In this work, passive radar using existing commercial transmitters, such as radio, television, or cellular telephony base transceiver stations, as illuminators of opportunity is considered. The work encompasses all main processing steps in passive radar: digital beamforming, clutter filtering, correlation processing, bistatic target tracking, target localisation and Cartesian target tracking.

A circular antenna array with digital beamforming is considered. An algorithm is proposed for optimisation of the beamforming coefficients to obtain a low sidelobe level and a narrow main beam. The problem of mutual coupling between array elements is also addressed, and a method for calibrating the array is proposed. The algorithms for coefficients optimisation and calibration are verified with real measurements.

The classical procedure for target detection in passive radar based on correlation processing is derived. Extensions of processing are analysed, which allow the use of longer-than-typical integration times and detect highly manoeuvring targets without performance degradation.

Two classes of clutter filtering algorithms are compared: iterative and block. In the case of the iterative methods, three classical filters, i.e. NLMS, RLS and LSL, are compared. In the case of the block methods, least squares matrix solution, block lattice filter and a modified block lattice filter, are compared. The analysis of different approaches involves an assessment of convergence rate, computational complexity and frequency selectivity.

Target tracking in bistatic coordinates based on the linear Kalman filter is introduced. The influence of several parameters, such as integration time and/or probability of false
alarm, on tracking performance in terms of accuracy of bistatic parameters estimation is
analysed. A tracking example of a real target with accuracy analysis is presented.

Two methods for target localisation in Cartesian coordinates from the bistatic mea-
surements are proposed. The methods are derived on the basis of algorithms known for
time-difference-of-arrival systems. The methods derived use closed-form equations. Equa-
tions for accuracy of the methods are derived and analysed. An example of target localisation
based on real data is presented.

The extended Kalman filter for tracking in Cartesian coordinates is introduced. Two
updating schemes are considered: parallel and sequential. A two-stage tracking algorithm,
which involves bistatic tracking and Cartesian tracking, is proposed. This approach allows
the ghost-target phenomenon to be significantly reduced, and localisation accuracy to be
increased.

The experimental FM radio-based passive radar PaRaDe, developed at Warsaw University
of Technology, is described. The hardware and software parts of the system are presented.
Real examples of detection and tracking of targets are presented.

Keywords: passive bistatic radar, passive coherent location, passive covert radar, digital
beamforming, crossambiguity function, target tracking, target localisation, software defined
radio.