PLAIN SAILING WITH W-BAND RADAR

SAM WOOD EXPLORES THE GROWING MARITIME INTEREST IN W-BAND RADAR AS AN ALTERNATIVE OR SUPPLEMENT FOR NAVIGATION AND POSITIONING IN GNSS-DENIED OR COMPROMISED SITUATIONS

Global Navigation Satellite Systems (GNSS) have become an indispensable tool for maritime navigation, providing accurate Positioning, Timing, and Navigation services worldwide. However, they are not without shortcomings that can impact the effectiveness and reliability of maritime operations. Which is why radar as a supplement to GNSS is vital to the maritime industry.

Despite its great strengths, GNSS in maritime environments can suffer signal obstruction due to tall ships, bridges, windfarms and oil & gas installations. Such obstacles can lead to signal loss or reduced accuracy, potentially compromising the safety and efficiency of navigation.

Interference is another weakness. Multipath interference occurs when GNSS signals reflect off surfaces such as water or vessels before reaching the receiver. This can result in distorted or delayed signals, leading to inaccuracies in positional calculations. In maritime settings, where the reflective surface of expansive water is the dominant feature, multipath effects are more pronounced and can introduce significant errors.

Critical situations

Maritime operations often involve challenging environments such as in polar regions. Here, GNSS signals may be weakened or completely unavailable due to signal degradation caused by ionospheric scintillation, multipath effects, or signal blockage. This limitation can hamper navigational reliability in critical situations.

Furthermore, GNSS signals are also susceptible to intentional interference, including spoofing and jamming. Spoofing involves transmitting false GNSS signals to deceive receivers, leading to incorrect position and timing information. Jamming involves the deliberate transmission of high-power radio signals to overpower and disrupt GNSS signals. Both activities can pose significant risks to maritime navigation, as vessels may be led astray or lose access to accurate positioning.

To mitigate these shortcomings, maritime navigation systems often rely on a combination of GNSS with other complementary technologies such as radar. These systems provide redundancy and enhance the overall reliability of maritime navigation, ensuring safer and more efficient operations at sea.

Why W-Band Radar?

Marine radar has long been a ubiquitous technology in the shipping industry since its development during World War II. It was mandated in 1942 that all U.S. and British commercial vessels be equipped with radar for safety, navigation, and enemy detection. Today, modern radar systems are capable of identifying ships, buoys, birds, and other obstacles within a specified radius.

The range of traditional radar units is determined by the width of the transmitted pulse and the number of pulses sent per second. Current systems can achieve a maximum range (Rmax) of 24 to 72 nautical miles and a minimum range (Rmin) of 20 meters.

Most marine radar systems operate on S-band and X-band frequencies. S-band operates at 3 GHz and has a range of 74 kilometres (40 nautical miles), while X-band operates at a higher frequency of around 10 GHz with a wavelength of 3 cm, offering better target resolution and high-resolution imaging.

However, W-band radar, a relative newcomer in maritime navigation and, operating at 76-77 GHz, provides the most impressive imagery and accuracy. This is becoming increasingly crucial in the ever more cluttered environs of offshore, nearshore, and inland waterways. It has a range of 500 metres and is resistant to adverse weather conditions.

W-band radar can be used in a wide range of near-distance applications, such as berthing, tracking small objects like swimmers and kayaks, and inspecting bridge structures and wind farms within inland waterways.

Selection and benefits

When selecting a W-band radar system, it is essential to consider Frequency Modulated Continuous Wave (FMCW) radar, which measures the distance of moving objects. FMCW radar achieves this by continuously varying the frequency of the transmitted signal over a fixed time period. It provides high range resolution and accuracy, offers rich data crucial for autonomous and semi-autonomous vessels, and can detect concealed targets and tangential motion effectively.

Four key strategic benefits of W-band radar for maritime automation and autonomous vessels are highlighted. These benefits revolve around situational awareness:

1. Localisation: The radar provides precise millimetre-accurate positioning in changing conditions, allowing decision-makers to confidently navigate through obstacles regardless of visibility or reliance on other positioning technologies.

2. Obstacle detection and tracking: W-band radar can identify and locate even small obstacles within a 500-meter radius, providing their positions relative to the vessel.

3. Dynamic positioning: The radar system, along with computer control systems, enables automatic maintenance of a vessel's position and heading using its own propellers and thrusters.

4. Autonomous berthing: Radar localisation allows for autonomous berthing by extracting landmarks onshore and in the nearby vicinity.

Utility in maritime navigation

There are numerous potential benefits of integrating W-band radar in offshore, near shore, ports and terminals, and inland waterway applications.

1. Obstacle Detection and Collision Avoidance: W-Band Radar can effectively detect and track small objects, such as icebergs, buoys, and other vessels, providing essential data for collision avoidance. Its high-resolution imagery allows for early identification of potential hazards, enhancing maritime safety.

2. Port Operations and Navigation: In congested port environments where GNSS signals can be unreliable or blocked by tall structures, W-Band Radar can serve as a reliable navigation aid. It offers real-time position updates and accurate mapping of vessel movements, enabling safe and efficient navigation within confined spaces.

3. Bad Weather Navigation: Adverse weather conditions often pose significant challenges to maritime operations, including reduced visibility and unreliable satellite signals. W-Band Radar's ability to penetrate fog, rain, and snow makes it a valuable tool for vessels navigating in challenging weather conditions. It provides reliable situational awareness and enhances vessel safety.

4. Search and Rescue Operations: W-Band Radar can play a vital role in search and rescue operations. Its high-resolution imaging capabilities enable effective scanning of the surrounding area, aiding in the detection of stranded vessels or individuals in distress.

Supplementing GNSS

While W-Band Radar offers unique advantages in certain maritime scenarios, it is important to note that it is not intended to replace GNSS systems entirely. Instead, it can serve as a valuable supplement to GNSS, providing redundant and independent positioning information. By integrating data from both GNSS and W-Band Radar, mariners can benefit from enhanced reliability, accuracy, and redundancy in their navigational systems.

In the maritime context, where accurate positioning and navigation are paramount, the utility and application of W-Band Radar as an alternative or supplement to GNSS systems cannot be overlooked. Its high-resolution imaging capabilities, ability to penetrate adverse weather conditions, and precise target detection make it an invaluable tool for enhancing maritime safety. By harnessing the strengths of both technologies, maritime operations can be conducted with greater confidence, resilience, and effectiveness.

The future

The current sensor implementation ranges from the increasingly cluttered environment of offshore to the expanding network of strategically significant inland waterways. What is clear is that technology has a crucial role in complementing and in many cases replacing human processes in vessel management and navigation.

Current forecasts indicate that remotely controlled craft will be ubiquitous well within this decade, to be followed closely by unmanned ocean-going vessels, all of which are set to transform maritime and many other industries that depend upon it, from renewable energy to the world's supply chain.

As sensory systems, from millimetre wave radar to satellite-enabled propulsion control become ever more commonplace in maritime automation, the fusion of multiple sensors will become the default, and in which near-distance radar will be a central component. W-Band Radar in the maritime context is, therefore, increasingly seen as a necessary supplement to GNSS.

Results from Navtech 2022 field trials of W-band radar on the River Torridge in Devon. Above left: Radar data (top) to detect kayaker (circled in red) from a range of around 250 m. The images immediately below were taken simultaneously by a GoPro camera aboard the trials vessel. Right: The vessel used for field trials data collection, fitted with a Navtech Terran360 radar

Navtech's radar-based localisation solution, Terran360, being successfully trialled with BAE Systems on London's River Thames to test performance and usability. Above left: Raw radar data collected on the test vessel and overlaid on a satellite image of the same location. Above centre: Terran360 radar mounted on BAE Systems' survey vessel. Above right: Radar point clouds (shown by blue and red dots) extracted by Terran360 to localise vessel position within the environment

Sam Wood is product manager at Navtech Radar (https://navtechradar.com/). Based in based in Wantage, Oxfordshire, the company innovates with radar to deliver world--first capabilities in highways safety, critical national infrastructure security and industrial automation. It is part of Halma PLC, named one of Britain's Most Admired Companies in providing innovative solutions to many of the key problems facing today's world.