

## Appendix B - TMM ISO21815 testing Methodology and acceptance criteria

Version 2.0 Updated 28/01/2022

The TMM OEM must provide a list of capabilities that it conforms to before testing (Appendix A). The testing procedure will evaluate whether the stipulated capabilities are performed according to the ISO/TS 21815-2 technical specification. The OEM will also supply one TMM platform in its entirety and should only require the stipulating connection method. The OEM will also prior to testing provide information on the default register settings as well as the values sent between in the data message. These values must be non-zero, non-zero values will not be accepted during the testing process and will be deemed as failure for the specific test. All values reported in Appendix A format prior to testing.

### Test Procedure

Upon receipt of the filled out specification sheet (Appendix A) the TMM will be connected to a CxD Emulator which will issue CxD messages and also test capabilities. The capabilities of the TMM will be tested using the following method for each capability. A full trace off all messages between CxD and Machine will be saved as well for later analysis.

- **Connector** – The test is to determine whether the correct connector is used and whether on first connection data between CxD and TMM is possible. The TMM must be capable of supplying at least 10A.
  - TMM will pass if correct connector is used with correct wiring and current draw of 10A is possible
- **Negotiation** - The most basic form of the ISOTS 21815-2 negotiation will be performed as any other form requiring the passing of keys and other info requires one on one development between the OEM and CxD and is therefore not generic. It will be assumed that if the minimum negotiation can be performed and due to more complex negotiation requiring direct development between TMM and CxD that testing the basic negotiation sequence is sufficient.
  - TMM will pass if negotiation sequence is completed successfully
  - This is a minimum requirement test
- **Renegotiation** – The test will test whether communication can be re-established after an initially successful connection and negotiation and then a subsequent failure in connection by physically severing the connection. The TMM must command a renegotiation to take place after the timeout has been reached using the RENEGOTIATE\_REPLY message
  - TMM will pass if a successful renegotiation is completed within 1s of restoring the connection
  - This is a minimum specification test
- **Capability enquiry** – The test will determine whether the TMM can successfully provide its capability to the CxD. This will be done by performing capability enquiry. This test will be done by using both the individual enquiry method for each capability on the CxD>>Machine Command messages and the MCAPS propulsion register. The OEM will have to sign a document (Appendix A) specifying which capabilities are on the TMM prior to testing.
  - TMM will pass either method if that method successfully provides the correct machine capabilities. Compliance to each method will be specified separately.

- This is a minimum specification test and one of the methods needs to pass to meet minimum specification not both.
- **Reading Protocol Registers** – This test evaluates whether the TMM can provide the correct register value upon a CxD read protocol registers command. The OEM must provide prior to testing a document (Appendix A) stipulating what values are inside the registers to validate whether the correct value is sent to the CxD
  - TMM will pass each type of register if the value read by the CxD is as stipulated by the specification sheet (Appendix A)
  - This test is not a minimum specification test
- **Reading Propulsion Registers** – This test evaluates whether the TMM can provide the correct register value upon a CxD read propulsion registers command. Not all registers will be tested, rather a single test of each type of register i.e. J1939, char4, int16 etc will be done. The OEM must provide prior to testing a document (Appendix A) stipulating what values are inside the registers to validate whether the correct value is sent to the CxD
  - TMM will pass each type of register if the value read by the CxD is as stipulated by the specification sheet (Appendix A)
  - This test is not a minimum specification test
- **Setting and reading Protocol Register** – The test evaluates whether the TMM is capable of setting values inside the protocol registers upon request from the CxD. The test will be evaluated for every different type of register which has writeable attribute, the standard registers however do not include all types which are writable. The test will be performed by setting a value and then reading the value from the same register. The TMM will only pass if the read protocol register test is successful as the reading of the register must be validated.
  - TMM will pass if the values read from the register after setting it corresponds to the set value and only if the Reading Propulsion Test was completed successfully.
  - This is not a minimum specification test
- **Reset of Registers** – The test evaluates whether the TMM system can correctly issue a reset registers command. A reset command will be sent after the registers have been set to non-default values. The reset register will be read and compared to the initial setting provided by the OEM in a signed document (Appendix A).
  - TMM will pass if the command is send correctly
  - This is not a minimum specification test
- **Propulsion Commands** – This test evaluates whether the TMM replies correctly to each of the direct action commands such as EMERGENCY\_STOP, SLOW\_DOWN etc. The TMM will be evaluated whether each of these messages are sent correctly.
  - The TMM will pass each of these commands if the command is sent correctly
  - This is a minimum specification test. The TMM must be capable of bringing the vehicle to a complete stop. Any combination of commands which can accomplish this will be deemed as meeting the minimum requirement.
- **Apply Propulsion Setpoints** – The test evaluates whether the TMM follows the proper procedure in receiving propulsion setpoint command. The CxD should first be able to set a setpoint, all possible ways should be tested and the CxD must meet one of these criteria. The report will specify which methods the TMM can use and which not. The precise value of the setpoint must be provided by the OEM in a signed document (Appendix A) prior to the test. The CxD must afterwards load propulsion setpoints. All possible methods will be tested (SELECT, MATCH\_TAG, APPLY\_FROM\_LIST, etc.) The TMM must be able to accept at least one of these methods to pass. The TMM will be tested if the setpoints are validated by

issuing a APPLY\_PROPULSION\_SETPOINTS\_CONFIRM command, this is not required by the standard but will be stipulated in the report if this is performed or not. The CxD will afterwards issue the command to apply, APPLY\_PROPULSION\_SETPOINTS, the propulsion setpoints if the correct procedure has not been performed then the TMM must reply with an error message

- TMM will pass if it follows the correct procedure and each aspect is completed successfully.
  - This will form part of the minimum specification if it is the only way the TMM uses to bring the machine to a complete stop
- **Machine Data** -This test evaluates whether the TMM correctly sends the machine data. The specific values which will be sent to the CxD must be provided in a signed document (Appendix A) prior to the test.
  - The TMM will pass if the values of received by the CxD Emulator corresponds to that send by the machine. All values will be tested whether they pass i.e. Gear position, direction of motion, speed, roll and pitch etc.
  - Certain measurements form part of the minimum specification. The TMM must be able to correctly send the following data to the CxD:
    - Direction of motion
    - Gear position
    - Payload status
    - All faults
  - If the following measurements are available on the machine, the TMM must be able to correctly send the data to the CxD:
    - Speed
    - Motion inhibit status
    - Override status
  - Other measurements that are included in the ISO standard but is not a minimum requirement are:
    - Rollback status
    - Traction status
    - Pitch
    - Roll
- **Incorrect Message Frequency** – The TMM will be tested to evaluate whether issuing the status and command messages at different frequencies affect the operation of the CxD. Since precise timing on CxD is an issue this test just validates the robustness of the CAN implementation. The timing frequency will be set from a slow connection of 250ms per message to 10ms for the status message, and from 250ms to 100ms for the command message.
  - TMM will pass if the frequency of messages does not affect the performance of the system
  - TMM will pass if response delay to CxD>>MachineStatus messages are below 100ms
  - This is a minimum specification test
- **Correct Message ID** -The TMM is evaluated on whether the message id from both the Machine>>CxD reply and data message IDs follow proper sequence. Any missing sequence IDs will be flagged. i.e. the message ID should increment and rollover while being unique. If the message ID is repeated or incorrect sequence is followed, then this is flagged.
  - TMM will pass if no error flags are set
  - Reserved SPN values must not be used (0xFA,0xFE,0xFF)

- This is a minimum specification test
- **Connection Stability** – The stability of the connection will be tested throughout testing and any connection issues such as delays in communication or dropping of connection will be noted
  - TMM will pass if connection is stable without significant drops, a single drop of connection will not result in failure, however if the connection is deemed to be too unstable the TMM will not pass.
  - TMM will pass if any connection dropouts are detected within 500ms and are infrequent during testing
  - This is a minimum specification test

### **Reasons for not Passing a Test**

The TMM will be deemed to fail a test if one of the following criteria is met

- Improper procedure is followed
- Loss of communication occurs during normal operations
- Incorrect values are read or set or sent
- Test is not completed i.e. the desired outcome is not achieved
- Minimum requirements not met

### **Supplied in testing report**

The report from the testing process will provide a detailed list of capabilities which the TMM successfully performs. The test report will indicate whether the TMM meets the minimum requirement also a list of aspects which are recommended but not a requirement. Next steps (such as continuing to next test, 1.2, or redoing test) will be made.