Remote sensing for automotive and security applications

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MICROWAVE INTEGRATED SYSTEMS LABORATORY

Microwave Integrated system laboratory and JLR parthersip

Current project funded by JLR ‘TeraSen’ consists of three parts:

- Terrain identification
- Road mapping/road profiling
- Speed over ground

Staff involvement: two senior Research fellow, two research fellow, 3 PhD 50% funded by JLR,50% by UoB

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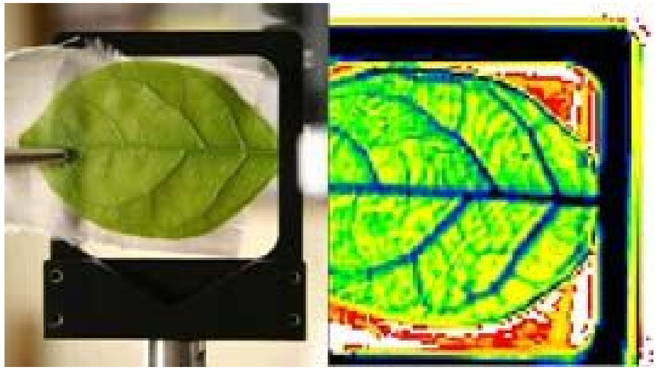
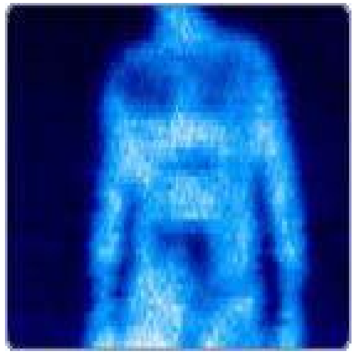
THz sensing-Applications



- Earth remote sensing
- Non-destructive testing of structural integrity
- Moisture content determination
- Coating thickness control
- Medical applications
- Concealed weapons detection



Path finding and obstacles avoidance in robotics

Self driving/autonomous vehicles

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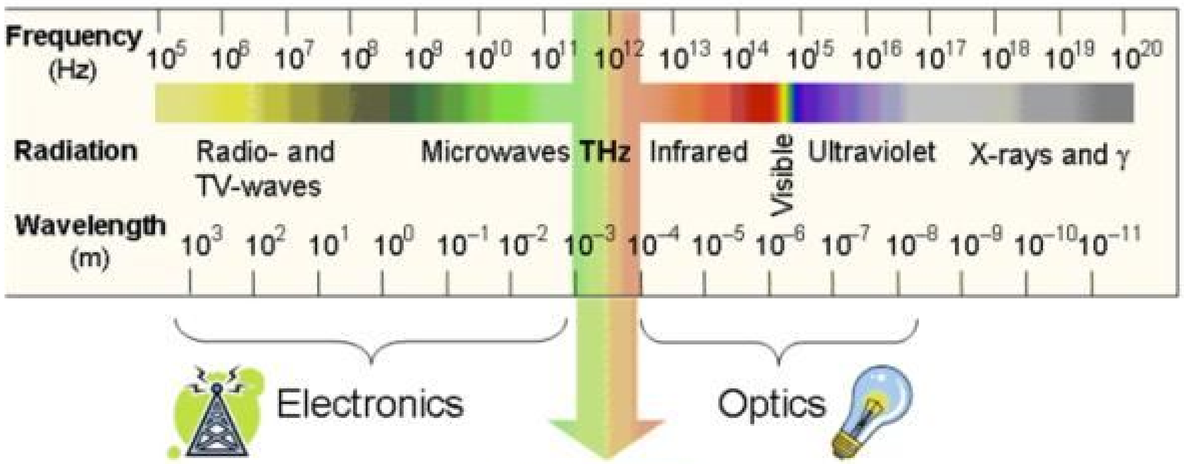
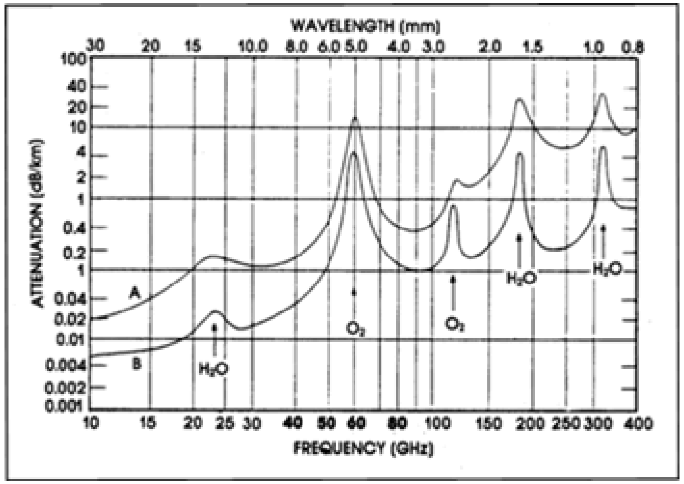
Future to THz?

A Trade off between microwave imaging and optical imaging

Microwave Frequencies	**Optics**
Lower resolution	High resolution
Lower attenuation	High attenuation in non transparent medium



Average resolution terahertz **Average attenuation**



Atmospheric gases attenuation

- Water vapour absorption
- Oxygen absorption

Precipitation Attenuation

- Rain
- Snow

➢Foliage Blockage

➢Scattering effects

Remote Road Surface Identification

Hazardous Road Surfaces:

Icy and Snowy Roads, Grass, Sand, Rough Gravel, Dirt, etc.

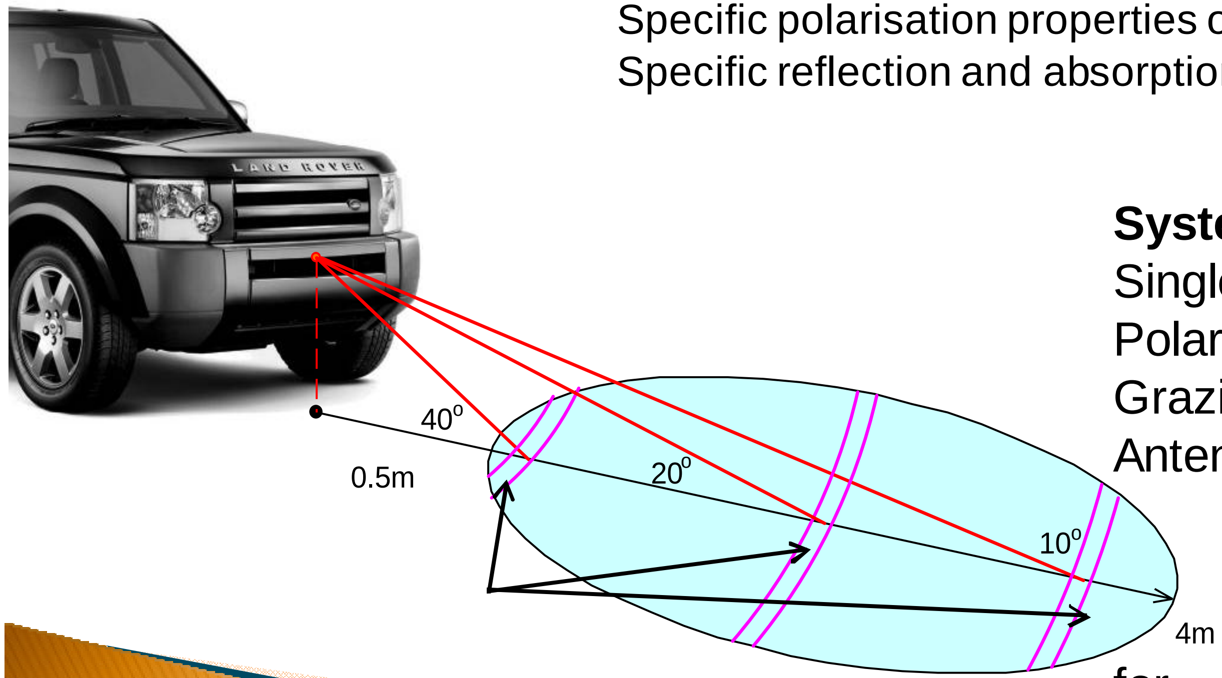
Remote Identification

24/7, all-weather, robust and compact sensors:

Radar and Acoustic Sensors may provide identification by :

Specific polarisation properties of the reflected signal

Specific reflection and absorption rate of radar and acoustic signals



System parameters:

Single or multi-frequency?

Polarization?

Grazing angle?

Antenna beamwidth?

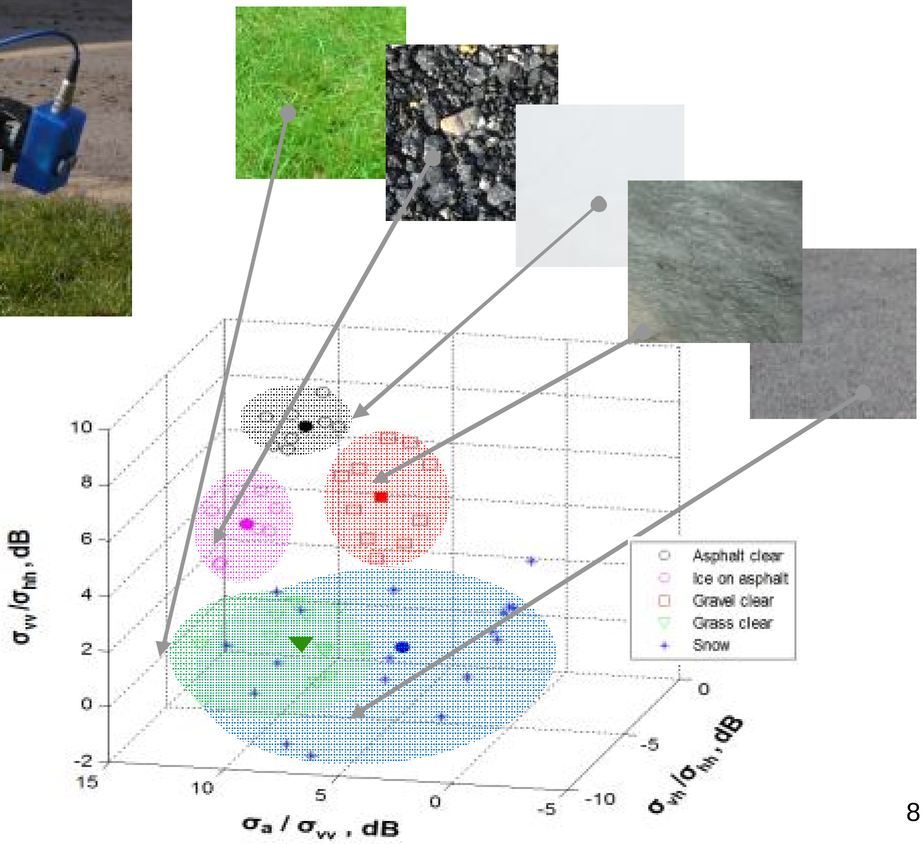
Signal processing:

Method of classification?

Signal parameters used for classification?

What we have so far?

Surface classification



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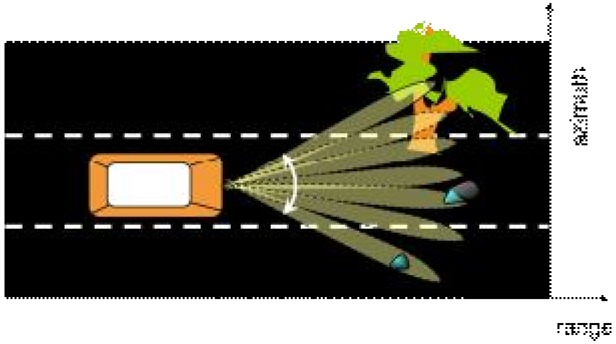
THz sensing in front of Vehicle (Ground Profiling)

JAGUAR LAND ROVER

Interrogation of the road ahead of the vehicle to be prepared for the approaching terrain

Aim: real time roads' image and image interpretation in complex environments (off-road all sort of features, humps , kerbs, potholes) in all weather conditions (rain, snow, spray) where traditional sensors fail

Optical sensors are most used driver assistance/path detection



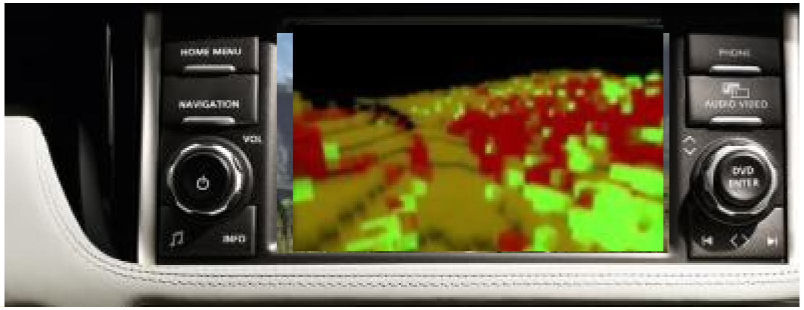
However they fail in

- Spray/fog/smoke
- Sand/dust storm
- Snow/rain

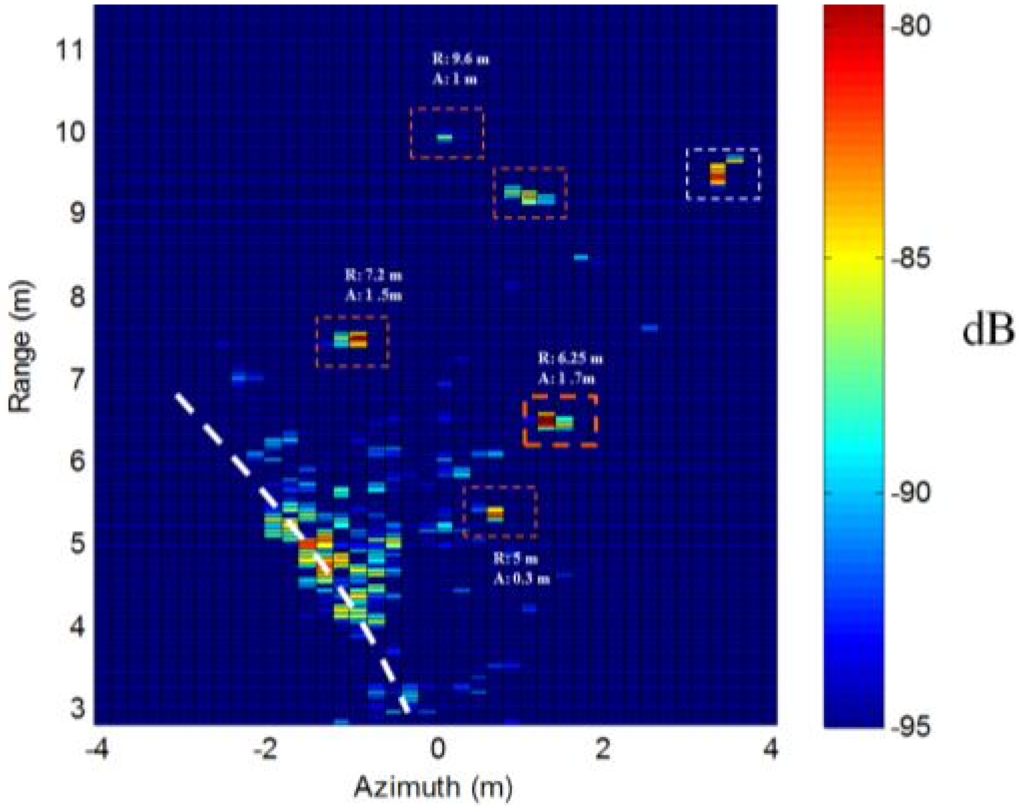
Microwave sensing in THz band provides

High resolution, ranging,

compact sensors/antennas

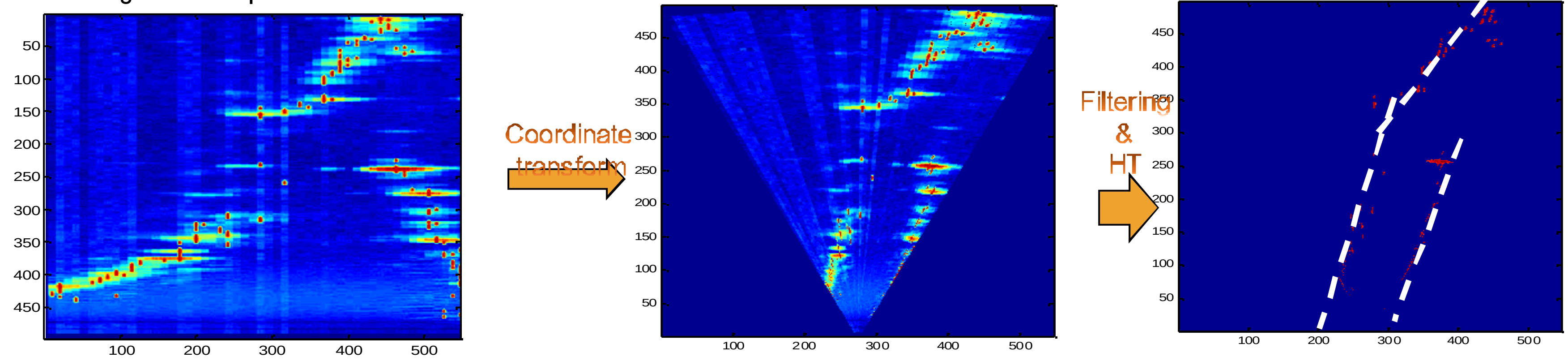


Road vision by developed radar sensors



94 GHz road image feature extraction By Hough transform

Radar image of road path in Cartesian coordinates



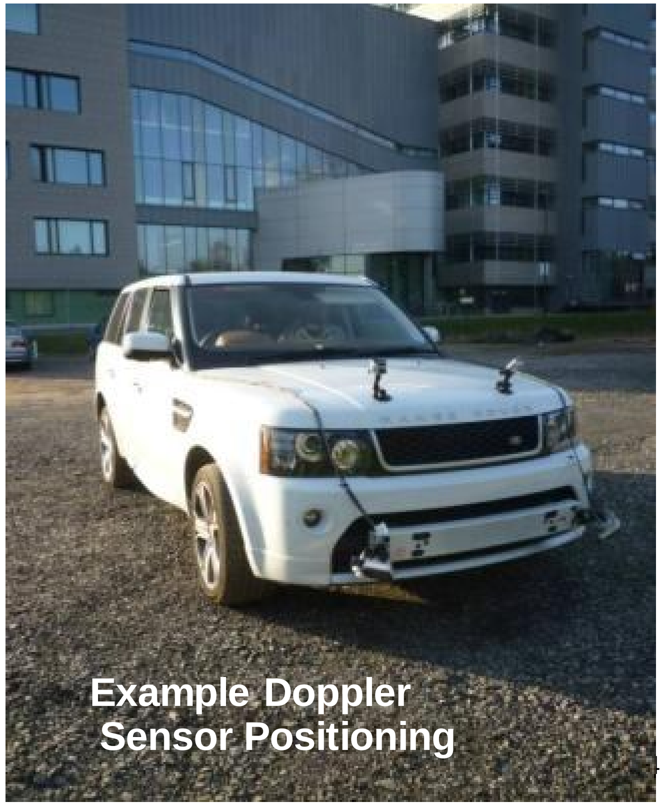
Speed over ground

Vehicle Speed Over Ground

The primary speed data for a vehicle comes from the wheel rotation rate.

This is not necessarily the true velocity of the vehicle – wheel spin, side slip.

- If true velocity (speed and direction) is known, automatic systems can be used to aid in recovering control of the vehicle.
- Developed a multi-sensor platform to evaluate effectiveness of fusion of various sensor types.
  - **Radar Doppler Sensors (x4).**
  - **Acoustic Doppler Sensors (x4).**
  - **Inertial Measurement Unit (9 d.o.f.).**
  - **Low cost GPS.**
  - **Existing car sensors – e.g. wheel speed, suspension height.**
  - **Differential GPS – truth data.**



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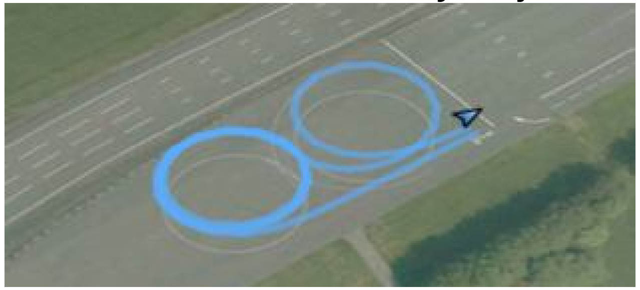
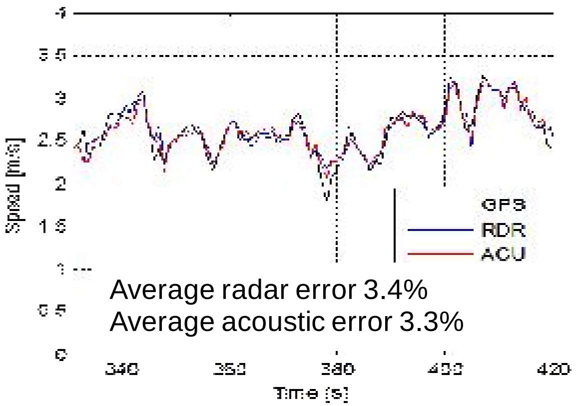
Vehicle Speed Over Ground

- Data has been collected on and off road with many trajectories and speeds (for post processing).


- Current Doppler analysis uses combined information from at least 3 Doppler sensors to estimate transverse and forward velocity, magnitude is then compared to GPS truth data.
  - Currently use spectral centre of mass of Doppler signature to estimate speed of individual sensor and then compute vehicle velocity.
- Currently using only Doppler sensors, average errors are mostly below 4%.
  - Dependant on terrain, sensor type and speed.
- Work is now moving into optimising Doppler speed estimation algorithms and fusing information from multiple sensor types (Kalman filter).

Velocity magnitude comparison



- 2006-2010 long term project funded by DTC and Selex Galileo:
- Ground and sea based Forward scatter radar for intruders detection and identification

Maritime Ultra-Wideband (UWB) Forward Scatter Radar (FSR) Surveillance Network

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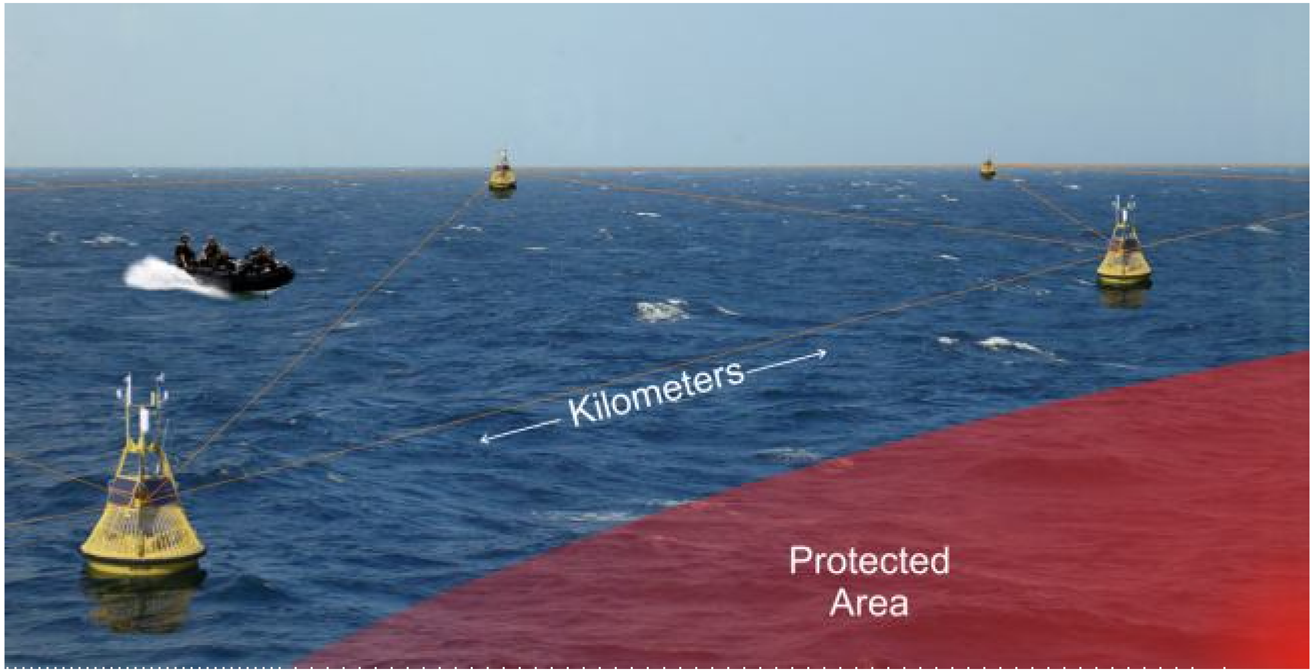
Maritime FSR Network Concept



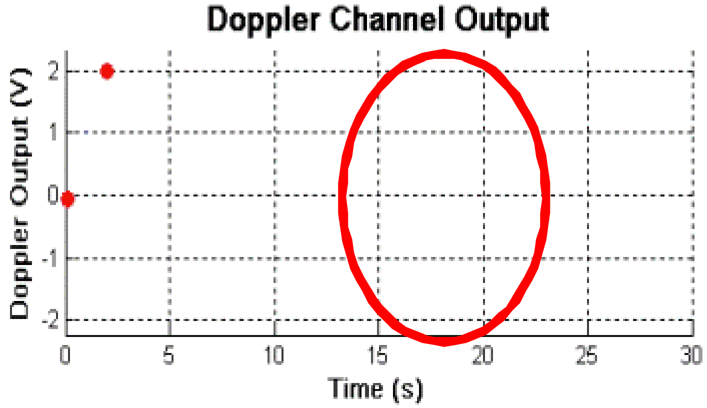
Small Inflatable Boat Detection

GPS tracker data for small boat target

Transmitter/Receiver – blue
Boat target - yellow

Target becomes visible

Underlying sea clutter level



Ground CW Forward Scattering Radar (FSR) Surveillance Network

EMRSDTC

: Electro Magnetic Remote Sensing Defence Technology Centre

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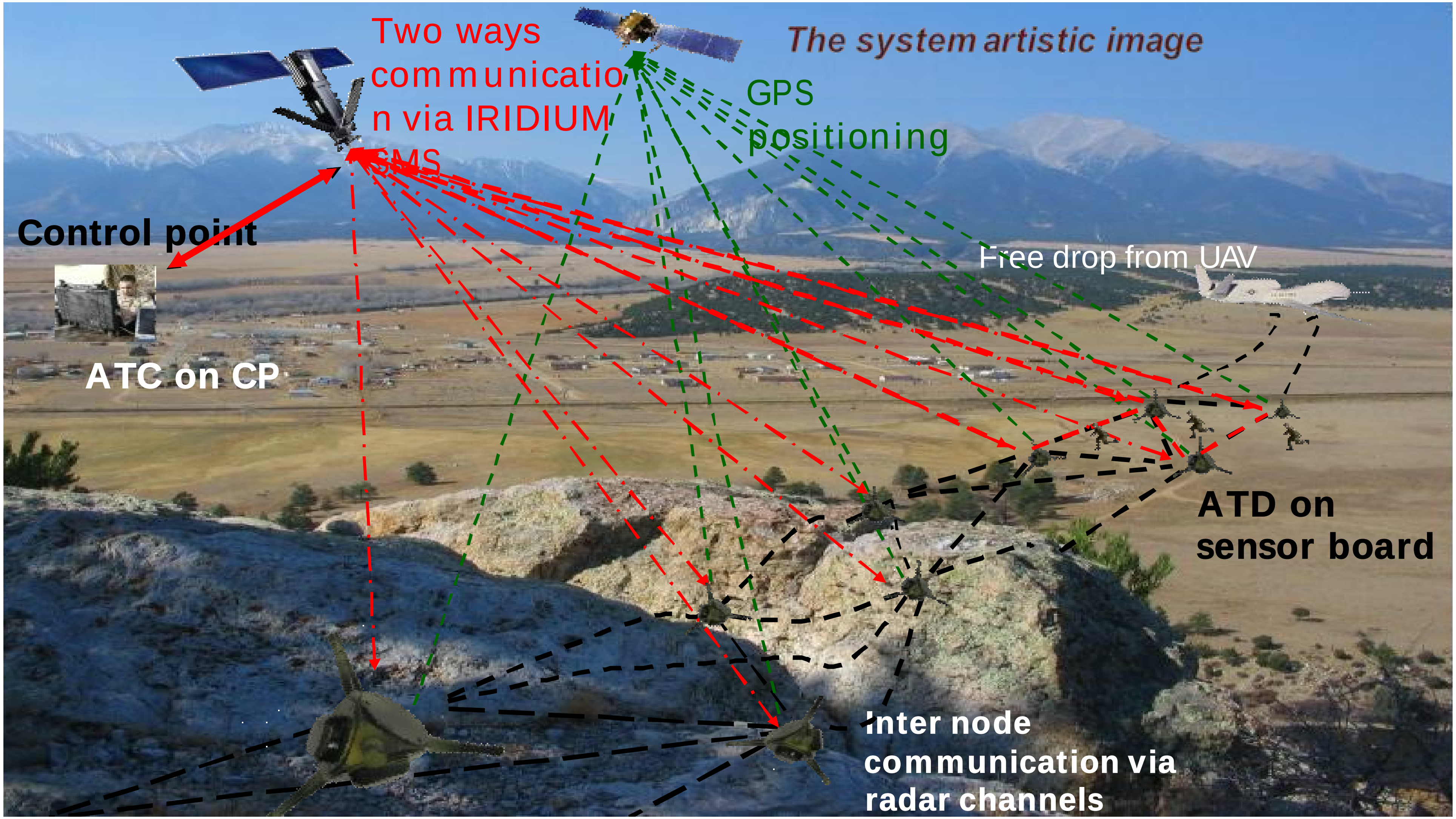


Two ways communication via IRIDIUM SMS
The system artistic image
GPS positioning
Control point
ATC on CP
Free drop from UAV
ATD on sensor board
Inter node communication via radar channels

FSR enhanced tracking and imaging:

Proposal preparation stage:

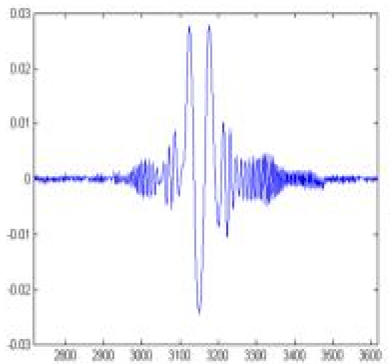
SISAR target imaging

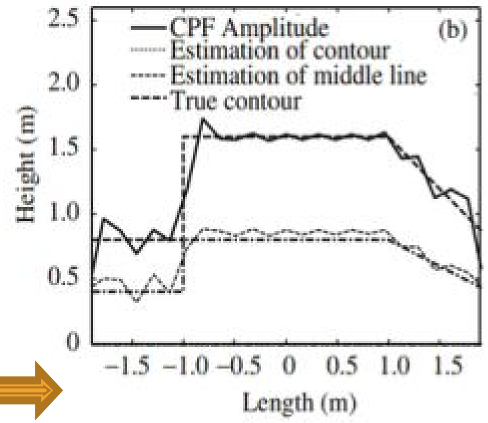
MIMO FSR

Shadow ISAR

utilizes the ISAR effect for the shadow aperture produced by Forward Scatter Radar system.

Target signature carries all information on the diffracting contour





Inverse diffraction Fresnel transform - target profile

MIMO FSR

Full knowledge of the target position and velocity components allows **locate** and **track** the target

Enhanced classification and **profile reconstruction** of the target

Use of **non-dedicated transmitters** of opportunity - low cost and easy implementation