Active and passive radio frequency imaging using a swarm of SUAS

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NATO SET 222

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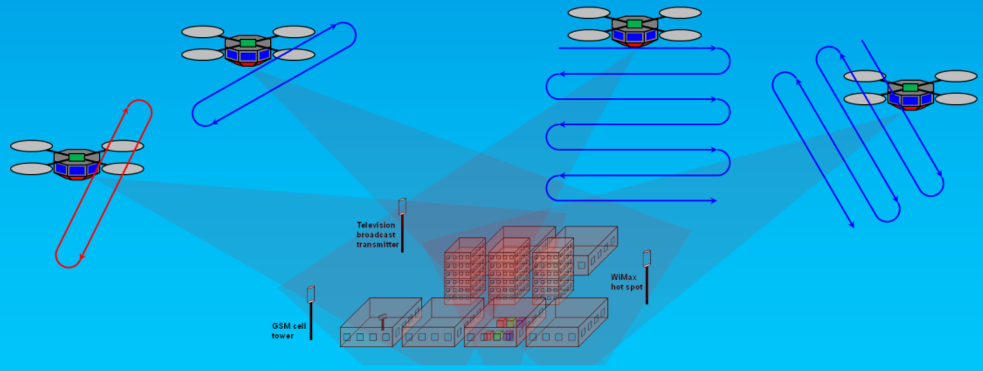

QinetiQ Proprietary

Contents

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Motivation

Knowledge of what's going on inside a building of interest is important for defence and security for:

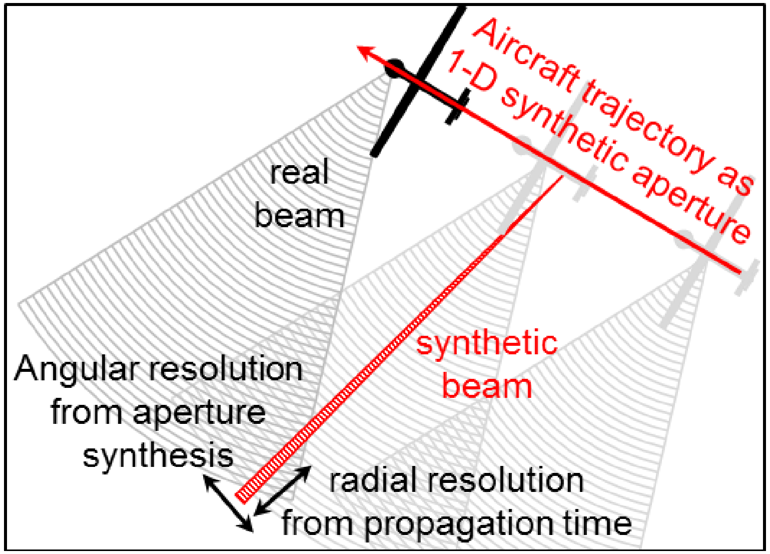
- Detecting concealed manufacturing activity
- Finding out about the internal structure of a building prior to entry
- Supporting disaster relief
- Identifying illegal storage activities

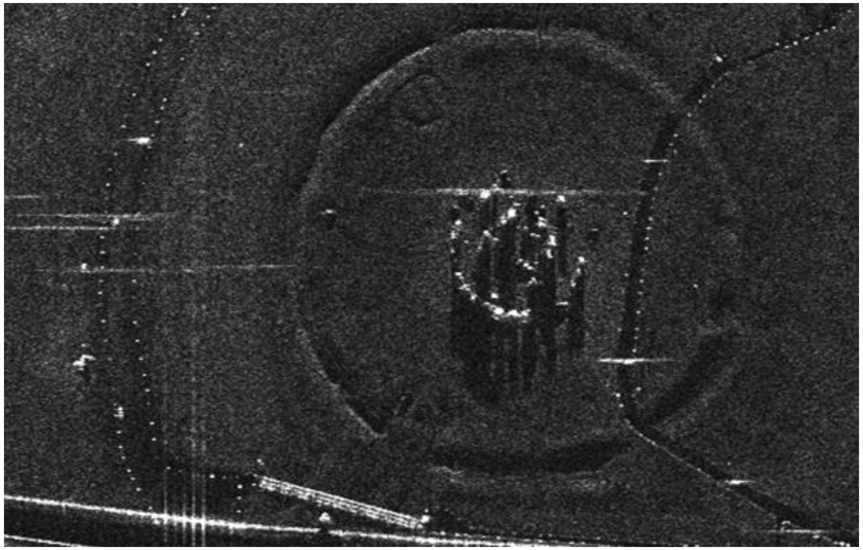
Radio frequency imaging provides a day/night, all weather solution with potential for building penetration dependent upon the frequency exploited.

Radio Frequency Imaging

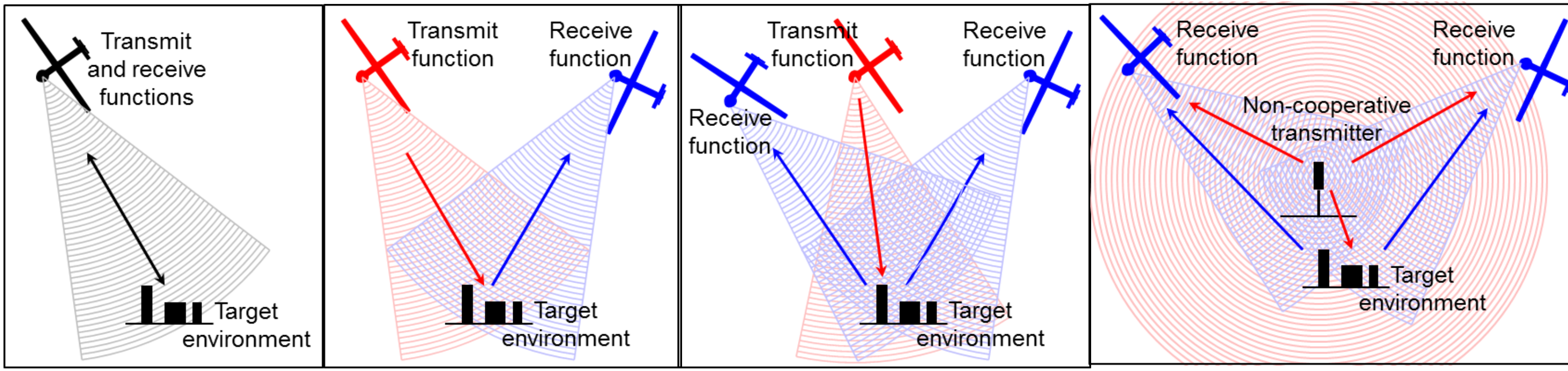
•Exploits the interaction of electromagnetic waves with the environment to form a high resolution "picture" of the environment and objects within it.

•Long wavelength (c.f. optical imaging) means that an extended 'synthetic aperture' is required to achieve fine angular resolution.





Bistatic and Multistatic SAR Concepts

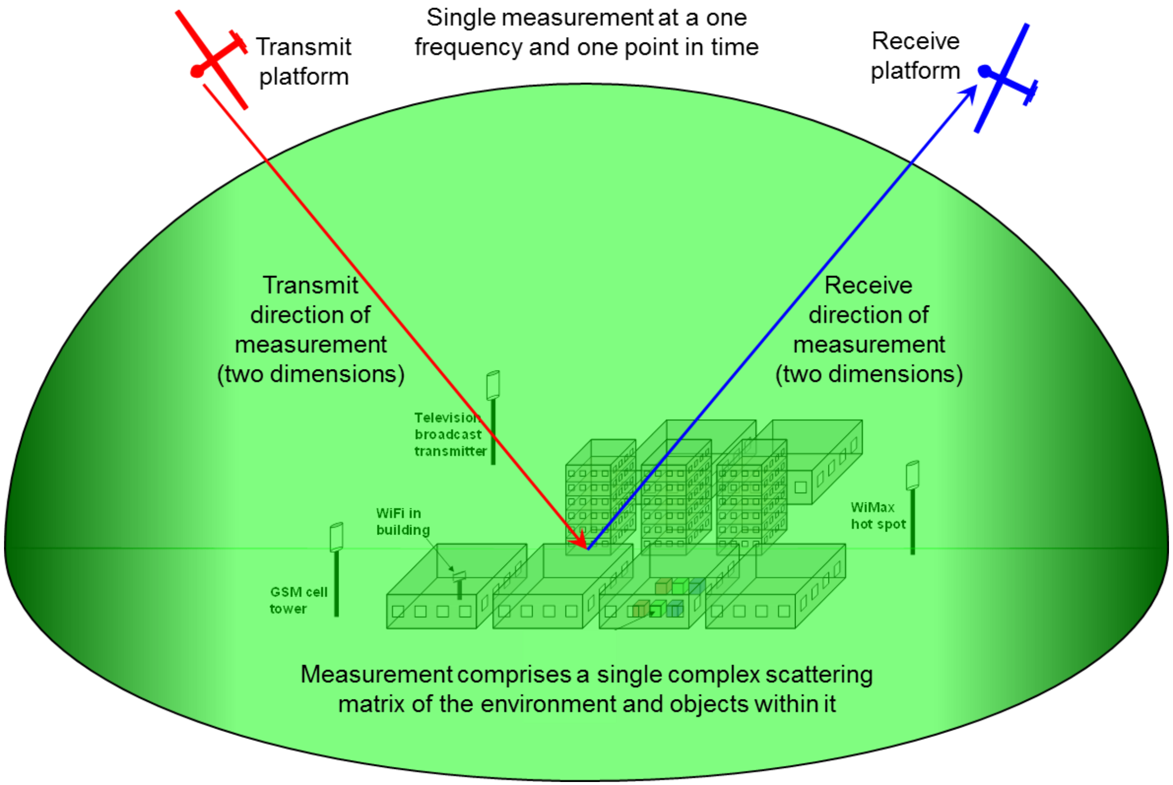


•Increasing the number of transmitters, receivers and platforms may increase the level of spatial information realised.

•Coherent integration over the collection aperture dictates that the entire sensing system is stable to a small fraction of the RF wavelength on a scale of the synthetic aperture.

•Aircraft require high grade navigation systems and sensors must include stable frequency references and a means of relating time between sensors.

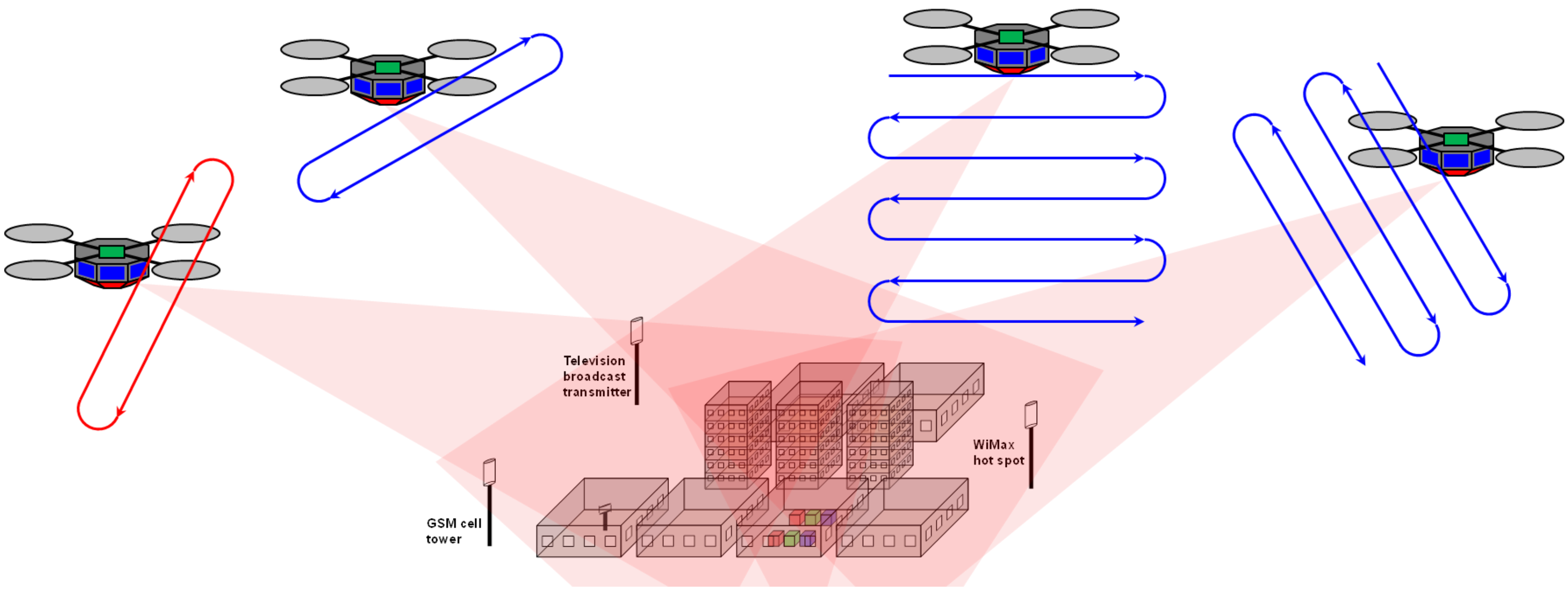
Measurement Diversity



Maximising measurement diversity is the key to applying RF imaging to challenging environments.

Measurement Diversity and Sensor Swarms

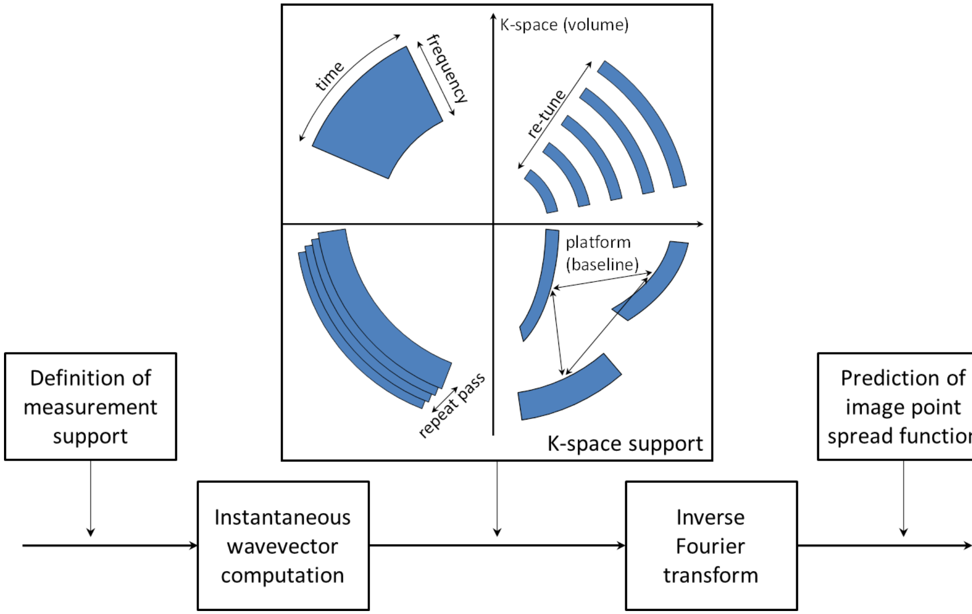
Small UAS and miniature RF sensors now offer the potential overcome traditional cost and flight trajectory constraints to enable diverse measurements in both the spatial and frequency domain.

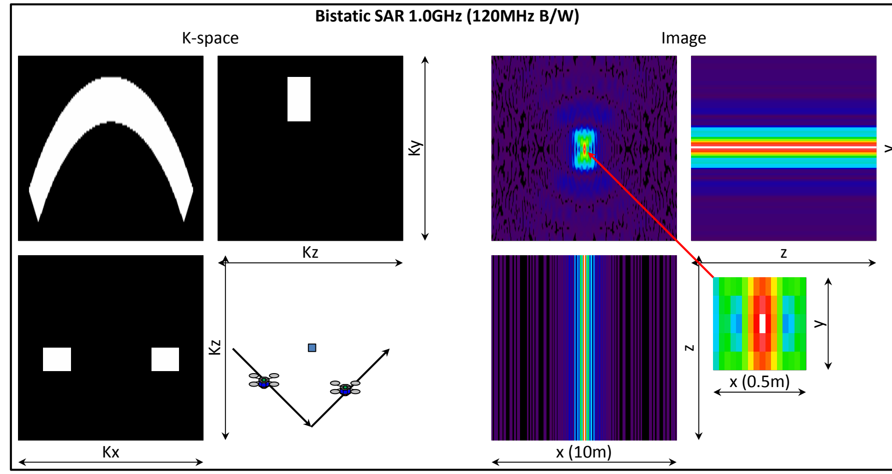


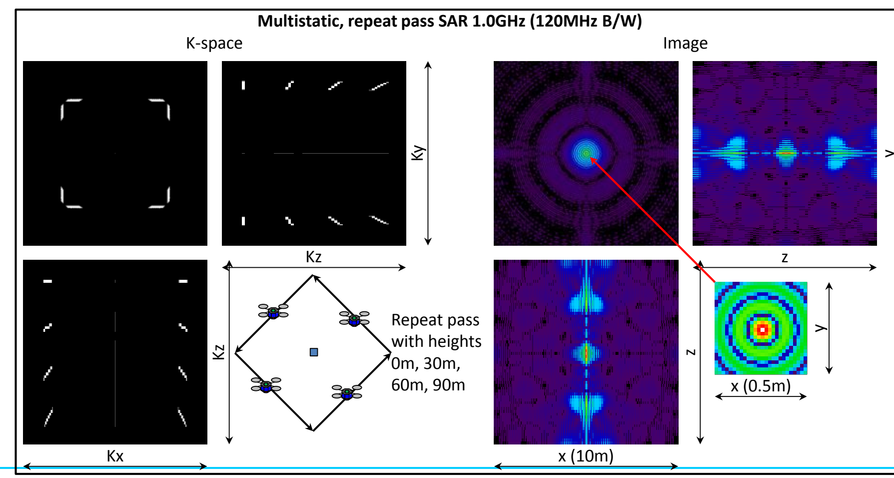
System Requirements

	Second order and higher to sub-wavelength accuracy (zeroth and first order terms result in geolocation errors but not defocus)	No requirement (accuracy requirements exist on the scale of the propagation time, i.e. order 1ms at most, but these are easily met using standard radar technology)
	Second order and higher to sub-wavelength accuracy (zeroth and first order terms result in geolocation errors but not defocus)	Second order and higher to sub-period accuracy (zeroth and first order terms result in geolocation errors but not defocus)
	Zeroth order and higher to sub-wavelength accuracy	Zeroth order and higher to sub-period accuracy

RF Imaging Performance Prediction

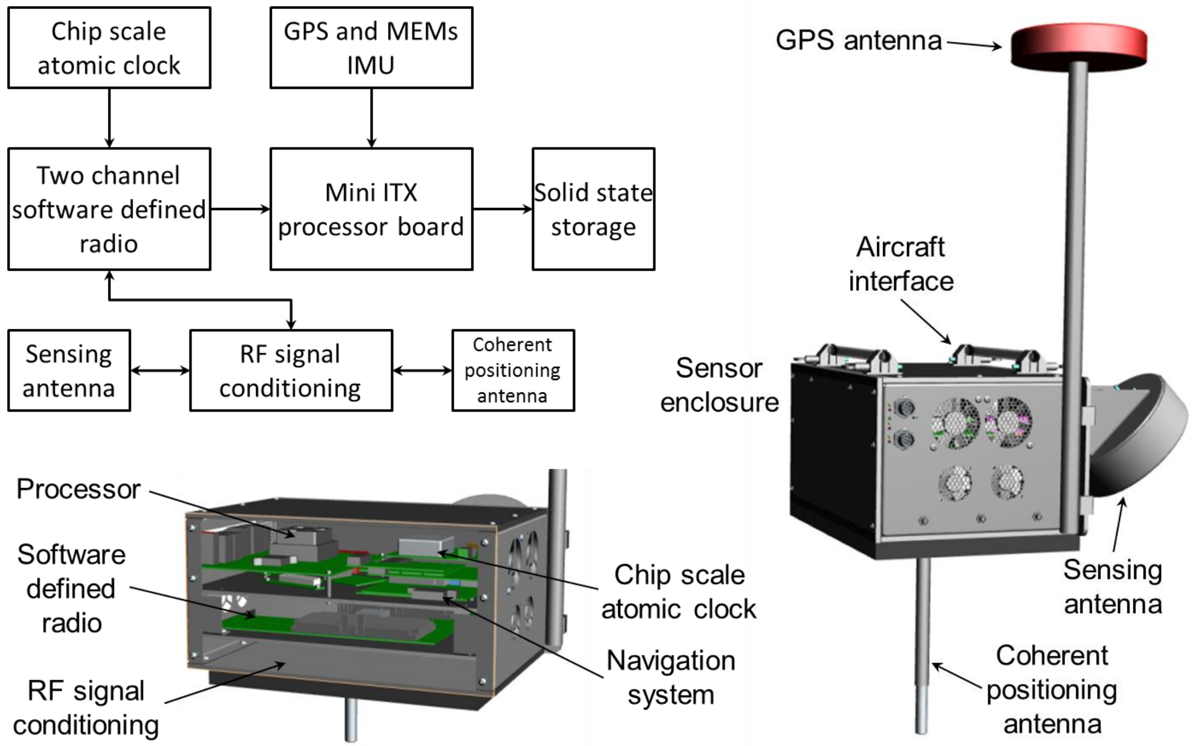






Point spread function predictions may form the basis of future optimisation of swarm trajectories and frequencies of acquisition to optimise intelligence gathering capability.

RF Imaging Sensor Technology for SUAS Swarms



Experimental System

•Seven sensors - both mounted on aircraft and static ground installations.

•Six Vulcan UAV Raven X8 multirotor aircraft and one smaller test aircraft.

•Individual autopilot, flight control and command/telemetry systems for each aircraft.

•Central ground segment to command and monitor all sensor and aircraft activities.

•Lab-based off-line processing using active and passive aperture synthesis techniques.

Summary and Conclusions

•There is an increasing need for intelligence gathering in challenging environments such as urban areas.

•RF imaging sensors must operate at lower frequencies than is traditionally used to achieve sufficient penetration of energy into the environment. Measurement diversity is the key to applying RF imaging techniques to challenging environments.

•A distributed, coherent, active/passive RF imaging system is currently being developed by QinetiQ for UK MoD using state of the art COTS components.

•Facilities are provided to achieve coherence between multiple sensors using dedicated timing waveforms broadcast between sensors.

•Planned flight test activities include experimentation against a range of test scenarios and a demonstration in September 2016.