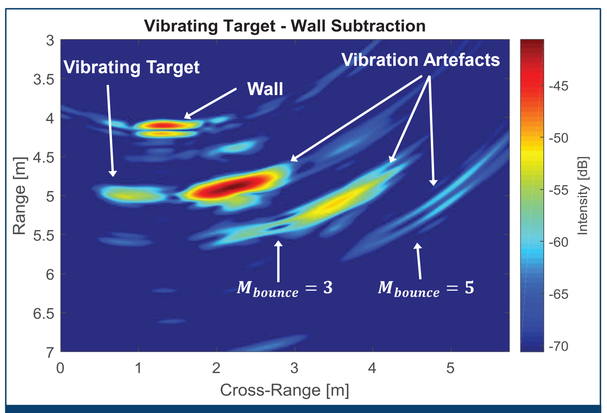
Radar	Vibration	Wall
Bandwidth: 3 [GHz]	Amplitude: 21.43 [mm]	Relative Permittivity: 5.5
Centre Frequency: 3.5 [GHz]	Frequency: 10 [Hz]	Conductivity: $1 \times 10^{-2.5}$ [S/m]
Aperture: 1.25 [m]	Effective Antenna Velocity: 2 [m/s]	Thickness: 90mm



Experimental scene setup showing the antenna platform and the vibration target.



Multipath Measurement – Static target with coherent subtraction of the wall signature.



Vibration Measurement – Vibrating target with coherent subtraction of the wall signature.

Mr. Brandon Corbett, Dr. Daniel Andre, Mr. Darren Muff, Dr. Mark Finnis

Centre for Electronic Warfare, Information and Cyber (EWIC), Cranfield University, UK Defence Academy, Swindon, United Kingdom

b.corbett@cranfield.ac.uk

www.cranfield.ac.uk