

University Defence Research Centre (UDRC) In Signal Processing



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[C4] Low SWAP Target Localisation and Spatiotemporal Beamforming

Theme: Detection, Localisation & Tracking

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Project Aims

- Develop a reconfigurable functional antenna array prototype to be used as a generic testbed for algorithm research and development.
- Low size, weight and power (SWAP) design of an array-sensor system for target localisation and beamforming.
- Key challenges: phase synchronisation of separate transceiver channels for reconfigurable array size, and practical array calibration techniques for reliable data acquisition.

SDR Testbed

Software Defined Radio (SDR) provides a readily available and highly reconfigurable backend for radio system design. A SDR peripheral digitizes the incoming RF. All baseband processing (e.g. mod/demod, coding, filtering) takes place on a PC.

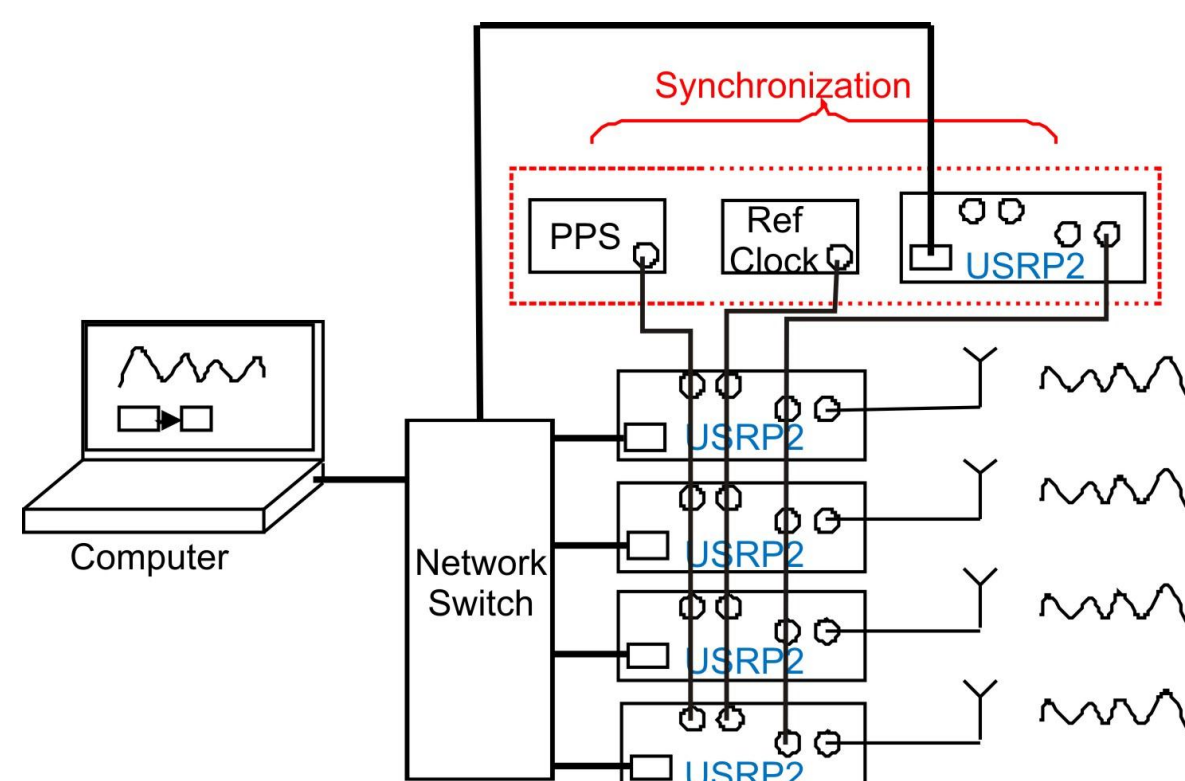
Universal Software Radio Peripheral 2 (USRP2)

- Low cost software radio peripheral from Ettus Research compatible with GNURadio
- Removable transceiver daughterboards for many different frequency ranges
- 100 MS/s 14 bit dual ADC
- 400 MS/s 16 bit dual DAC
- Gigabit Ethernet Interface
- 25 MHz Bandwidth on TX and RX
- 2.3-2.9GHz daughterboards used (RF2400)
- **12 USRP2 boards have been successfully connected to a PC via a standard low cost network switch.**
- RF data can be reliably received.
- Open Source GNURadio is used to set RF front-end parameters, acquire data and implement algorithms.



Key Challenge: Synchronisation

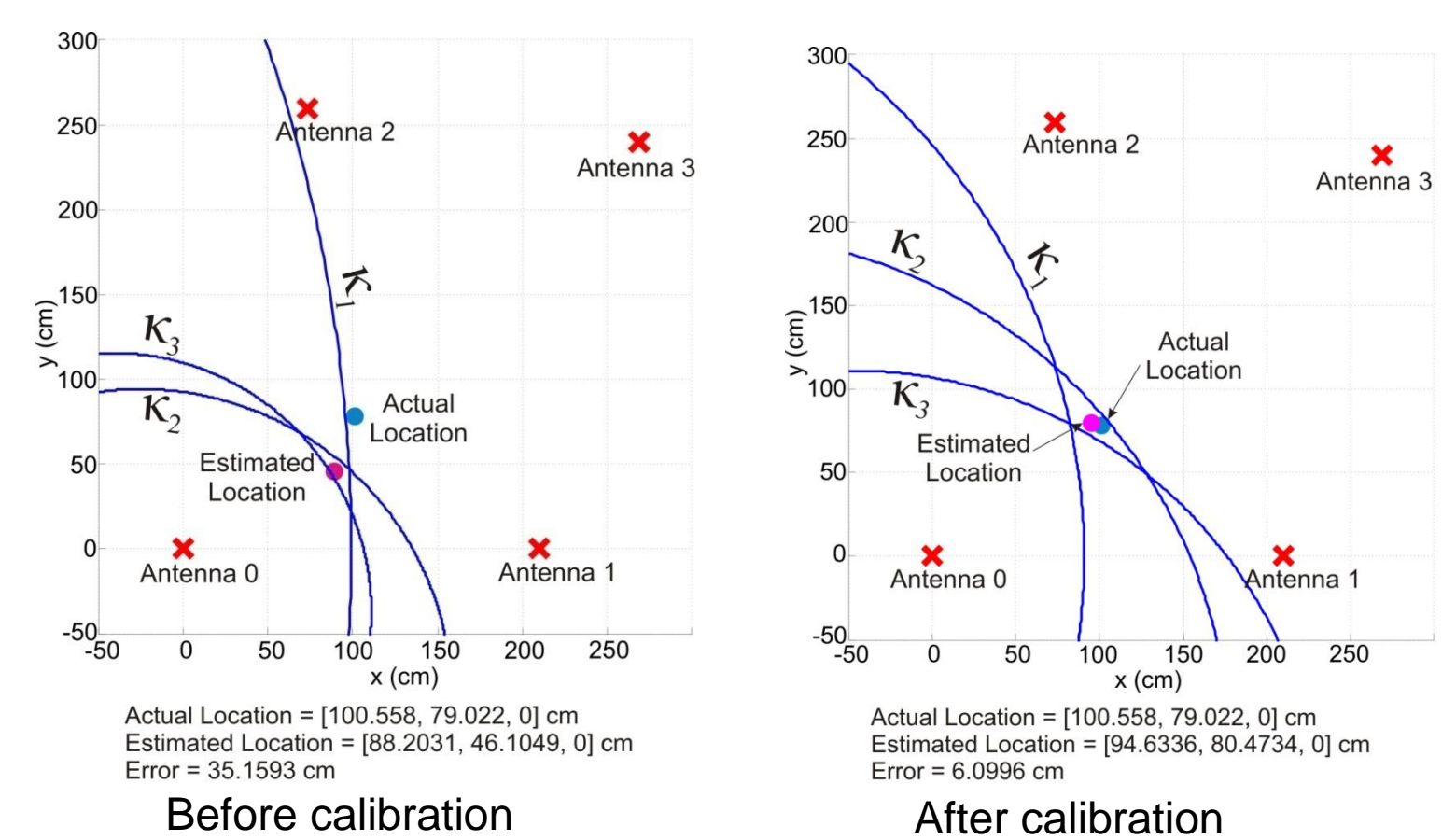
A standard array system achieves synchronisation using a single local oscillator distributed to each channel and uses a common clock. The USRP2 boards are timestamp synchronised using an external PPS signal. The local oscillators can be synchronised using a reference 10 MHz clock. This works well in terms of effectively eliminating relative phase shift over time. However, every time a board re-tune command is sent there is a new phase ambiguity between the boards. A new synchronisation approach has been developed to overcome this.



- USRP2 boards have two RF ports for duplex operation.
- A signal applied to the non-selected port couples into the software selected receive channel.
- An RF signal applied directly to the second RF port of each of the USRP2 boards in the array can thus be used to discover the phase ambiguity without any manual calibration step.
- It has to be separable in some way from the wanted signal

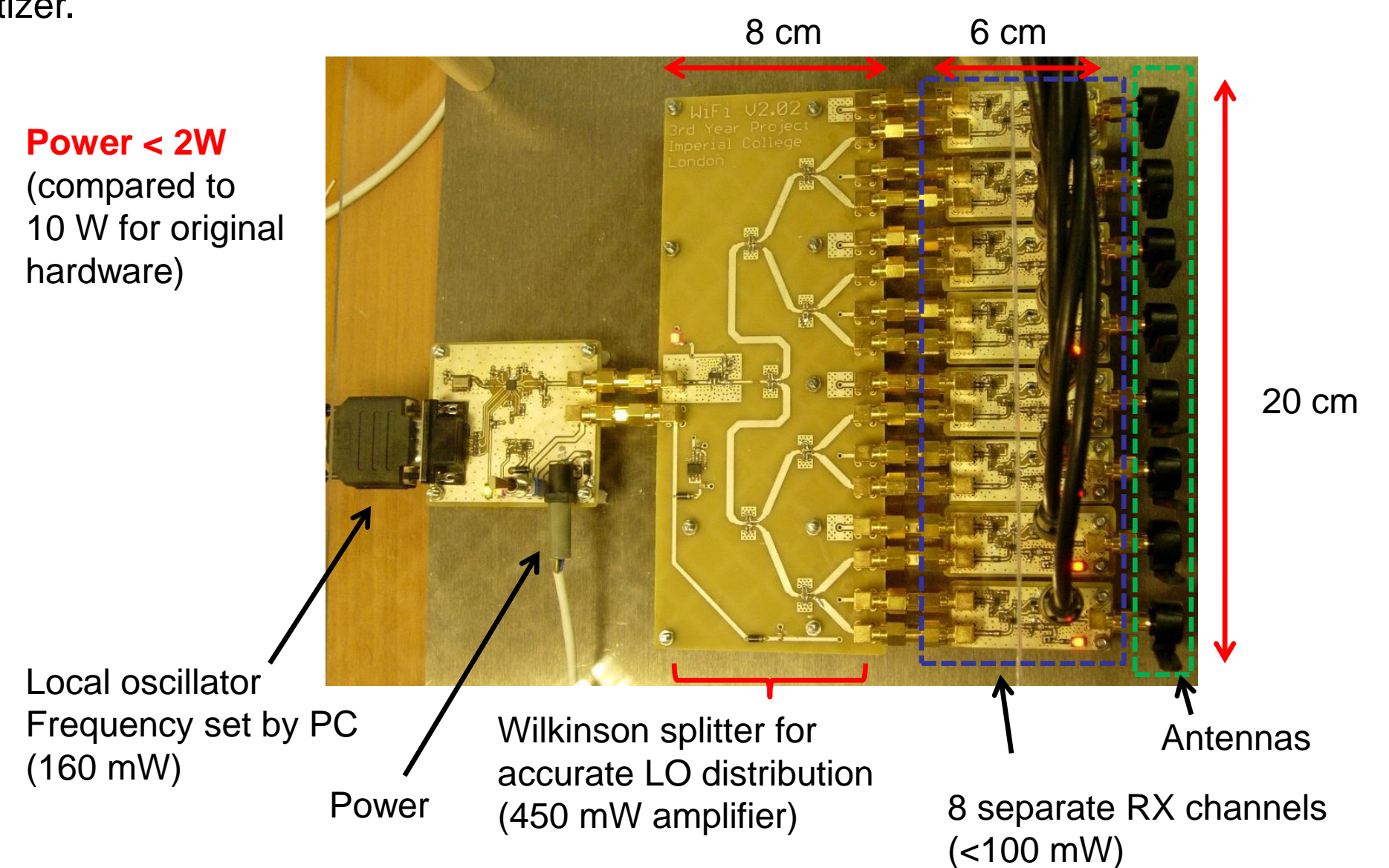
Evaluation of a New Algorithm

The new testbed was used for the practical evaluation of a previously untested wide-aperture localisation algorithm developed at Imperial. The anechoic chamber was used to allow experiment and theory to be compared, which were shown to match well. [Presented at the SRD'11-WInnComm conference in November 2011 in Washington DC.]



Low SWAP

A low size, weight and power (SWAP) SDR array system has been designed and built using off-the-shelf components. It interfaces to the PC using a National Instruments digitizer.



Exploitation

- Evaluation of calibration algorithms developed in UDRC project C1.
- Implementation of narrow aperture direction-of-arrival algorithms and beamforming techniques.
- Development and testing of novel wide aperture localisation techniques (e.g. collaboration with UDRC project O05).
- Future exploitation of SDR approach to further develop low SWAP technology to achieve a high level of hardware re-use for multi-functional operation, i.e. wideband SDR architectures could achieve beamforming, target localisation, communications intercept, electronic surveillance and radar with the same hardware.
Example application: Unmanned Aerial Vehicles.



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