WHITE PAPER:
HOW ACCURATE IS BlueTraker® VMS?

1. Introduction

1.1. Abstract

Environmental and fisheries regulatory organizations use tracking and monitoring system solutions in commercial fishing to track and monitor the position, direction and movement activities of fishing vessels at sea. Authorities allow or restrict areas where fishing vessels can practice fishing. The reasons behind regulating certain areas at sea are to provide sustainable rate of fish, where fish population declines over time due to heavy fishing practices. This paper discusses the importance of providing accurate position information of any monitored fishing vessel in real time, by installing reliable tracking and monitoring technology on board the fishing vessel.

1.2. Purpose

The intention of this document is to present the level of accuracy of Global Navigation Satellite Systems (GNSSs) modules embedded in BlueTraker® Vessel Monitoring System devices, which enables us to assure the quality standard of every BlueTraker® VMS device. This is unique in maritime industry. To tackle this problem, an analysis of the accuracy and precision of GNSS position measurements was performed for BlueTraker® VMS devices, produced by the company EMA Ltd. in Slovenia (EU). Each BlueTraker® VMS device has an embedded GNSS module that provides location, speed and heading data. The device sends these data to the Telematic Data Server (TDS), which then processes the data.

2. Problem

The accuracy and repeatability of position data is one of essential attributes to define the quality of BlueTraker® VMS terminals. Confidence in the data is therefore one of the most important requirements of users and Fishing Monitoring Centres (FMCs) alike, who are often left with the unanswered question: *How accurate and precise are specific VMS terminals?*

3. Solution

We performed an analysis on a batch of more than 1000 BlueTraker® VMS units in the production process during a six-month production period.

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3.1. Accuracy and Precision

In measuring and testing the consistency of location data received from the GNSS module, the terms “accuracy” and “precision” are used.

By definition, accuracy is the level of measurement relating to a certain reference point, which in our case means that the distance of each location point from our reference point (the actual location of the device) is measured. Precision is defined as the level of consistent measurements when repeated.

Accuracy and precision are used when defining the quality of GNSS location, as presented graphically in Figure 1 below. In the first phase of the measuring process, we focused on these two measurements.

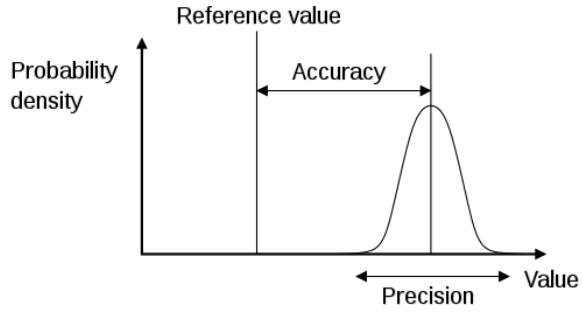

Figure 1: Probability density for accuracy and precision. Source: Wikipedia.org.

3.2. CEP and R95

When analysing accuracy and precision, there are many criteria relevant for these two measurements. Most commonly, Circular Error Probable (CEP) is used. By definition, CEP is the radius of a circle, centred about the reference/mean point, whose boundaries are expected to include 50% of all the location points. Another, stricter criterion is also used: R95, which is defined as an area that includes 95% of all location points around the reference/mean point. CEP and R95 are used in specifications of GNSS systems, so it is important for use to specify these data to the end customer.

3.3. Calculating Accuracy and Precision

It is possible to calculate the accuracy of every location point from each BlueTraker® VMS device. In our testing procedure, the distance of each location point from the reference point was calculated. The reference point is specified according to World Geodetic System (WGS) standards. In this way we obtained several measurements from multiple locations for each device.

Calculation of precision was performed in a different manner than in the case above. For each device, the mean value of all the location points was calculated. This value was then used as a reference point. With this information, the distance of each point from our calculated reference point was then calculated. In this way, we obtained two series of distance measurements (accuracy and precision) for each device.

4. Calculating CEP and R95

4.1. Statistical methods

As defined above, CEP is the radius of a circle in which 50% of all measurements are included. In statistical terms, CEP is equal to the median when calculating the CEP for each device. The median is defined as the value that separates the population in two halves (50%). With this method, one can calculate a CEP for each device from numerous distance calculations. By doing this, we obtained the CEP for the accuracy and precision of each device.

When calculating R95, which is by definition the radius of a circle in which 95% of all measurements are included, calculation from CEP is presented below.

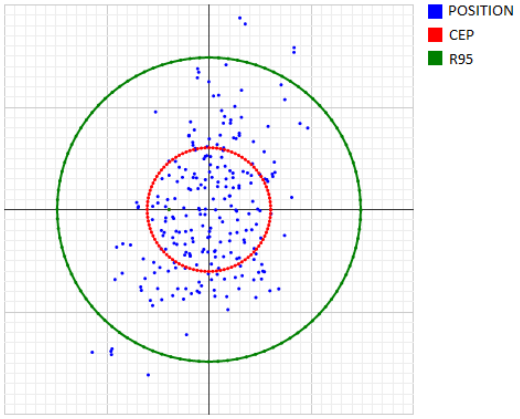

Figure 2: Illustration of CEP and R95. Source: Blog.oplopanax.ca.

4.2. CEP to R95 Calculation

To avoid the need to calculate the top 95% of all the measures by using statistical methods, a more practical solution is used in industry by calculating R95 from CEP.

A formula, which is used in practice, is proposed: $R95 = 2{,}1 \times CEP$.

With this in mind, one can easily calculate R95 for the accuracy and precision of all devices directly from CEP. In this way we obtained four results (CEP and R95 for accuracy and precision) for each device. In this way, we were able to statistically analyse the data for the whole fleet and calculate the actual accuracy and precision of all the devices that were tested during our production process. Below, we summarize all the results and analyse the distributions of CEP and R95 for accuracy and precision.

5. Results and Conclusions

5.1. Testing Population

During the six-month production period in EMA (April–October 2015), 1115 BlueTraker® VMS devices were tested in our production process. Testing occurs after the devices are assembled and before shipping to the distributor or customer. This testing procedure is automated under special conditions and enables testing and monitoring of a number of parameters. Also, it is the last quality check before shipping and assures the expected functioning of devices.

Below, we present the results of CEP and R95 analyses for the accuracy and precision of the tested devices.

5.2. Results of CEP and R95 Analysis

We present graphs of CEP and R95 accuracy and precision distributions for all the tested devices in Figures 3 and 4. The devices are grouped into 0.1 m classes. The Y-axis represents the number of devices in each of these classes.

The X-axis is the CEP or R95 radius in metres. We can see normal distributions for all four analysed cases. Our comments on the results are presented below both graphs.

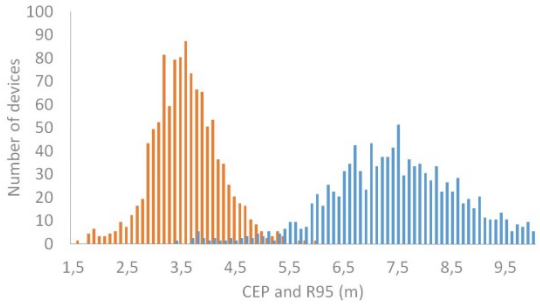

Figure 3: Distributions of CEP (orange) and R95 (blue) - Accuracy of all 1115 devices.

Graphs of CEP and R95 (accuracy) in Figure 3 show normal distributions around the mean values (CEP = 3.7 m; R95 = 7.6 m). There are essentially no values that stand out from these distributions, which confirms that the production process is very good in general.

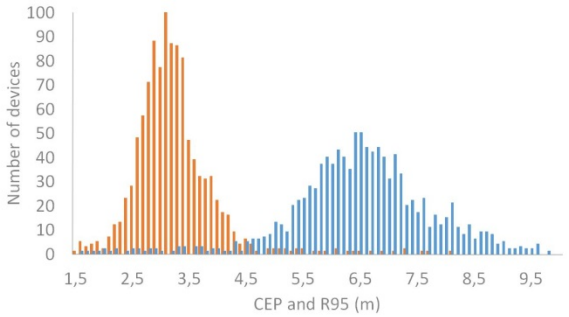

Figure 4: Distributions of CEP (orange) and R95 (blue) - Precision of all 1115 devices.

Graphs of CEP and R95 (precision) in Figure 4 show normal distributions around the mean values (CEP = 3.1 m; R95 = 6.6 m). There are essentially no values that stand out from these distributions, which demonstrate high quality of the production process in general.

The acquired data serves for quality control of our products later in our production process. Because we want to improve the quality of our devices, we continuously aim to minimize CEP and R95 for accuracy and precision.

5.3. CEP and R95 as a Quality Standard

As Figures 3 and 4 show normal distributions with very few anomalies, it is evidenced that the production process of BlueTraker® VMS devices in EMA is of a high quality level without major discrepancies. However, we want to improve our processes and the quality of our products. Accuracy and precision are the key parameters of our devices, besides the communication channel and power management.

We propose to use CEP and R95 as the criteria for quality control in our production. The proposed values are as follows:
- **CEP (accuracy) = 5 m.** 98.2% of all BlueTraker® VMS devices in our production testing procedure meet this criterion.

- **CEP (precision) = 5 m.** 97.8% of all BlueTraker® VMS devices in our production testing procedure meet this criterion.

All of the devices that do not comply with the standards above are retested or discarded.

6. Conclusions

In recent BlueTraker® quality control research, performed by EMA Ltd in 2016, we have come to conclusions that all BlueTraker VMS devices provide reliable and high quality technology, which is ensured during quality control over production process. There are several benefits for users of BlueTraker® technology:

Trust: Users can be confident that each BlueTraker® VMS terminal is tested extensively during the manufacturing process;

Confidence: Position reports are within CEP confidence levels;

Quality control: EMA has strict control over the manufacturing process, immediately monitoring the state of quality, and can act accordingly;

Prevention of illegal activities: For the maritime industry, obtaining accurate vessel locations is of the utmost importance in order to detect illegal activities (trans-shipments, violations, etc.).

About BlueTraker® VMS terminal

The BlueTraker® VMS is the latest generation of marine graded satellite terminals specifically developed to monitor fishing vessels. BlueTraker® VMS is known for its integrated design, incorporating all the electronic inside a single terminal housing:

- Central Processing Board;
- GPS receiver;
- GPRS modem;
- Iridium modem;
- Back-up rechargeable battery;

BlueTraker® VMS provides a wide array of unparalleled benefits, unequaled on the global market:

- Lower operating costs and high frequency of position reports at the same time;
- Seamless automatic switching from GPRS to SAT channel and back;
- Low installation cost and improved safety and security through one-cable installation, connecting the device to the power source;
- No need for any on-site intervention using over the air firmware upgrading;
- Reliable and cost-efficient operation through a robust and maintenance-free device;
- Enables integration with the existing FMC infrastructure regardless of the communication channel;
- Operates for up to 3 full days on the embedded battery in the event of a power failure;
- Simple mounting with a RailMount or UniMount mounting kit;
- Unrivalled safety and security level, and fully compliant with Council Regulation (EC) Nos.2371/2002 and 1224/2009.

About EMA

EMA, headquartered in Slovenia, is a leading maritime tracking and traceability specialized company with 25 years history. Its mission is to develop, manufacture and market a range of intelligent, remotely operable machine-to-machine equipment and systems. Moreover, BlueTraker® solutions are applicable to a broad range of industries, mainly using satellite communications technology to monitor remote stationary or moving objects. EMA provides turnkey solutions to end customers, technology providers, product providers and system integrators on maritime markets worldwide.

For more information, visit www.bluetraker.com.

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