**I-VMS Device Test - Evidence Requirements for Type Approval**

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1. **Introduction.**

Interested device suppliers wishing to supply the under 12metre fishing industry with an I-VMS approved product must undertake the following steps in order to evidence their products meet the I-VMS Specification of requirements and meet UK I-VMS legislative requirements.

Applicants must evidence their products meet the I-VMS Specification of requirements via a combination of.

* Supplier declarations
* Written explanations
* Certifications and self-evidence
* Evidence from core testing outputs (This document explains what is required)

Upon the MMO receiving and reviewing the evidence submitted, The MMO will notify Applicants whether devices have either passed the evidence validation or have failed validation. Where an initial failure notification has been provided, suppliers will be notified of the reasons and offered one period to resubmit additional evidence for re-evaluation whilst the submission period remains open. Please refer to the I-VMS requirements of participation document.

This document specifically relates to the core tests required and the test evidence required. This document should be read in conjunction with the I-VMS device specification of requirements. For the other forms of evidence, please refer to I-VMS Response Requirements which break down all other evidence requirements required.

These core tests should be undertaken by an independent company which specialises in testing and certifying GPS and navigation-based products. The tests here cover aspects such as device accuracy, power management, tamper aspects (e.g., sending of tamper alert), and GPS/GSM blockage.

There are also a set of integration tests which will be perform when suppliers are setting connection to the UK VMS Hub, this will also include evidencing the devices' ability to deliver variable reporting rates.

These tests below do not require integration to the UK VMS Hub. However, they are crucial in ensuring devices are fit for our fishing industry and are accurate and robust. The data outputs from these devices will play an important part in understanding where our fishing industry operates and their fishing impacts. Therefore, the positional accuracy of the data is paramount. These tests have strict pass/fail criteria against requirements.

Please do not submit your evidence until you have all the documentation completed, this includes the core test evidence. Supplier should contact IVMS@marinemanagement.org.uk if they have any queries relating to this document.

1. **Summary of device test evidence**

**Prior to testing device, we expect the tester to check general device functionality**

* Device powered up correctly, LED emitted
* Check that position reports sent/received with expected content and formats
* Check that no tamper alert messages are appearing upon receipt of device (to ensure no damage of device during delivery)
* Short dynamic tests – outdoor, low speed, some obstructions

**Accuracy tests – Device reporting every minute**

* Static set-up for a minimum of eight hours above pre-surveyed point
* Open sky, low multipath
* Test repeated for three times in each case
	+ primary power,
	+ internal battery
	+ varying voltage (within specified power range)
* Check that measured horizontal accuracy <5m CEP
	+ 50% of all reports must be accurate to +/-5m
	+ 95% of all reports must be accurate to +/-10m

**Obstruction/Blackout Tests**

* Multiple tests
	+ Static set-up to simulate obstructions
	+ Physical shielding of device to block GNSS and GSM signals
* Check that correct status flag sent when no GNSS signals available and that output messages are stored and re-sent later if GSM signal is lost
* Check what happens at low numbers of satellites – 5->4->3->2->1
* Expect correct status recorded when device does not have enough satellites

**Power Management**

* Operate device on primary power and battery power
* Check that correct status/event flags are sent to indicate switch to and from primary/internal battery source
* Check that correct number of reports and low battery status are sent before battery power runs out.
* Operate device with varying voltages on primary supply and check correct behaviour at limits

**Tamper Test**

* Tamper with device (open up casing) and check that tamper alert is sent
* Provide test assurances that you cannot gain access to the device and change SW or setting without tamper alert being raised.
* Test should include looking at wireless connections (e.g., Bluetooth, WIFI) as well as opening up the device with power off, etc. How does a supplier determine whether the device casing has been opened whilst powered off?
1. **Detailed test report outputs**.

Device suppliers must provide one report detailing the conclusion of the device testing against these elements.

As a minimum this should include:

1. a test ID (referenced in the description of tests table. See example in annex A)
2. details of their testing set-up and methodology.
3. dates and times of testing.
4. the levels of testing; and
5. the results and findings for all testing requirements specified.
6. The test report must be signed by supplier as a formal declaration

The MMO shall be responsible for reviewing the evidence provided and may request further information from the device supplier when verifying the outputs from the test procedures.

**The MMO is responsible for assigning MMO I-VMS type approval status.**

Please follow the detailed information on each of the test elements required.

1. **Position Accuracy Tests (PASS/FAIL)**

|  |  |
| --- | --- |
| Test **PERF-001**: Positional Accuracy in Static Test running on Power Supply | To check that the device reports correctlyTo check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy when have power supply.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| Test **PERF-002**: Positional Accuracy in Static Test running on Battery | To check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy when running on battery.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| Test **PERF-003**: Positional Accuracy in Static Test with Power Fluctuations | To check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy and not affected by power fluctuations.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| Test **PERF-004**: Positional Accuracy in Static Test running on alternative Power solutions | To check that the device reports correctlyTo check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy when have alternative power supply.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |

## **Rationale behind tests**

Validation that I-VMS device provides the level of accuracy required within the specification of requirements. The test report could be used as important evidence to support any positional accuracy disputes and investigations. The relevant requirements for these tests are to validate sections:

***4.1 Positional requirements***

***a) The I-VMS device must employ a GNSS augmentation accurate to +/- 5m to meet national reporting requirements.***

***The device must demonstrate that:***

***• 50% of all reports must be accurate to +/-5m***

***• 95% of all reports must be accurate to +/-10m***

***3.4.1 Powered directly from the vessel’s primary power supply***

***Where a device is using a vessel’s primary power, the I-VMS device must have the capability of being continuously powered and meet the following:***

1. ***The I-VMS device must be able to cope with power fluctuations likely to be experienced on board fishing vessels without any degradation to performance.***

Based on these requirements the tests must be able to provide reliable measures of horizontal accuracy in representative conditions.

The tests should be repeatable so that it is possible to compare performance between different power situations (battery, primary power, etc...). It is necessary to try to re-create representative conditions for the test, i.e., open sky without blockages.

The advantages of static testing are that real signals are used to give realistic performance figures, a high accuracy truth is easily available for generating reliable performance statistics, and the tests have a good degree of repeatability to allow comparison between different power options for a device, and for comparing between devices. The fact that the receiver is static should not make any difference to the performance – in fact, it should allow a better estimate of the performance because there are no issues with the quality of the ‘truth’ solution.

It is true there are potential issues with the results not being representative of operational conditions due to a risk of increased multipath, but this is mitigated though setting up the receiver in an open area with clear sky view and measuring the performance with a comparison GPS receiver at the same time as an independent check of performance.

**Static tests.**

In this test set-up the device is placed over a point with known coordinates and kept in place for several hours.

Pros

* Uses real GPS signals so performance figures are realistic
* Using fixed point with known coordinates means that high accuracy truth is available for error analysis
* The tests can last for many hours in order to obtain a representative accuracy value over a wide range of satellite geometries
* The test set-up is easy to repeat for different tests (e.g., primary power supply vs. battery) and for different devices

Cons

* Risk that conditions are not entirely representative of operational conditions at sea.

## **Details of Set-up**

The details of the set-up for each test are described below:

* Documentation is reviewed to identify the GNSS and augmentations that are used by the equipment.
* Locate device at known surveyed point using very precise GPS techniques.
* Antenna for comparison receiver set-up a short distance away (approx. 1metre)
* Device under test and comparison receiver are both kept static for a minimum of 8 hours and position reports must be collected every one minute
* After the end of the test, position reports are downloaded, and position errors (compared to surveyed position) are computed, and error statistics are generated.

These tests are repeated with;

1. the device on primary power supply (**PERF-001**),
2. on internal battery power (**PERF-002**),
3. on primary power supply at different voltages within the allowed range (**PERF-003**) -see specification of requirements.
4. on all alternative power solutions (**PERF-004**) *(Add PERF-005, PERF-006 etc. for each alternative power solution)*

It is expected that the measured horizontal position accuracy will better than 5m (at 50% level) in all tests.

## **Expected results**

The accuracy tests performed on the device following the set-up described above, should be:

* The 50% horizontal error was less than 5m in all tests.
* The 95% horizontal error was less than 10m in all tests.
* The comparison receiver should broadly have had a performance with 50% horizontal error of ~1.3m and 95% error of 2m.
* No obvious difference between the tests with different power configurations – performance on primary power and on battery was the same.
* Report generated and positional accuracy passed for PERF-001 to PERF-004.

Detailed test evidence must be provided as part of any type approval validation.

1. **Obstruction/Blackout Tests (PASS/FAIL)**

|  |  |
| --- | --- |
| Test **BLACKOUT-001**: Physical Shielding of Antenna | To check what happens when physically shield the antenna to block signals - should get a warning of loss of GNSS, certainly should not get high errors without any sort of warning |
| Test **BLACKOUT-002**: Complete Loss of Signals | To check what happens when no signals are received by the receiver - should get a warning of loss of GNSS, certainly should not get high errors without any sort of warning |
| Test **BLACKOUT-003**: Position reports with marginal numbers of satellites. | Position reports with marginal numbers of satellites: We expect that if more than 4 GPS satellites are in view (or 5 or more GPS + Glonass) then a valid position report will be generated. Conversely, if less than 4 satellites are available, we expect the status to indicate ‘no GPS fix’. |

## **Rationale behind tests**

This ensures the robustness of a device and it exhibits the correct behaviour when the GPS and/or GSM signal is not available. The relevant requirements for these tests are:

***4.1 e) Following a break in the communications at the time a position report is required to be transmitted, the data report must be stored, batched, and forwarded on restoration of the communication link.***

* 1. ***c) Following a break of the communication link, at the time a position report is required to be transmitted, the report to be sent must be stored. On restoration of the link, the I-VMS device must be capable of:***
* ***immediately transmitting reports that provide the current position along with an appropriate status code to indicate there had been a broken link.***
* ***and then transmitting all stored reports between those times, earliest first.***

***4.2 a) As a minimum, the following event status codes must be provided from the device to the UK VMS Hub with an appropriate position report for national reporting requirements:***

* ***loss of connection with the GSM/GPRS network (when restored).***
* ***antenna blockage or no position fix obtained at appointed time (when restored).***

At the heart of these requirements are strict binary actions:

* no GPS position -> send report with correct status flag
* loss of GSM -> store reports and re-send when connection is re-established, along with status flag indicating GSM connection was lost.

Based on these requirements, the tests must consider the following properties:

* The tests must be able to unambiguously block **GPS** satellites in a controlled, repeatable manner
* The tests must be able to unambiguously block **GSM** signals in a controlled, repeatable manner

As such these tests are ideally suited to controlled environment because the intention is to unambiguously block the appropriate signals (GPS, GSM, or both) because that creates a clear situation in which the device must send the appropriate messages. The device does not know (or need to know) what has caused these situations. Therefore, it is not necessary to try to re-create an operational scenario that may or may not cause these situations. In fact, trying to replicate an operational case where the signal may or may not be blocked is not appropriate for these requirements because it creates ambiguity in the expected device behaviour.

The blackout tests are designed to assess the behaviour of the device when the GNSS signals are increasingly blocked. Blackouts are induced both through physical blockage of real signals and interruption of simulated signals.

The three key blackout tests are defined:

**BLACKOUT-001:** Physical shielding of antenna

**BLACKOUT-002:** Physical blockage of real satellite signals when I-VMS device is static.

**BLACKOUT-003:** Position reports with marginal numbers of satellites. What information and status codes are generated with marginal number of satellites?

For each test, the position reports from the I-VMS device should be analysed to check the status codes and position errors. Two COTS GNSS receivers (one GPS and one Glonass) should also be used in some tests for comparison purposes.

## **Details of Set-up**

Based on the considerations described above, the following test set-up is used:

* Set-up device on battery and place at known surveyed point.
* Check device is reporting a GPS position
* Set up comparison receiver and check that is receiving GPS signals
* Put device and comparison receiver in desktop anechoic chamber to block all signals and leave for short period (at least 10 minutes)
* Open chamber and remove device and comparison receiver
* Download position and status reports and check behaviour during test

Putting the device in the chamber guarantees that all GPS signals will be blocked, and the device should not be able to compute a position so testers can check that the correct status flag is produced.

There are GSM antennas on the chamber to allow the device to communicate. These can also be disconnected to ensure the GSM is also blocked completely.

## **Expected results**

The analysis focuses on the position status with marginal numbers of satellites and on the behaviour after an outage. In particular, the analysis will look at:

* **BLACKOUT-001:** What happens when physically shield the antenna to block signals – should get a warning of loss of GNSS, should not get any high errors without warning. Time to First Fix: After the position solution is lost, we should expect that it will return within a few minutes once enough satellites are available again.
* **BLACKOUT -002:** What happens when no signals are received by the receiver – should get a warning of loss of GNSS, should not get any high errors without warning.
* **BLACKOUT -003:** Position reports with marginal numbers of satellites: We expect that if more than 4 GPS satellites are in view (or 5 or more GPS + Glonass) then a valid position report will be generated. Conversely, if less than 4 satellites are available, we expect the status to indicate ‘no GPS fix’.

For the tests it is expected that reports from the device will be sent every 60-seconds.

* When analysing the reports corresponding to the times during the GPS/GSM blockage tests when the device was in the chamber, we would expect reports with a ‘no GPS position’ status/event would be recorded when no GPS position was available.
	+ GNSS position should be provided as long as 4 or more satellites are available
	+ No position should be provided when less than 4 satellite signals are available
	+ The appropriate status flag should be sent when no position are available
* If the GSM signal was lost, then the device should have stored the position reports (whether or not they had valid position) and re-send them once connection was re-established.
* Report generated.

**Reasons of failure.**

It could be that the device does not send reports when it has no GPS position. That would be a failure against requirement 4.2a (status codes) from the specification.

It could be that device does not store reports for forwarding on when it loses GSM connection. That would be a failure against requirements 4.1e from the specification.

It could be that the device did correctly send reports to the server but there was a configuration problem or error in the logic that prevented these reports from being sent on to the GUI. This would require further analysis from device supplier to determine if this was the case.

Remedial action will be required.

Detailed test evidence must be provided as part of any type approval validation.

1. **Power management tests (PASS/FAIL)**

|  |  |
| --- | --- |
| Test **POWER-001**: Resistance to Voltage Spikes and Drops | To check that the device still functions and provides position output when voltage spikes and drops |

## **Rationale behind tests**

These tests are to ensure all devices and power components are suitable for our fishing industry and will provide fishers the required levels of power to fully operate an I-VMS whilst they are out at sea. The relevant requirements for these tests are:

***3.4.1 Powered directly from the vessel’s primary power supply***

***Where a device is using a vessel’s primary power, the I-VMS device must have the capability of being continuously powered and meet the following:***

1. ***The I-VMS device must be able to cope with power fluctuations likely to be experienced on board fishing vessels without any degradation to performance. These arrangements must include provisions for:***
* ***working across a range of voltages typically in use by fishing vessels at sea, as a minimum coping with variations between 8 to 36 volts, allowing a nominal supply of 12v or 24v DC.***
* ***protection from: voltage surge, voltage spiking, and reverse polarity events.***
* ***power conditioner (also known as a line conditioner or power line conditioner).***

## **Details of Set-up**

Based on the considerations described above, the following test set-up is used:

* Power fluctuations shall be tested in the laboratory by varying the input power to the I-VMS and comparing with normal, stable power.
* Power variation shall be tested in the laboratory by providing a range of input power supplies from 8v to 36v. For each voltage, the impact on functionality and performance shall be analysed.
* Spikes, surges, and reverse polarity shall be tested through a laboratory test using a variable power supply unit. Advice and permission will be sought from the manufacturer. An inspection of the device design will confirm the presence of adequate power management within the device to support the testing.

In all the above, the I-VMS device performance will be assessed using off-air GNSS signals. The impact of varying the input power on performance will be recorded and monitored.

The inclusion of a power conditioner within the device should be confirmed by inspection of documentation and inspection of the device. The component should be identified and analysed for performance through inspection of the product sheet and technical specification.

## **Expected results.**

It is expected that the device should be able to deliver the following.

* Operate against the voltage parameters and fluctuation.
* Manage against spikes, surges, and reverse polarity
* Display external electronic indicators to indicate to the vessel master that a vessel’s I-VMS primary power supply is connected to the device
* Provide the relevant status/event alert when the power source has switched and when the battery is at a low status.
* Provide at least 1,000 reports whilst on battery alone.
* Alternative power solutions also provide the correct level of sustain power
* Report generated.

Detailed test evidence must be provided as part of any type approval validation.

1. **Tamper tests (PASS/FAIL)**

|  |  |
| --- | --- |
| **TAMP-001** | Check on detection methods |
| **TAMP-002** | Check on ability to change positional fix by manual intervention |

## **Rationale behind tests**

Another key element of the type approval process is to validate the resistance to tamper effects, deliberate or otherwise. The minimum requirements for these tests are:

***3.3 f) The external casing of the I-VMS device must be physically sealed before being installed, and the means provided to detect any unauthorised opening or other physical interference or ingress of the I-VMS device. As a minimum, this must consist of a sensor in the device that detects when it is opened and transmits a position report with the appropriate event status code when the communication link(s) are re-established.***

* 1. ***g) Once the I-VMS device is sealed, any adjustments or reconfiguration to scripts, reporting frequencies and other software functionality must only be possible via a communications link by the device supplier and by engineers authorised by the supplier opening the I-VMS device on board the vessel.***

***4.1 b) There is to be no external input to the positioning system, such that it must not be possible to change the positional fix by manual intervention.***

The purpose of the test is to assess the protection deployed within the I-VMS device to prevent physical and electronic tampering. More specifically there is a need for the test to assess that information (serial number, configuration settings) and software stored on the device cannot be amended/change/deleted without using authorised channels and protocols or without detection.

## **Details of set up**

The test should make use of skilled personnel. A checklist should be produced which shall detail the full inspection and ensure consistency among testing.

The test sequence is presented as follows:

* An important aspect will be to audit the manufacturer’s process for assigning serial numbers and software to the device, as well as their process for factory reset and reconfiguration or software updates. These steps may introduce vulnerabilities.
* An analysis of the process for onsite resolution/reconfiguration by an approved engineer shall also be analysed alongside the offsite, remote configuration of the device via wireless communications link.

The test will examine both aspects of physical tampering and interrogation as well as use of electronic means.

In relation to the physical/manual tampering, the inspection shall examine the exterior of the device and identify markings related to the construction and assembly process of the casing and how the enclosure is attached to the internal board/modules. The process shall also identify any visible physical seals. All visible external physical features, joints, fixings (including screws, clips etc.) and connectors shall be identified and analysed for their purpose, including:

* Diagnostics ports
* Antenna connectors (e.g., GNSS, DGNSS, GPRS)
* Electrical Power connectors
* Airflow ducts etc.
* Switches (including on/off, factory reset)
* Any output cables/connectors (e.g., external display, data download)
* Any input cables/connectors (e.g., from external navigation device, markers, or other sensors)

The device should be opened for a visual inspection of the interior. Any physical (or electronic) sealing or shielding and anti-tamper components (security micro-switch) shall be located, identified, and documented. The inspection shall continue to identify the quality and robustness of the construction and the components’ critical modules including:

* Processor
* data streams, memories, and storage (solid state and removable)
* GNSS module (and augmentation)
* GPRS/communications module
* other components of interest to other tests, e.g., power distribution, protection etc.
* other components (e.g., Bluetooth, Wi-Fi, etc. that could present a vulnerability)

In terms of electronic tamper, the inspection test shall identify all wired and wireless interfaces and analyse their purpose and the opportunity for attack or spoofing.

In both attack scenarios (physical/manual and electronic) the tester shall be seeking to gain assurance that the opportunity for tamper and interrogation (deliberate or otherwise) is minimal and that protective measures have been implemented to ensure the reliability of the device and prevent the following:

* Interfacing the device to another device (or emulator)
* Interfacing the device to external modules or components
* Removing components, data and/or software
* Replacing components, data and/or software

The analysis will rely on an inspection of the device as well as an inspection of the documentation received from the manufacturer. The depth of analysis that can be undertaken will be dependent on the cooperation received from the I-VMS device manufacturer.

## **Expected results.**

It is expected that the device should be able to deliver the following.

* means provided to detect any unauthorised opening or other physical interference or ingress of the I-VMS device (PASS/FAIL)
* must consist of a sensor in the device that detects when it is opened and transmits a position report with the appropriate event status code when the communication link(s) are re-established. (PASS/FAIL)
* no external input to the positioning system, such that it must not be possible to change the positional fix by manual intervention (PASS/FAIL)
* software stored on the device cannot be amended/change/deleted without using authorised channels and protocols or without detection. (PASS/FAIL)

# **Annex A. Description of tests and TEST ID references required.**

|  |  |  |
| --- | --- | --- |
| **Element** | **Test ID** | **Description of tests required** |
| Accuracy | Test PERF-001: Positional Accuracy in Static Test running on Power Supply | To check that the device reports correctlyTo check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy when have power supply.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| Accuracy | Test PERF-002: Positional Accuracy in Static Test running on Battery | To check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy when running on battery.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| Accuracy | Test PERF-003: Positional Accuracy in Static Test with Power Fluctuations | To check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy and not affected by power fluctuations.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| Accuracy | Test PERF-004: Positional Accuracy in Static Test running on alternative Power solutions | To check that the device reports correctlyTo check (with live signals, in open sky, in static set-up) that the performance of the positions reported by the device are within the required accuracy when have alternative power supply.***The device must demonstrate that:******• 50% of all reports must be accurate to +/-5m******• 95% of all reports must be accurate to +/-10m*** |
| GNSS blackout | Test BLACKOUT-001: Physical Shielding of Antenna | To check what happens when physically shield the antenna to block signals - should get a warning of loss of GNSS, certainly should not get high errors without any sort of warning |
| GNSS blackout | Test BLACKOUT-002: Complete Loss of Signals | To check what happens when no signals are received by the receiver - should get a warning of loss of GNSS, certainly should not get high errors without any sort of warning |
| GNSS blackout | Test BLACKOUT-003: Position reports with marginal numbers of satellites. | Position reports with marginal numbers of satellites: We expect that if more than 4 GPS satellites are in view (or 5 or more GPS + Glonass) then a valid position report will be generated. Conversely, if less than 4 satellites are available, we expect the status to indicate ‘no GPS fix’. |
| Power Management | Test POWER-001: Resistance to Voltage Spikes and Drops | To check that the device still functions and provides position output when voltage spikes and drops |
| Tamper | TAMP-001 | Check on detection methods |
| Tamper | TAMP-002 | Check on ability to change positional fix by manual intervention |