



**UNIVERSITY OF  
BIRMINGHAM**

# **Cognitive Real-Time System for Autonomous Vehicles**

**(104268-CORTEX)**

## **University of Birmingham Campus Driving MIMO Dataset Repository Description**

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## 1. Introduction

This report describes the dataset that is used for initial comparison of performance of DBS (Doppler Beam Sharpening) applied onto MIMO data received from a 8Tx + 16Rx MIMO array radar performance, with that of data from the University of Birmingham Experimental PolarRad-79 mechanically steered radar.

## 2. Experimental Setup

### 2.1 Equipment required

Data collection was done using the equipment listed in Table 1. Most of this was placed at the rear of a Land Rover vehicle, with the radars looking out at the rear, with the rear door opened, as shown in Figure 1.

Both radars will operate at the same time. But the Inras Radarlog can only operate in only MIMO mode where a virtual array of 64 elements is created as discussed in the next chapter, Digitiser box

*Table 1: Equipment required for data collection*

Type	Model	Notes
Radars	PolaRAD-79	Mechanically steered radar
	Inras Radarlog (main MIMO sensor)	77 GHz Radar 4Tx-16Rx, MIMO + Doppler capable
Video	ZED stereo camera	Requires a computer with an Nvidia GPU.

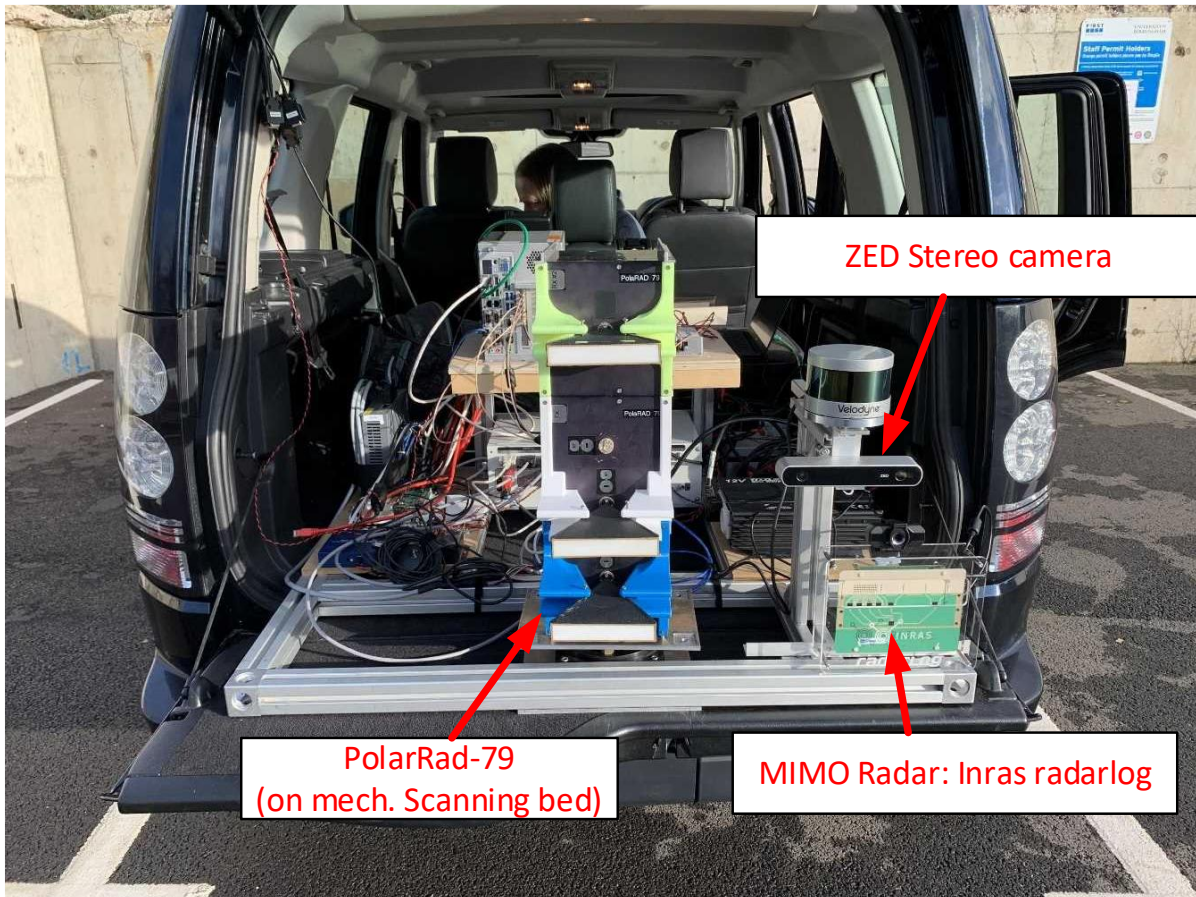


Figure 1: Setup of equipment at rear of vehicle for data collection.

### 3. Radar Parameters

#### 3.1 PolaRAD-79

PolaRAD-79 was operated with fan beam image antennas using an external digitiser to provide high-resolution and longer-range radar imagery up to 600 m. Standard operating parameters for the PolaRAD-79 are provided in Table 2. Full bandwidth was used. Due to overlap with the Radarlog, some degree of interference was expected.

Table 2: Settings for the PolaRAD-79 radar

Parameter	Symbol	Value	Unit
<u>PolaRAD-79 Setting</u>			
Centre Frequency	$f_{centre}$	78.5	GHz
Bandwidth	$f_{BW}$	5.0	GHz
Number of samples per chirp	$n_{samples}$	80000	
Chirp Ramp-Up time	$TrampUp$	2	ms
Chirp interval time (approx.)	$Tp$	5	ms
Frame interval time (approx.)	$TInt$	1	s
<u>Resulting Performance</u>			
Range Resolution	$R_{res}$	3.0	cm
Maximum unambiguous range	$R_{unamb}$	600.0	m

#### 3.2 Inras Radarlog

The Inras Radarlog is a 77GHz radar with four transmit elements at  $3.5\lambda$  spacing and sixteen receive elements at  $\lambda/2$  spacing, having MIMO capability. It can operate in two modes, a MIMO mode where it emulates a one-way radar with 64 receiving elements to beamform, or a Doppler mode where it operates with a faster PRF but only using its real physically 16 receive elements to beamform. For this dataset on the MIMO mode was used, and as such only this mode is described.

In MIMO mode the active transmitters, within the Inras Radarlog, cycle from chirp-to-chirp in the order: TX1-TX2-TX3-TX4. With four transmit elements and sixteen receive elements the Radarlog would produce a virtual array of 64-elements, but the spatial configuration of the antennas on the Radarlog, would give three overlapping virtual elements. Removing these overlapping elements would emulate an equivalent of a 61-element  $\lambda/2$  spaced antenna array (one-way only). Removal of the overlapping elements is usually done before MIMO beamforming processing of the radar signals from the Radarlog. The chirp timing for MIMO operation is shown in Figure 2, and the recommended settings for data collection in this mode is given in Table 3.

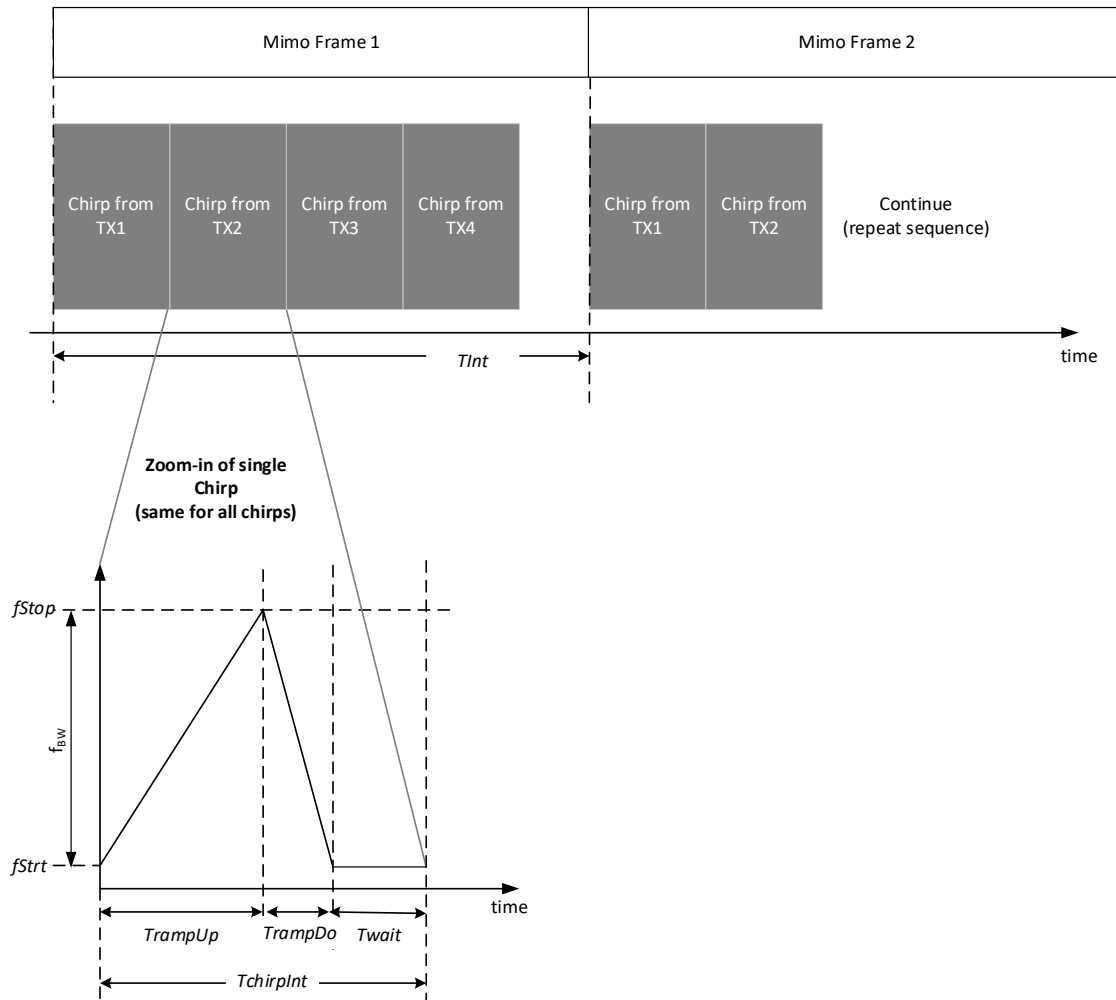


Figure 2: Inras Timing diagram in MIMO mode

Table 3: Inras Radarlog settings for MIMO data collection.

Parameter	Symbol	Value	Unit
<u>Radarlog Setting</u>			
Centre Frequency	$f_{centre}$	77	GHz
Bandwidth	$f_{BW}$	2.0	GHz
Number of samples recieved	$n_{samples}$	2048	
Chirp Ramp-Up time	$TrampUp$	204.8	us
Chirp Ramp-Down time	$TrampDo$	18.8	us
Chirp interval time	$TchirpInt$	230	us
Active MIMO Frame Duration ( $4 \times TchirpInt$ )	$Tactive$	0.92	ms
MIMO Frame interval time	$TInt$	1	ms
Active Duty Cycle ( $Tactive/TInt$ )		92	%
<u>Resulting Performance</u>			
Range Resolution	$R_{res}$	7.5	cm
Maximum unambiguous range	$R_{unamb}$	76.8	m
Maximum unambiguous Doppler Velocity	$v_{unamb}$	$\pm 1$	$ms^{-1}$

## 4. Radar Scene for Measurements

### 4.1 Munrow Car Park

Figure 3 show an optical image of the scene recorded in the Munrow Car Park on the University of Birmingham campus. Radar data and optical image were captured from the rear of the vehicle which was moving away from the scene visible in the photograph. Vehicle forward velocity is recorded alongside radar and camera data.



Figure 3: *Image of scene captured in Munrow Car Park*

### 4.2 Under Muirhead Tower

Figure 4 shows an optical image of the scene recorded under Muirhead tower on the University of Birmingham campus. Radar data and optical image were captured from the rear of the vehicle which was moving away from the scene visible in the photograph. Vehicle forward velocity is recorded alongside radar and camera data.

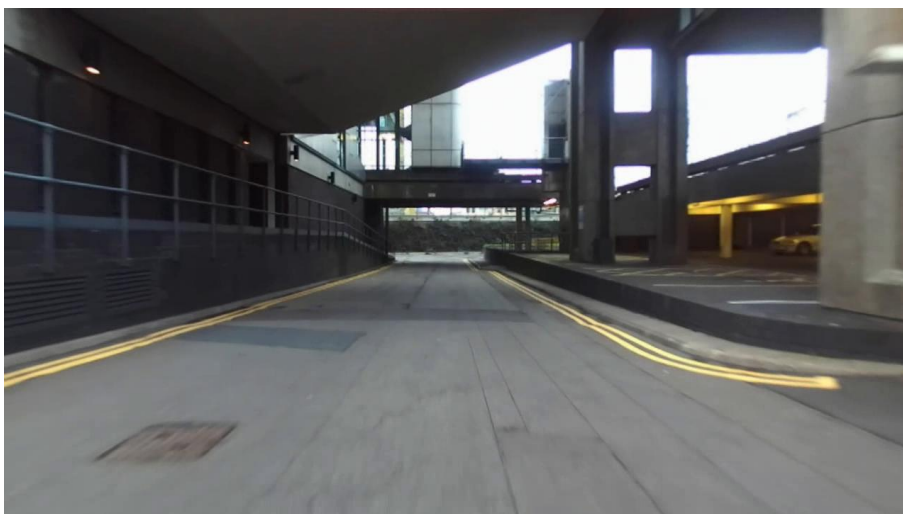


Figure 4: *Image of scene captured under Muirhead Tower*



## 5. Files and Data Structure

### 5.1 Data Set Files

The files stored in this repository are as follows:

1. munrow\_car\_park.mat (Munrow Car Park scene)
2. under\_muirhead\_tower.mat (Under Muirhead Tower scene)

### 5.2 Data Structure

Data files are provided in standard MATLAB .mat file format with the following variables:

- **inras\_data:** Inras RadarLog data, 2048x16x4x128 real matrix representing
  1. 2048 time domain samples per chirp
  2. 16 receive elements
  3. 4 transmit elements
  4. 128 MIMO frame intervals
- **calRadarlog:** Inras Radarlog complex weights to calibrate virtual array response
- **polarad\_data:** 2x80000x111 complex matrix representing
  1. 2 receivers
  2. 80000 complex domain time samples per chirp
  3. 111 angular positions uniformly distributed from -30 deg to +30 deg
- **camera\_image:** 720x1280x3 uint8 matrix containing still optical image of the scene
- **velocity:** Platform velocity in m/s
- **velocity\_mph:** Platform velocity in mph