UNIVERSITY OF BIRMINGHAM

MICROWAVE INTEGRATED SYSTEMS LABORATORY

MIMO and multistatic radar - maritime domain

UCL seminar 17.04.09

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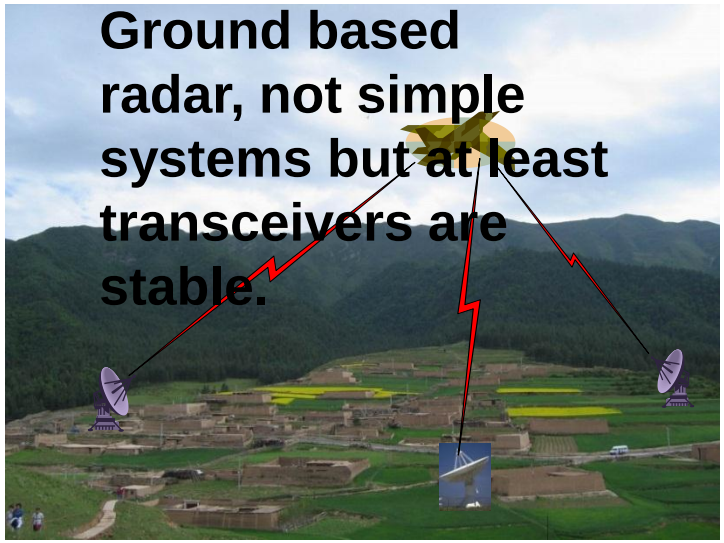
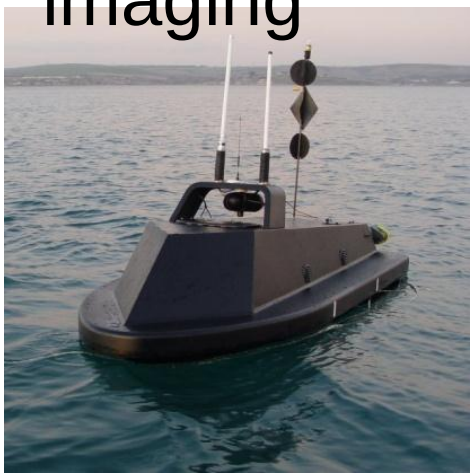
Maritime – where should the transmitters and receivers be positioned ?



New threats, new problems – automatic targets (with priori not clear specified shapes!) recognition - imaging



Stealth, unmanned, high speed

USS Cole attacked by suicide mission on an inflatable boat

What is on this boat? Fishermen? Illegal immigrant? Guns? Kamikazes?

More assets to be protected 7/24

In contrast to WW II we can not destroy all suspicious targets – too politically sensitive. We should know what is on the boat – <u>target recognition or better even imaging (non optical) is a very high priority.</u>

How to protect ? New technology ?!



We need monitoring systems:

- ✓ ***Cost effective***
- ✓ ***Operating 24/7***
- ✓***Covering large areas***
- ✓***All weather***

For:

- ✓***Targets detection***
- ✓***Positioning***
- ✓***<u>Automatic recognition</u>***

How MIMO/Multistatic radar may help?

To "see" hard targets – stealth, low speed, small size?

To introduce microwave, weather independent image of targets?

To overcome a complex landscape issues?

Problems, problems – to be solved

Targets MS reflections

on sea surface, low flying

civil vs foe

Clutters MS reflections

littoral waters

developed sea

wideband and UWB

Radars' positions

aircraft, vessels, buoys

sea shore

Problems

synchronisation

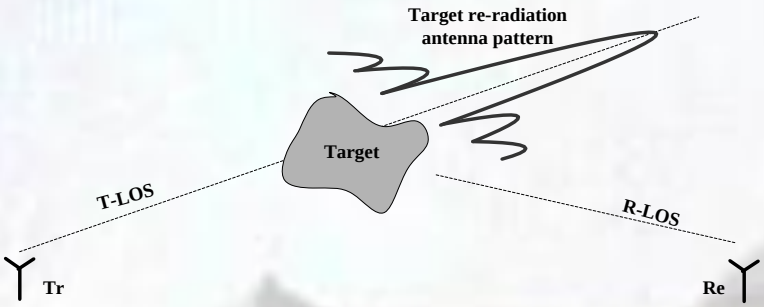
coherency

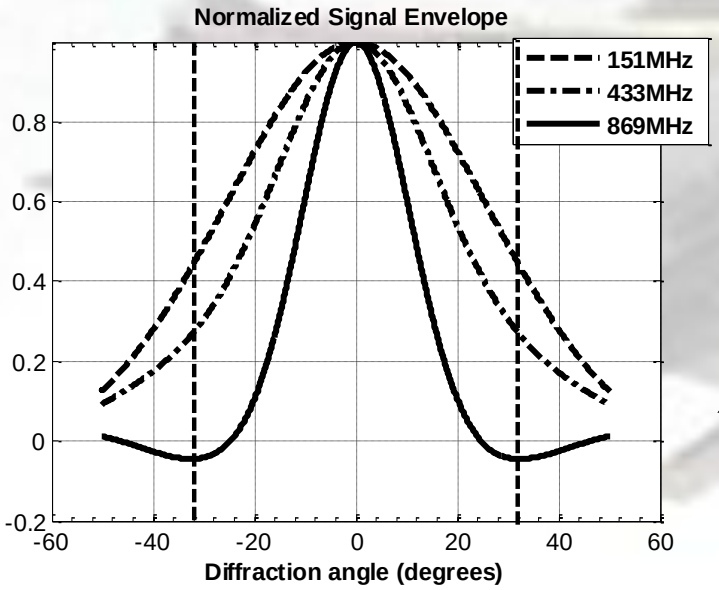
MIMO sensitivity to real world scenarios

Automatic target recognition – imaging in MultiSite radar. Is that a realistic task?

Forward Scattering Radar

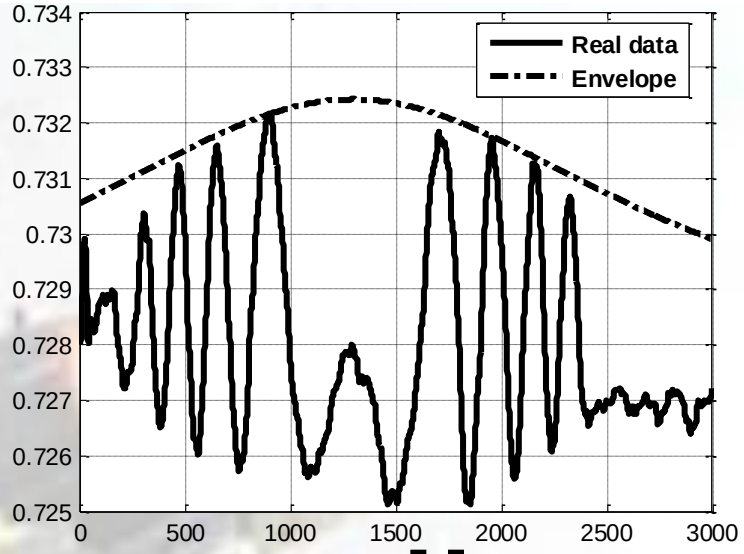
Doppler signature in FSR





X

Experimental data
151 MHz



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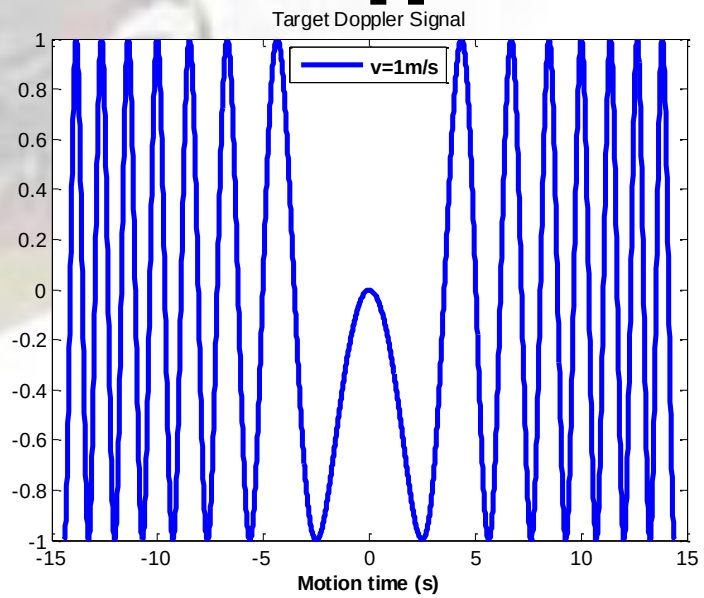
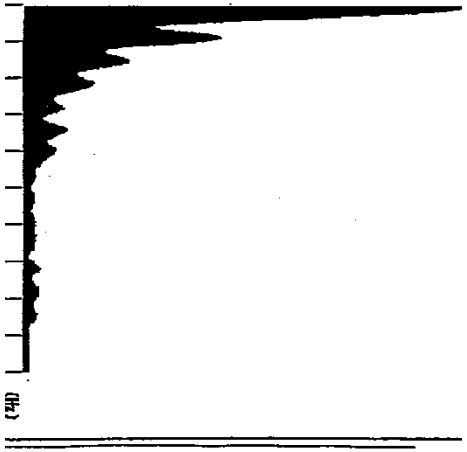


Automatic classification of air targets

(Chapursky, et.al, IEEE Radar conference, 2000)

Space spectrum and photo of Mig 21



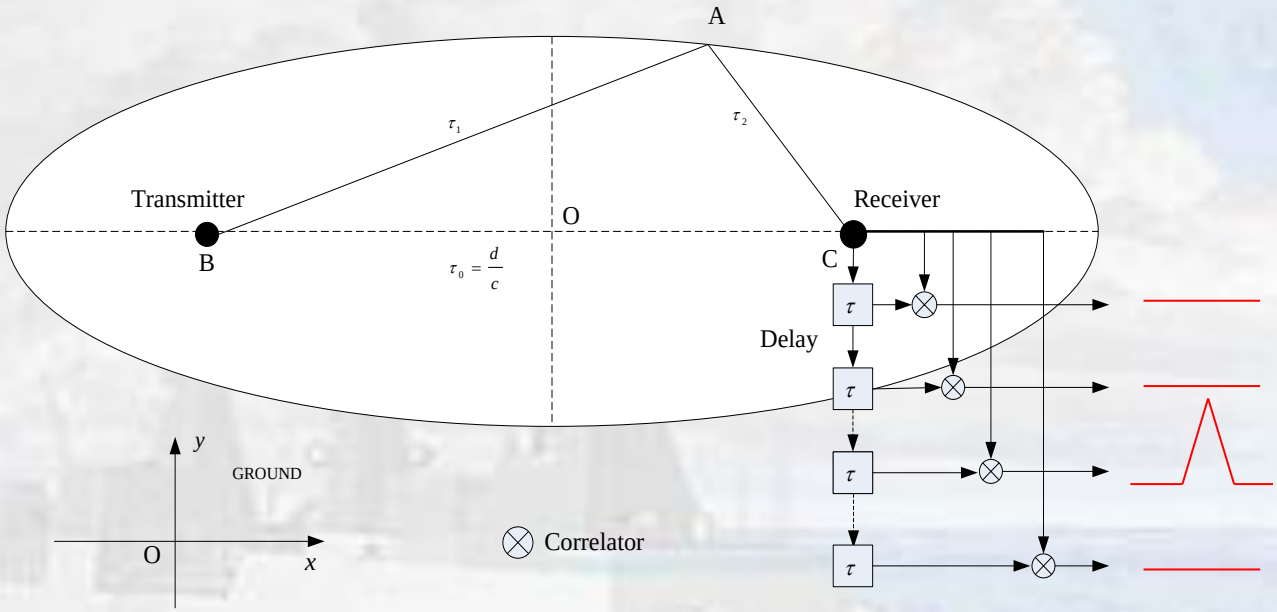
Space spectrum and photo of Mig 31

900 MHz FSR, 50km range, 1 W transmitter

It is clear to see the essential difference between the two space spectrums

Ultra Wideband Forward Scatter Radar

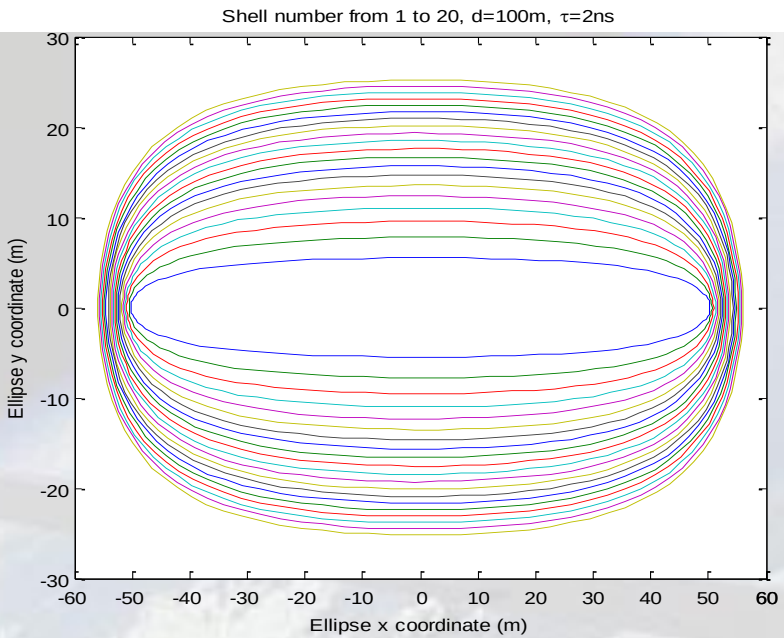
a possible system

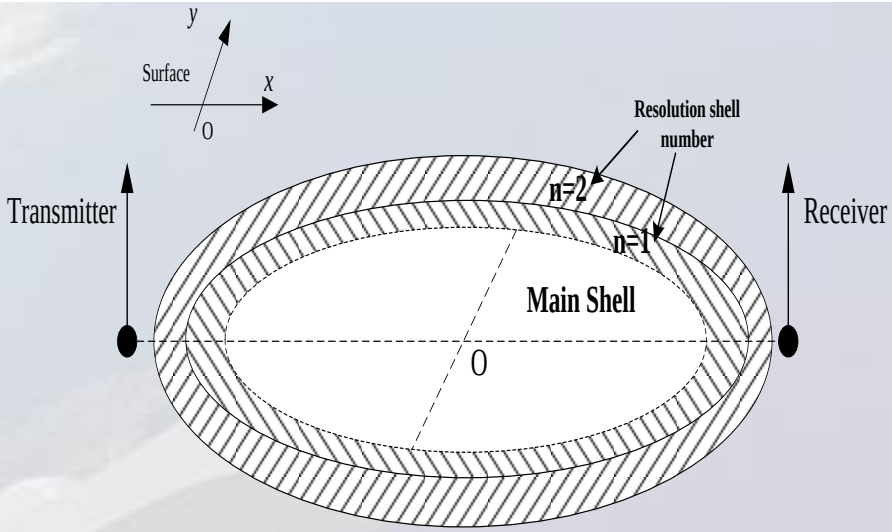


- UWB pulses as the ranging signals – Pulsed (or UWB-modulated CW) system, unlike its narrowband counterpart
- Target range found by passing reflected signal through a standard multi-channel correlator
- Reference signal for correlation: Synchronised direct path (Tx-Rx) signal

Introducing some degree of space resolution

Resolution shells

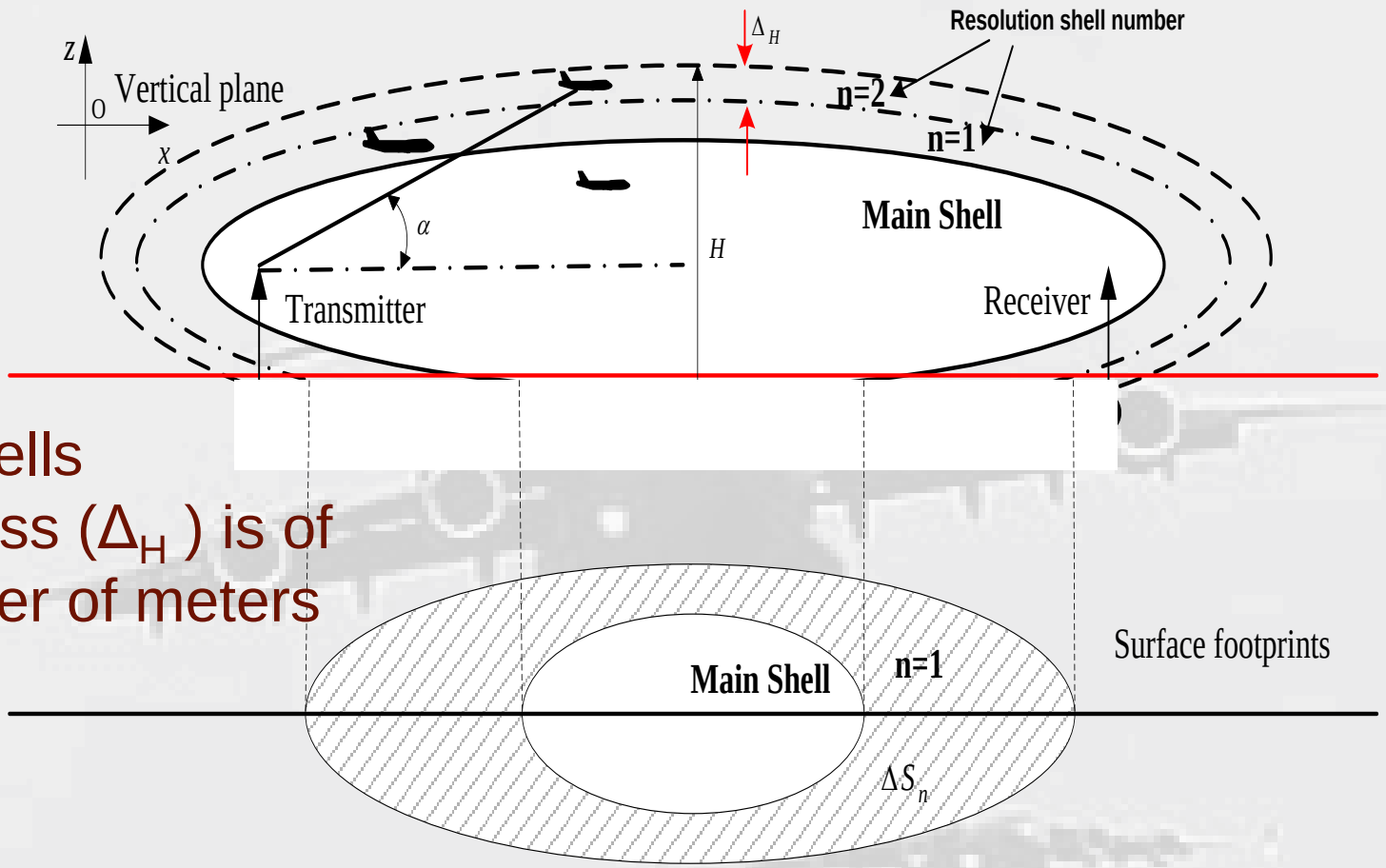




- Target located within an annulus formed by two confocal ellipsoids (iso-range contours) - Resolution shell
- Shells' thickness depends on pulse duration and baseline length
- Unlike narrowband FSR, we can operate on a specified number of shells

Clutter present in the received signal will only come from one shell, not from the whole illuminated area

UWB FSR potential – low altitude targets



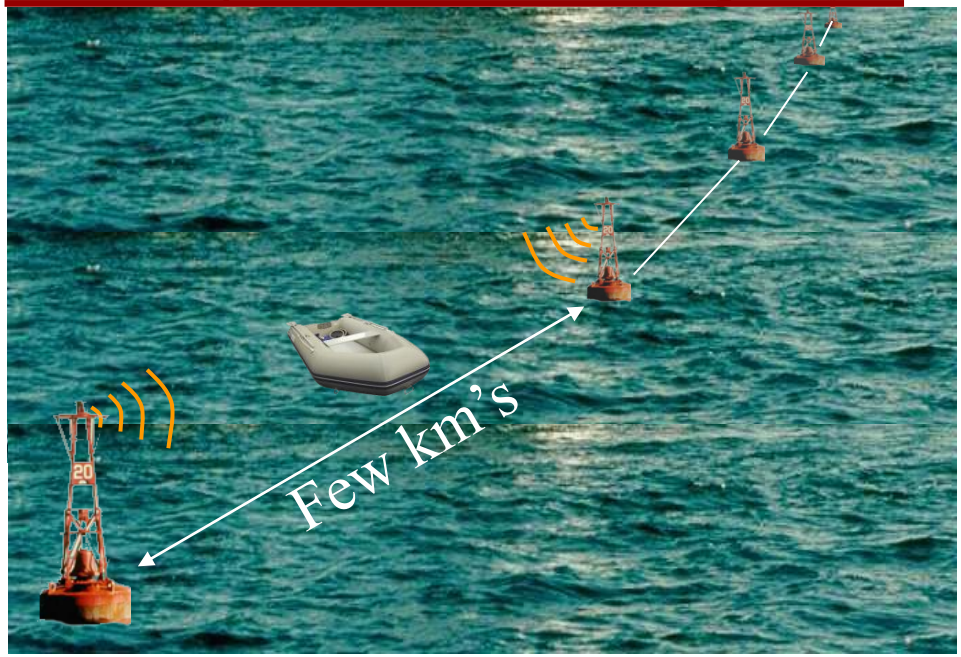
The shells thickness (Δ_H) is of the order of meters

- Resolution of targets flying in different formations
- Ground clutter reduction
- Target position direct estimation

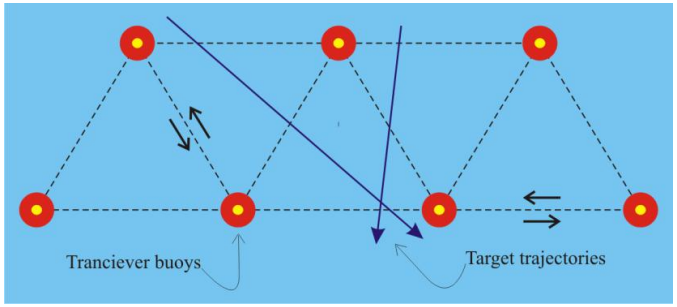
MISL, University of Birmingham

- Ultra Wideband Bistatic/Multistatic/Forward Scattering Radar Anchored Buoys' Based network – as a practical goal, for hard targets detection and automatic (you wish!) recognition/imaging

10 GHz, 42 dBm2 small jet ski



10 dBm²/m² in FS direction



Omnidirectional antennas

Enhanced target RCS

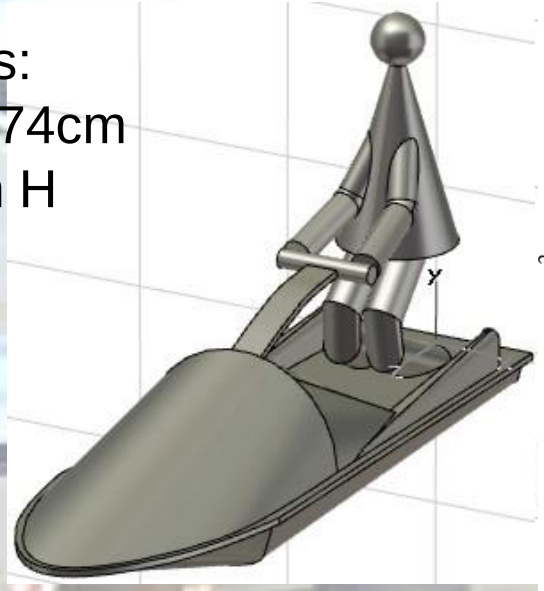
Reduced (?!) sea-clutter level

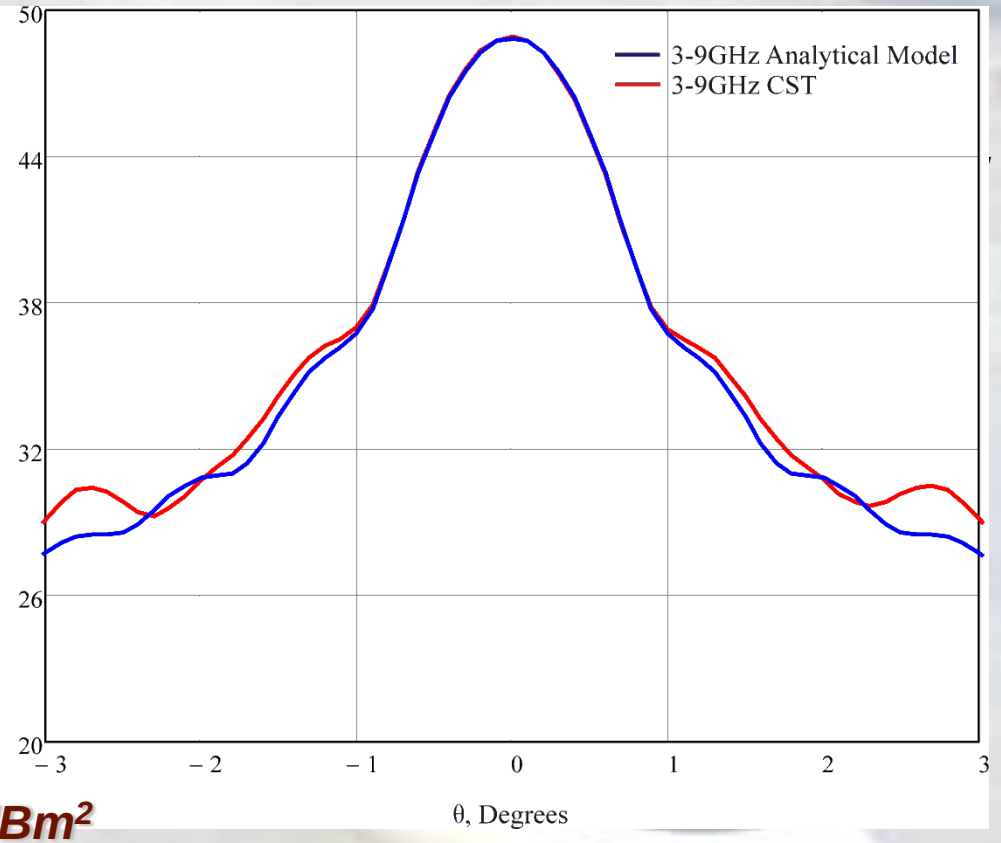
Financially and morally supported by SELEX Galileo

11

Low RCS maritime targets

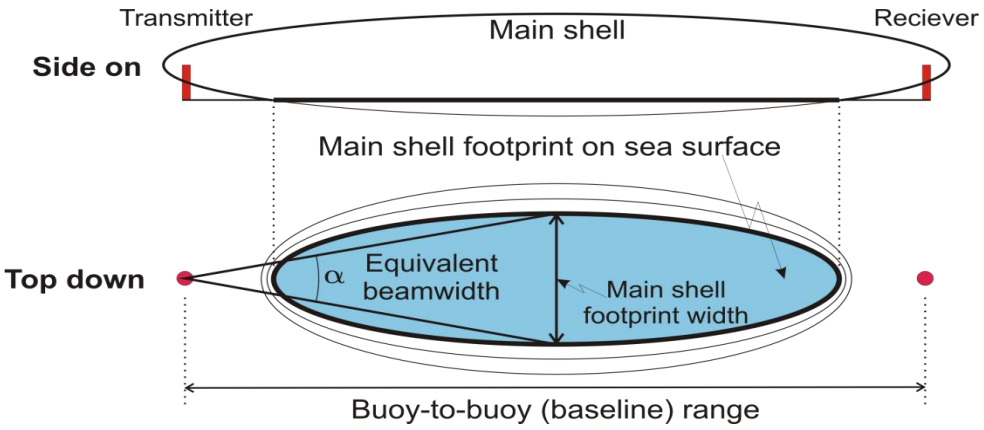
Dimensions:
200cm L x 74cm
W x 130cm H

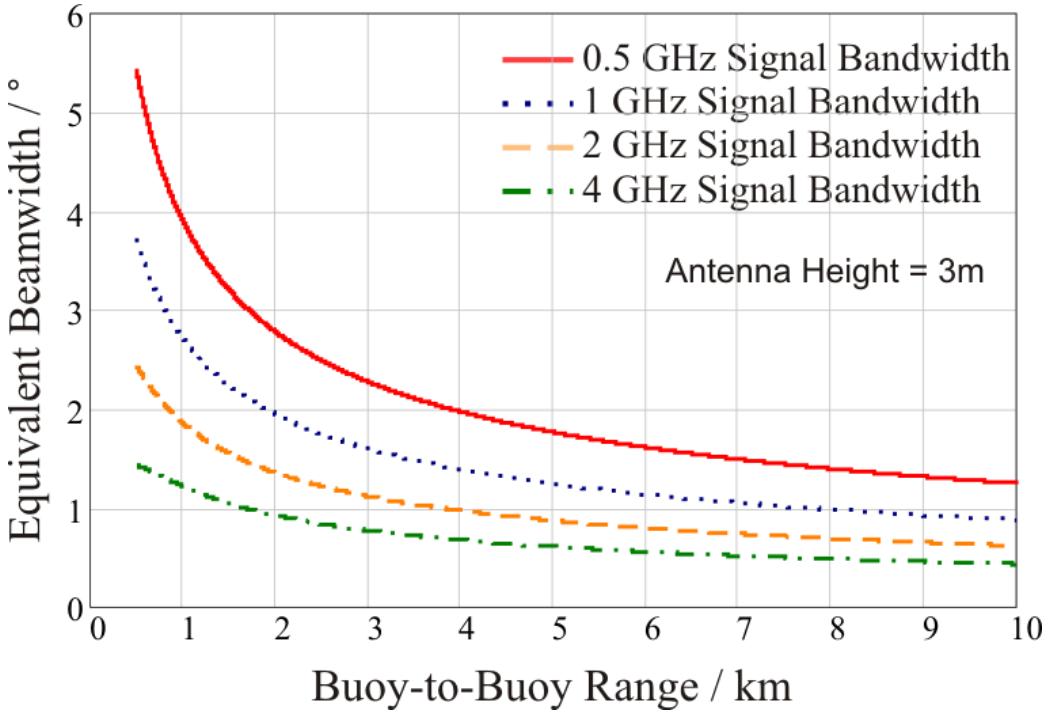




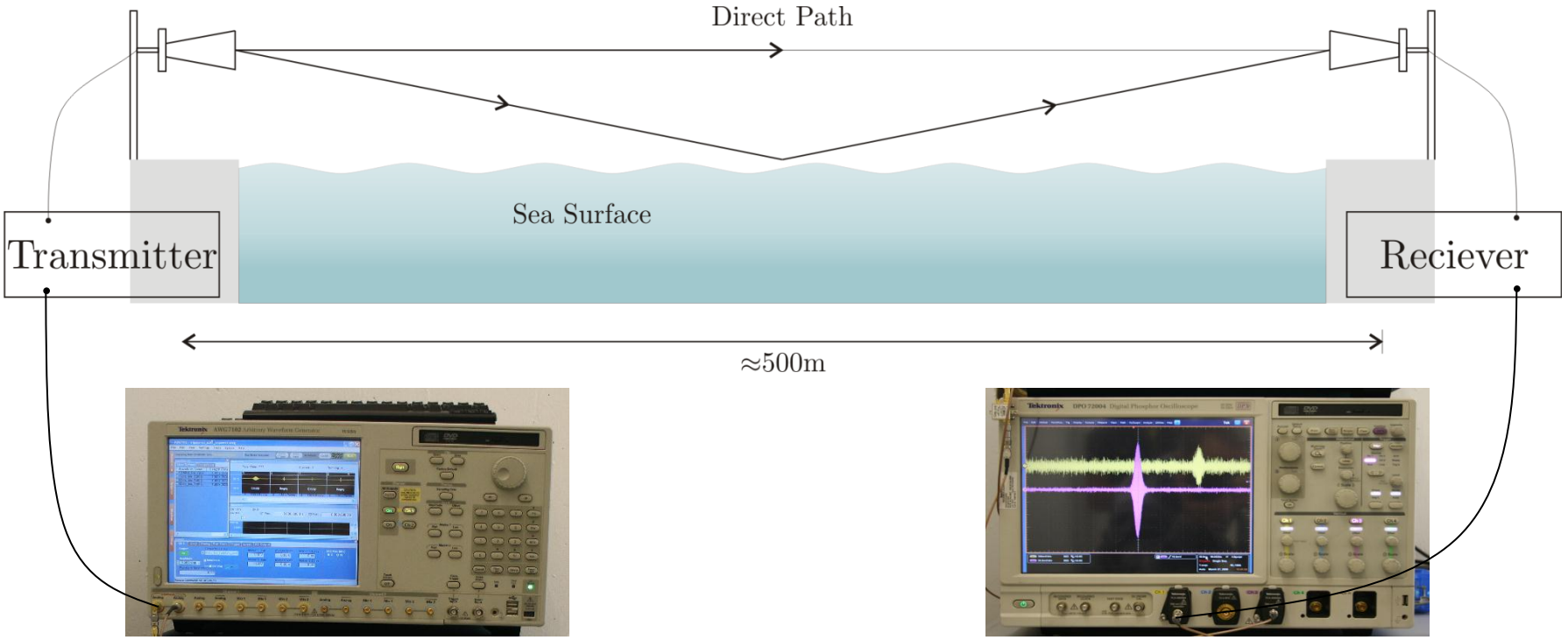
FS CS of Jet-Ski (UWB 3-9 GHz) - ~40 dBm²

UWB FSR: omnidirectional antennas imitating narrow beam (but low gain) antennas





Generic experiments



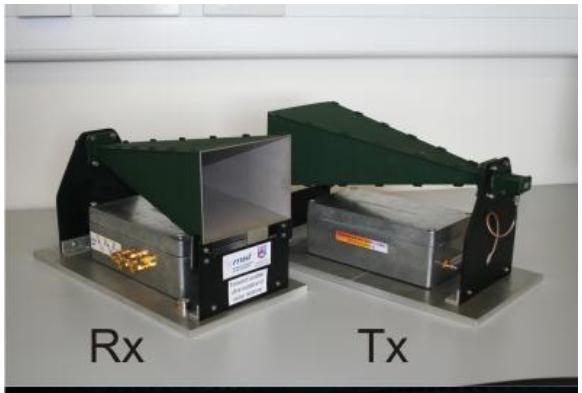
Tektronix AWG7102
Arbitrary Waveform Generator

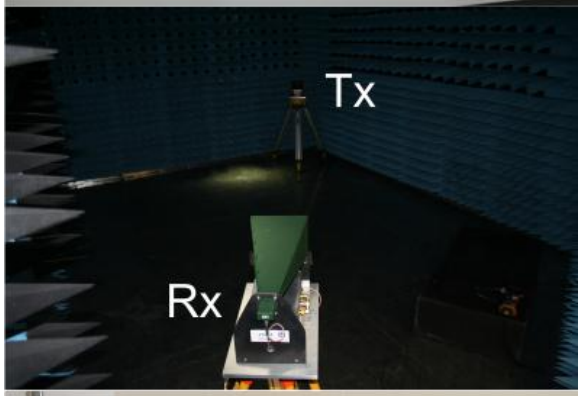
• 10 GS/s sample rate on two channels simultaneously
• 20 GS/s sample rate (interleaved)
• 10 bit vertical resolution

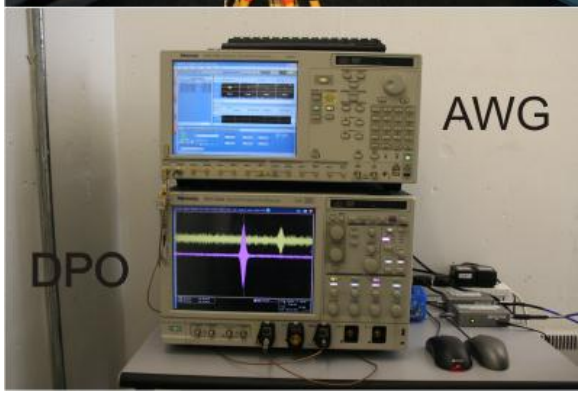
Tektronix DPO72004
Digital Phosphor Oscilloscope

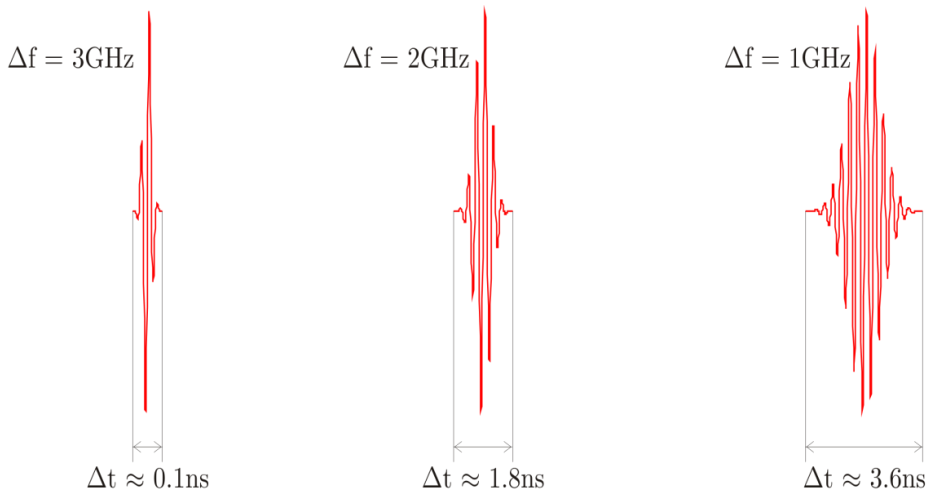
Four channels simultaneously,
• Up to 20 GHz bandwidth
• Up to 50 GS/s real-time sample rate
• Up to 250 Mega-sample record length
• > 300,000 waveform captures/s

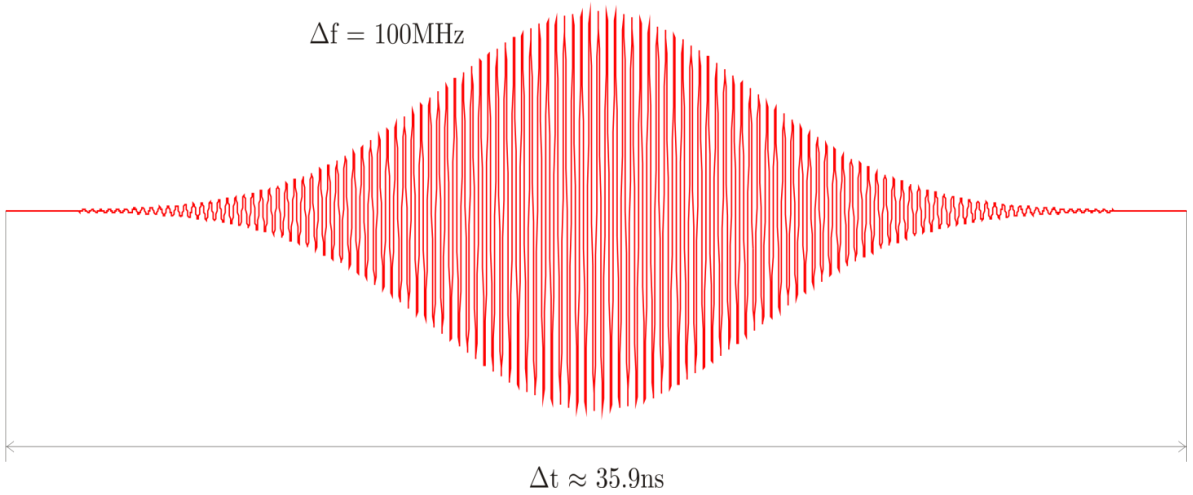
Hardware and signals





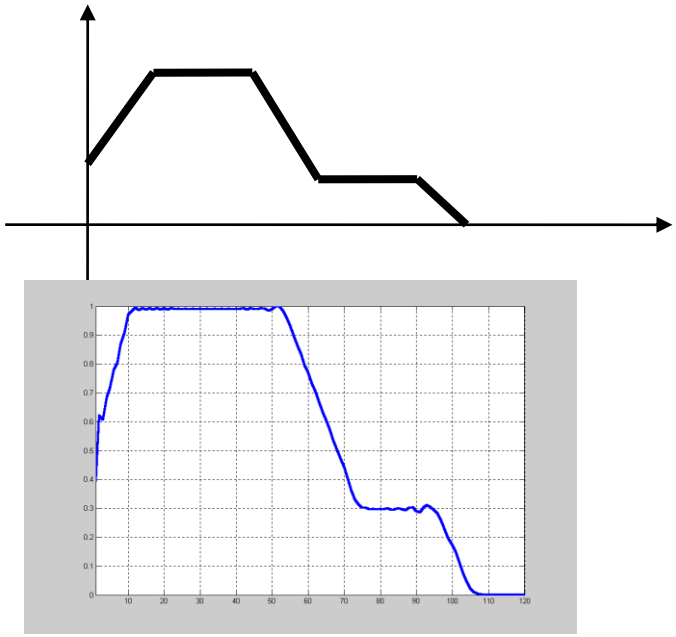






Target profile reconstruction in FSR

- Very, very first results:



Profile reconstruction in idealised conditions, modelling

Summary

- Bistatic radar may have valuable applications in maritime surveillance applications, particularly in detection of low-signature targets (RHIBs, jetskis, …)
- Ultra Wideband Forward Scatter Radar (UWB – FSR) has some particular attractions
- Passive Bistatic Radar may have some applications too, but depends critically on adequate illumination of the maritime target scene.

Thank you

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Welcome to a wide discussion on MIMO MultiStatic Radar for maritime applications