FMCW Radar Implementation in River Information Services in Poland

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Abstract: *River Information Services (RIS) were implemented in Poland in 2013 on the lower part of the river Oder. Their numerous system sensors include FMCW radars. Shore based radars provide data for various services, such as traffic information, traffic management and calamity abatement support. The Polish RIS system uses the 4G™ FMCW radars. Considering their low output power, small size, weight and width of the radar beam, they appear best suited for the system. The stretches of waterways covered by the radars are located in urbanized, harbour and non-urbanized areas. The RIS implementation included deployment of nine radar sensors on bridges, two on masts, and one on a building. The article presents experience after the first year of operation of FMCW radars in the Polish RIS system.*

1. Introduction

Radar systems are commonly applied in vessel traffic management. Until recently, the use of radars was limited to marine Vessel Traffic Service (VTS) systems. Together with the implementation of inland navigation systems, radars became part of the RIS. One of the functionalities of the VTS in inland navigation is Vessel Tracking and Tracing (VTT). Its objectives include ensuring safety of inland navigation and monitoring vessel traffic. The topic of vessel tracking and tracing is discussed in [1-8]. A radar image data merged with Automatic Identification System (AIS) and Inland Electronic Navigational Charts (IENC) data create the so-called Tactical Traffic Information (TTI). Data for navigational aims is also discussed in [9-16]. Tactical Traffic Information may be utilized by skippers or VTS operators in situations which require snap decisions concerning navigation. Radar stations are usually deployed for the surveillance of traffic in single locations or larger areas, where navigation is difficult. Some RIS systems feature complex networks of radar sensors. For example, the VTS-Scheldt system has 21 radar stations and five traffic centres. The Scheldt Radar Chain enables the monitoring of vessel traffic on an extensive area of waterways. The data provided by radars, in combination with data on the traced vessels, facilitate visualisation and assessment of navigational situations.

The establishment of VTS systems on river stretches is compliant with the EU Directive, which provides for radar sensor networks as part of the RIS systems. The VTS systems should be established in locations which, for whatever reason, are difficult for navigation. Certain aspects of radar sensor deployment are discussed in [17-19]. Methods based on Digital Terrain Modelling [20-25] and other methods of navigational data processing [26 -28] are extremely helpful in the study and analysis of navigational data. The first RIS system in Poland was deployed in 2013 on the river Oder, with the RIS Centre in Szczecin. Its VTS system uses FMCW radars [29], whose technical specifications, parameters and mounting systems are best suited for this type of waterways. This paper discusses the implementation of FMCW radars in the Polish RIS system.

2. Radar sensor network

The Polish RIS system uses 12 FMCW radars, deployed in locations difficult for navigation. The radar sensors are generally mounted on platforms on bridges and masts, and one of them is mounted on a building [29]. Mounting the sensors on platforms enables the monitoring of adjacent waters. Figures 1, 2 and 3 present the locations of radar sensors in the RIS system (radar positions are marked in green).

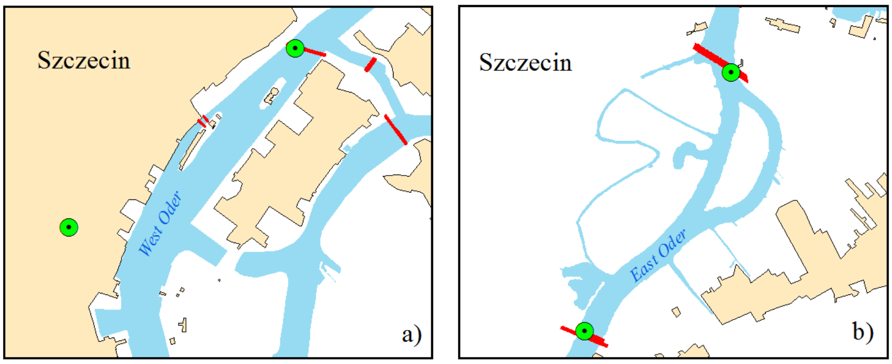

Figure 1. Locations of radars in Szczecin (West and East Oder).

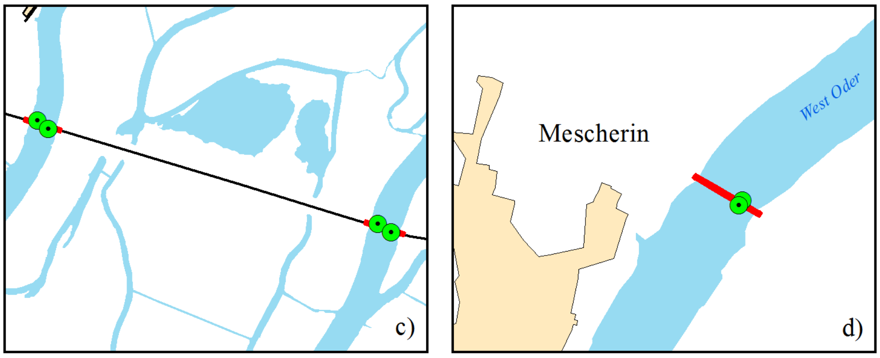

Figure 2. Locations of radars on two bridges over the motorway and on the Mescherin bridge.

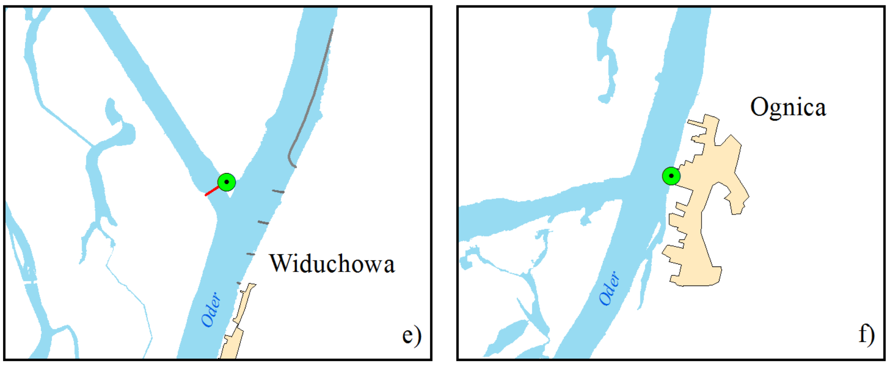

Figure 3. Location of radars on the Widuchowa weir and the berth in Ognica.

Before the deployment, locations of radar sensors were tested based on visibility analyses and with the use of a test radar mounted on a floating unit. The analyses, adjusted to accommodate radar image distortions, enabled an assessment of the ultimate radar overlay of the intended area [17-19]. The radar sensor network consisted of the broadband 4G™ radars, whose basic parameters are presented in Table 1.

Table 1. Selected parameters of the broadband 4G™ radar

Radar Power Requirements	*Output Power*	*Transmitter Frequency*	*Diameter*	*Product Height*	*Product Weight*	*Beam Width*
12v / 20 Watt	165mW nominal	X-band - 9.3 to 9.4Ghz	489 mm	280 mm	7.4 kg	Adjustable between 2.6° and 5.2°

This type of radar proved to be best suited for the area of deployment. The radars were mounted both in urbanized and non-urbanized areas and on stretches of transit inland waterways, where the environmental impact mattered a lot, considering, among other things, the proximity of densely populated areas. Owing to their low output power, FMCW radars proved to be appropriate for such conditions. Additionally, radar radiation could be limited through the use of sector antennas, which further diminished the environmental impact. Moreover, relatively small and lightweight, FMCW radars could be mounted on lightweight arms fixed to the main platforms (bridges, grid towers, a building). Figure 4 presents some examples of mounting locations.

Figure 4. Radars mounted on lightweight arms on a bridge (left), a steel tower (middle) and a building (right).

The radar signals were processed by a computer in an IT rack, where they were merged with data from an ICT system for subsequent transmission to the RIS Centre via wireless network and, in one instance, via an optical fibre cable. The wireless network connections were also used for the transmission of other data, such as the video signal from CCTV cameras or readings from water level measurements performed with the use of microwave sensors. At the RIS Centre, the radar data were merged with navigational charts for convenient visualisation against a backdrop of navigational data, made possible thanks to a RIS-dedicated geoinformatic system.

3. Data merging at the RIS Centre

At the RIS Centre, radar data is merged with electronic charts for inland navigation. The merged data can be viewed on panel displays and desktop monitors for convenient analysis by system operators.

The merged radar data enable monitoring the area in various weather conditions. Figure 5 presents radar data from two radar stations, merged with an electronic chart. The aggregated data create a TTI image. One radar station is located on a building and uses a scanning sector. Its target area comprises a bend of West Oder with a slipway, harbour basins and an approach to a railway bridge, narrowed by two islands. The target area of the two other radars, mounted on the Mescherin bridge, covers the adjacent waters.

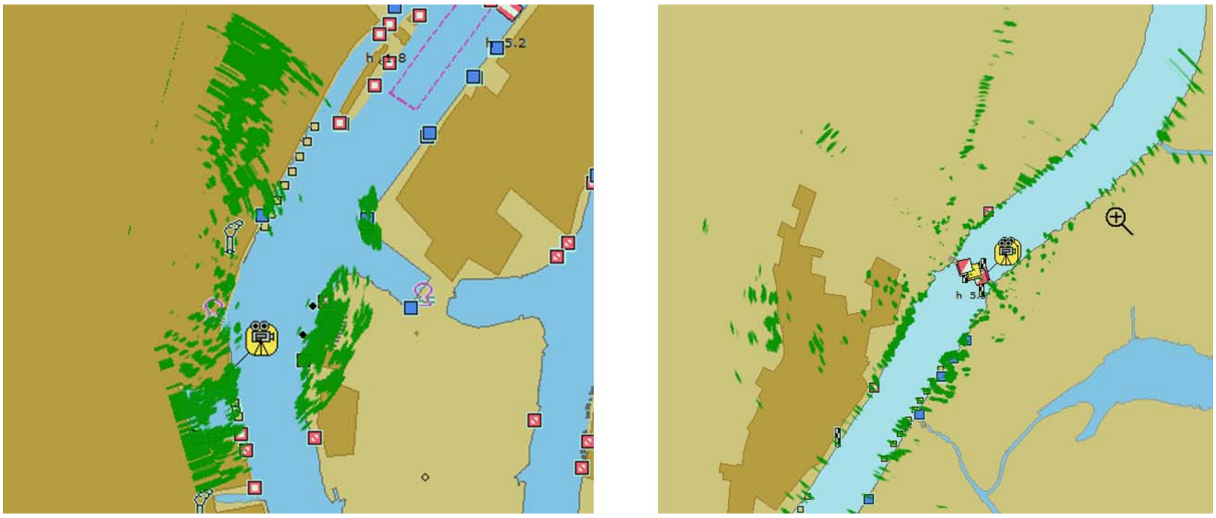

Figure 5. Merged radar image from a sensor on a building (left) and two sensors on the Mescherin bridge (right).

FMCW radars are state-of-the-art devices with detection capabilities equal to those of the traditional impulse radar technology. Figure 6 presents radar overlay of a sensor located on a mast in a waterway traffic surveillance station in Widuchowa.

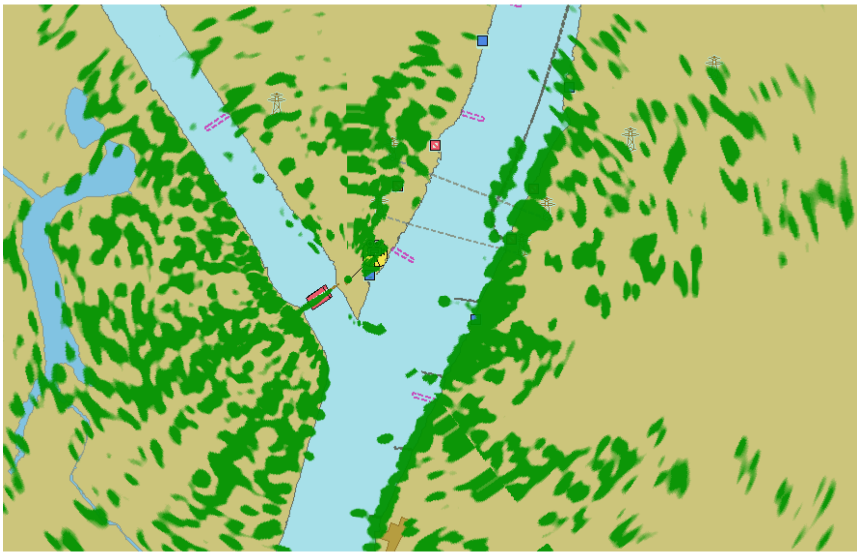

Figure 6. Merged radar image from a sensor on a mast at the Widuchowa Weir.

An analysis of radar target echoes on the water surface reveals echoes of buoys located at the groynes, an echo of the weir, and partial echoes of the groynes and the training wall (which partially jut out of the water). The radar also detects inland navigation vessels in the area. Due to the beam width, the echoes overlap the water, reducing the effective detection area. An assessment of the effect of echo distortions may be performed already at the stage of visibility analysis at the phase of designing radar sensor networks [17, 30, 31].

4. Conclusions

The paper discusses the implementation of FMCW radars in the RIS system in Poland. Numerous advantages of this type of radar may be utilized in designing radar sensor networks for inland navigation. Thanks to their low output power, they easily meet the environmental standards, which is more problematic with traditional impulse radar technology. They can be easily fitted on various platforms. One of its drawbacks is the small size of the antenna, which, with an increased echo width, hinders long-range detection. In many cases, however, this flaw is negligible, since river bends often restrict the detection range to 2-3 kilometres anyway. The radars detect most objects in the target area. No problems with the detection of inland navigation vessels have been observed during the study. FMCW radar data can be easily merged with electronic charts and AIS data for the generation of Tactical Traffic Information.

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