

Technical Guidance Notes and Technical Specification for F5J Altimeter/Motor Run Timers

Version 1.0

Amendments List

Initial Publication: Date

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INTRODUCTION

1.0 PRELIMINARY REMARKS

1.1 Purpose of this Document

The FAI CIAM rule making/amendment process is geared to maintain competition rule stability and as such presents some difficulties in areas subjected to rapidly changing technologies. To overcome this problem, the CIAM Bureau is investigating a way of resolving this problem with a system of “technical considerations” outside the rule making process that will enhance a class but not impinge on the class rules.

As part of that potential system, this document provides technical guidance on the specification, testing and application of Altimeter/Motor Run Timers (AMRTs) for use in F5J competitions. The information contained is relevant to AMRT manufacturers, competition organisers, competitors and persons involved in the evaluation of AMRTs.

1.2 Philosophy behind the AMRT Specification

International competitions attract large numbers of competitors, each of whom is entitled to three models. Consequently competition organisers could expect to be presented with a significant number of AMRTs from a number of different manufacturers for scrutineering and verification purposes.

It is against this background that the AMRT Specification has been formulated with the following objectives:

- a) To accurately determine the ‘Start Height’ as required for the competition.
- b) To minimise any ambiguity in reading the ‘Start Height’ from the AMRT.
- c) To provide a safe working environment for official timekeepers when reading the AMRT.
- d) To ensure that the AMRT can only function as required by the rules of the competition and cannot be operated, unintentionally or otherwise, in any other manner.
- e) To retain ‘Start Height’ information for subsequent resolution of any disputed reading.
- f) To provide a standard method of operation so that, irrespective of AMRT manufacture, verification testing can be performed easily with a defined test procedure.
- g) To define standard connectors for compatibility with test facilities and to reduce the risk of accidental damage during handling by competition officials.
- h) To provide a standard method of determining that the AMRT is of the type for which an approval has been granted.

MANUFACTURERS INFORMATION

2.0 AMRT TECHNICAL SPECIFICATION

This section is the formal specification for AMRTs intended for use in the F5J competition environment.

2.1 An electronic AMRT carried in an F5J model shall fulfil the following technical specifications:

- a) It must use the barometric pressure measurement technique.
- b) Altitude indication must be based on the International Standard Atmosphere, as defined in ICAO Document 7488/2.
- c) The method of converting pressure measurements to height information must be such that the specified accuracy is maintained across the full working range of the AMRT.
- d) It must record the maximum difference in pressure altitude ('Start Height') in accordance with the following definition:

‘Start Height’ is defined as the recorded maximum difference in pressure altitude, measured in metres, from initialisation until 10 seconds after the motor is stopped manually by the competitor or automatically by the Motor Run Timer, whichever occurs first.

- e) The Motor Run Timer must stop the motor 30 seconds after it is started at launch, if it has not

already been stopped by the competitor within this time limit.

- f) The AMRT must not allow any restart of the motor at any time during the flight.
- g) The AMRT must have compatibility with ESCs using the nominal 1 to 2 milliseconds control signal from the receiver such that no low speed motor drive occurs when "motor stop" is instituted either by the competitor or the AMRT.
- h) The supply of power to the AMRT shall be that available from the receiver output to the ESC at the receiver motor command connector. If the power source to the receiver is supplied via the ESC motor command connector, it is permissible for this to be supplied to the receiver via the AMRT.
- i) The connectors of the AMRT shall be of a universal type compatible with JR/Futaba and must be proof against any misalignment that could result in electrical damage to the AMRT or connected equipment. Where an extension lead is used to satisfy this requirement it must be secured to the AMRT in such a manner that it cannot be unintentionally removed.
- j) The AMRT shall be provided with a digital display. The display may be an integral part of the AMRT, or a separate module that is either carried within the model or is detachable.
A detachable AMRT display may be used to service any number of AMRTs of the same approved type.

2.2 Characteristics of the AMRT

- 2.2.1 The accuracy of the determined 'Start Height' shall be within the range plus or minus 2.5 metres. This accuracy must be achieved across an ambient ground level pressure range of 750 to 1050 hPa and across an ambient temperature range of 0 to +50 degrees centigrade.
- 2.2.2 The calculation of 'Start Height' shall incorporate any calibration parameters provided by the pressure sensor manufacturer.
- 2.2.3 The sampling rate of the pressure measurement used for 'Start Height' determination shall be a minimum of 10 samples per second.
- 2.2.4 Any firmware processing of pressure measurements (or height information derived from such measurements) used for 'Start Height' determination, must not result in a modification of the maximum height as would be detected by the single measurement sample representing the peak value.
- 2.2.5 The timing accuracy used for the Motor Stop function and 'Start Height' determination shall be equal to or better than 0.1 seconds.
- 2.2.6 There must be no configurable settings or adjustments that allow the user to modify the operation of the AMRT such that it will operate outside the requirements of the competition rules.
- 2.2.7 Any additional features incorporated into the AMRT by the manufacturer, must not cause any variation in the sampling rate or timing functions, nor affect the ability of the AMRT to satisfy the requirements of the competition rules.
- 2.2.8 The resolution of the display when showing the calculated 'Start Height', shall be 0.1 metre, this to be displayed with the format "xxx.x". Leading zero characters may be blanked. (When using the final calculated 'Start Height' for scoring purposes, the reading shall be rounded down to the nearest full metre.)
- 2.2.9 On completion of the period ending 10 seconds after "motor stop", the recorded 'Start Height' shall be continuously transferred to the display with a minimum repetition rate of once per two seconds. This function shall commence automatically when the recording of the 'Start Height' has been completed.
- 2.2.10 The display shall show the firmware revision level of the AMRT, in the format "Fx.x" with any leading zero characters blanked.
- 2.2.11 Display of the firmware revision level shall occur for the first 3 seconds following the application of power to the AMRT. On completion of the 3 seconds period, the display shall continue to show any previously recorded 'Start Height', or cleared status indication, until such time as a Motor Start signal is detected. This sequence shall occur irrespective of whether an input command signal is being applied to the AMRT.
- 2.2.12 If the display is not an integral part of the AMRT, the method of transferring the information to the display shall be immune to any form of corruption or modification from external sources.

2.3 Recording the ‘Start Height’

The AMRT shall record the ‘Start Height’ in accordance with the following procedure:

- (a) Immediately on application of power to the AMRT it must determine a zero height reference level from which any subsequent ‘Start Height’ will be determined. Any previously recorded ‘Start Height’ must NOT be erased at this point.
- (b) This function shall be carried out with the model at ground level at the location specified within the competition rules.
- (c) A maximum of 5 seconds is permitted for the zero height reference level to be determined, during which period the AMRT shall not respond to any Motor Start signal instituted by the competitor or resulting from receiver start up procedures.

Note: A Motor Start command is defined as any control signal exceeding 1.2 milliseconds.
- (d) After power has been applied to the AMRT, the ‘Start Height’ determination and the start of the Motor Run Timer will be initiated by the Motor Start signal instituted by the competitor. Such initialisation must clear any previously recorded ‘Start Height’.
- (e) The cleared status of any previously recorded value shall be indicated on the display as a sequence of dashes (- - - . -). This shall be carried out in such a manner that if a detachable display were to be connected it would show the cleared status.
- (f) When the Motor Start signal has been instituted by the competitor, the AMRT will determine, and record, a new ‘Start Height’ replacing the previously cleared status.
- (g) When power is removed from the AMRT, the ‘Start Height’ or cleared status indication must be retained by the AMRT. The application of power to the AMRT must never erase either the recorded ‘Start Height’ or the cleared status indication. Only the Motor Start signal instituted by the competitor may do this.

3.0 TECHNICAL CONSIDERATIONS

This section is provided as design guidance on AMRTs intended for use in the F5J competition environment.

3.1 Restriction on User Configuration Options

Whilst for commercial considerations manufacturers may wish to produce AMRTs adaptable for differing applications, when used in the F5J competitive environment, the installed firmware shall have dedicated F5J functionality with no user configurable options. The purpose of this is to eliminate any possibility of errors in operation due to incorrect configuration settings.

3.2 ISA Calculation

Pressure at a given location is caused by the weight of the atmosphere above. This varies with air density, humidity, gravity and temperature. In addition, temperature itself reduces as height increases. Consequently height is not directly related to pressure and some form of standardised definition is required to enable instrumentation based on barometric pressure to be used to determine height.

The International Standard Atmosphere (ISA) assumes a mean sea level pressure of 1013.25 hPa at a temperature of 15 degrees C, a specified temperature lapse rate with height, a specified gravitational force and a given molecular density of air.

Conditions on any day are unlikely to correspond exactly with the ISA model; a typical spread of 50hPa can occur at a given location due to normal meteorological conditions. Consequently significant variations will occur from true geographic height. However for aviation applications, including F5J, all instruments calibrated and operating in accordance with the ISA standard, will produce the same result.

3.2.1 In the lower atmosphere (up to 12kM), the ISA relationship for a pressure P, can be described by the following formula:

$$\text{Altitude} = K1 \times \{1 - (P/Po)^{K2}\} \text{ metres}$$

$$\text{where } K1 = 44330.76923 \text{ metres}$$

$$K2 = 0.190266669$$

$$Po = 1013.25 \text{ hPa (ISA sea level pressure)}$$

K2 is derived from the universal gas constant, temperature lapse rate, gravitational force,

molecular mass of dry air and temperature with respect to absolute zero.

This formula results in a relationship between pressure and height that is represented by a curve that is steeper at high pressure/low altitude and less steep at low pressure/high altitude.

Over the range of site elevations that might be encountered for F5J competitions, the nature of the ISA relationship is significantly non-linear. There is approximately 14% difference in the pressure reduction of a 200 metre launch commencing at sea level compared with one starting at 1500 metres.

- 3.2.2 The calculation of F5J “Start Height” requires a precise measurement of the difference between two ISA pressure altitudes. The first is the zero reference value at ground level for the local site elevation. The second is the maximum altitude that occurs during the launch phase of the aircraft.
- 3.2.3 In order to achieve sufficient accuracy for F5J, the method of firmware processing of pressure data is important. Whilst ideally the ISA computation should be performed by an arithmetic calculation with maximum precision, processing constraints may make this impractical. It is permitted to use an algorithm approach to emulate the computation provided it can be demonstrated that an appropriate accuracy is maintained and no discontinuities are introduced in the ISA curve.
- 3.2.4 In order to maintain overall AMRT accuracy within the specified tolerance, the accuracy of the firmware ISA computation should be within the range plus or minus 0.5 metres.
- 3.2.5 AMRT manufacturers may wish to adopt pressure sensor modules that have an inbuilt pressure-to-height conversion. In such a case, it must be demonstrated that the computation complies with the accuracy requirements over the specified working range of the F5J application.

Note: In this context, results from calculations using the formula of the 1976 US Standard Atmosphere, agree closely with those of the ISA formula in the lower atmosphere and are considered acceptable over the F5J working range.
- 3.2.6 Pressure sensor offset errors will influence the ‘Start Height’ calculation. However, since ‘Start Height’ is the difference between two readings, much of any offset error is removed from the result.

3.3 ‘Start Height’ Determination

- 3.3.1 ‘Start Height’ determination requires the AMRT to perform a peak (height) detection function for the time duration commencing at switch-on initialisation, until 10 seconds after the motor has been stopped.
- 3.3.2 The F5J competition application requires the ‘Start Height’ to be determined with the best possible accuracy and all manufacturers’ AMRTs should exhibit similar characteristics.
- 3.3.3 Initialisation following power-up, and the acquisition of the ground level (zero height reference) reading should be accomplished with due allowance for any time required for the pressure sensor device to stabilise.
- 3.3.4 During the launch phase, the dynamics of the flight envelope are subject to rapid change and the transition through the peak can occur within a short time period. Item 2.2.3 defines the minimum acceptable sampling rate for detecting the peak. It is not permissible for additional filtering or smoothing to be incorporated in the firmware as this can result in a downgrading of the ability to accurately detect the peak value.
- 3.3.5 Oversampling functions incorporated within
- 3.3.6 Pressure sensor devices: the pressure sensor device may be used subject to being configured in a manner that maintains the integrity of readings taken at the specified sampling rate.
 - (a) Are subject to variation due to temperature. Many sensor manufacturers specify the inclusion of temperature data in the processing of the pressure data. Manufacturers’ recommended firmware procedures must be incorporated into the AMRT firmware.
 - (b) Can be affected by strong light falling on the sensitive area, therefore they must be mounted within the AMRT in such a manner that the sensitive area is shielded from strong light levels.
- 3.3.8 The accuracy tolerance stated in item 2.2.1 is the maximum permitted when all possible variations are at worst case conditions. No individual factor should contribute a significant proportion of the total permitted variation.

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3.4 Motor Run Timer

- 3.4.1 The Motor Run Timer function must operate with the accuracy specified in item 2.2.5.
- 3.4.2 On initial power-up of the AMRT, the Motor Run Timer must be protected from false triggering during the period defined in Item 2.3 (c). After this period, the Motor Run Timer shall commence operation and 'Start Height' determination shall be initiated on the first occasion that the command signal exceeds 1.2 milliseconds.
- 3.4.3 After the Motor Run Timer has been triggered, the timing of the motor run ceases when either the command signal reduces below 1.2 milliseconds, or the elapsed time reaches 30 seconds and a definite stop command must be applied to the ESC by the AMRT.
- 3.4.4 The 'Start Height' determination process shall continue for a further 10 seconds after the instant of "motor stop".
- 3.4.5 Once the definite stop command has been applied to the ESC, the system must not respond to any further changes in the motor command signal.
- 3.4.6 A small amount of hysteresis is permitted in the sensing of the 1.2 milliseconds motor command signal to eliminate malfunction with jittering command signals.
- 3.4.7 Monitoring of the timing functions is achieved with the aid of the displayed information as detailed in Items 2.3 (a) – (f).

3.5 Retention of 'Start Height' Reading

- 3.5.1 In the normal competition environment the 'Start Height' reading is obtained immediately following the landing of the aircraft, without power removal from the system.
- 3.5.2 There is a requirement for the AMRT to retain the 'Start Height' reading when power is removed. The primary reason for this is for purposes of reading dispute resolution and possible AMRT investigation away from the aircraft installation.
- 3.5.3 Erasure of the stored 'Start Height' reading shall only occur in accordance with the sequence detailed in Items 2.3 (a) – (f).

3.6 Display Considerations

- 3.6.1 The display readout should employ characters that are easily legible in normal outdoor ambient light levels. It is not acceptable to require adjustment of contrast levels to suit ambient conditions.
- 3.6.2 Character height should be such that no optical aids other than normal spectacles are required in order to observe the readings.
- 3.6.3 The formation of the numeric font must be unambiguous. With some font formats it may be necessary for manufacturers to substitute a capital letter "O" character to replace a slashed through zero numeral in order to avoid confusion with the numeral 8.

3.7 ESC Compatibility

There is no defined standard for the manner in which ESCs (electronic speed controllers) initialise to the range of motor command signals. In addition, programmable transmitters allow the user to set the motor command signals to any value within the programmable range.

- 3.7.1 Commercial pressures will encourage AMRT manufacturers to configure their products to operate with the majority of available ESC devices.
- 3.7.2 The F5J specification of motor on threshold at 1.2 milliseconds has been selected as being compatible with most known equipment but cannot be a guarantee of correct operation for every combination of transmitter, receiver and ESC.

3.8 Connector Compatibility

- 3.8.1 AMRTs exist that do not fully satisfy the shrouded connector requirement. Whilst a bare pin arrangement may be acceptable for many other applications, the F5J competition environment requires event officials to handle competitors' equipment for verification purposes. There is, therefore, the potential to cause accidental damage. For this reason, the use of shrouded connectors has been specified. It is permissible to supply an extension cable to meet the shrouded connector requirement provided that it is mechanically restrained at the connection to the AMRT in such a manner that it cannot be unintentionally removed.

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- 3.8.2 Where the readout display is detachable, the AMRT manufacturer must ensure that where a non polarised connector is used, incorrect insertion cannot cause damage to the AMRT or display.

COMPETITION INFORMATION

4.0 Installation Environment

- 4.1.1 The installation and functioning of the AMRT, the transmitter and its programming, receiver and ESC, is the sole responsibility of the competitor, who must ensure that they operate together in the correct manner as required for the rules of the competition.
- 4.1.2 The AMRT must be installed in such a way that it is protected from pressure fluctuations other than changes in atmospheric pressure which result from the height of the model above ground level.
- 4.1.3 The AMRT must be placed inside the model in the state as supplied by the manufacturer. The use of any method that modifies the true barometric pressure at any time is prohibited.
- 4.1.4 Adequate venting shall be provided to minimise any uneven pressure distribution within the model in the region where the AMRT is installed.
- 4.1.5 The ESC must always operate via its series connection to the AMRT and not with a direct connection to the receiver.
- 4.1.6 Where the readout display is an integral part of the AMRT the AMRT shall be installed in such a manner that it is readily accessible for viewing the readings.
- 4.1.7 Where the readout display is not an integral part of the AMRT, the connection facility for the display unit shall be readily accessible for the purpose of connecting the display unit to view the readings.
- 4.1.8 The competitor's AMRT shall be installed in such a manner that it can be easily removed from the model for verification purposes at any stage during the period of the contest.
- 4.1.9 The connectors linking the AMRT to the receiver shall be readily accessible so that a monitoring AMRT with appropriate interconnection can be fitted on demand by the Contest Director. Such monitoring AMRTs will serve to verify 'Start Height' whilst maintaining the normal operation of the competitor's own installation.
- 4.1.10 If a competitor incorporates an additional lead extension for use with a detachable display, it is the competitor's responsibility to ensure compliance with section 3.8.2.

5.0 VERIFICATION OF AMRTs

This section details procedures for verifying the operation of Approved AMRTs for use in the F5J competition environment. It is provided as a guide for both competitors and competition organisers.

5.1 Purpose of Verification

All AMRTs used in an F5J competition are required to be of an Approved Type. The verification process serves to ensure that no individual AMRT operates in a manner different from others in use at the competition. As such, comparison methods are employed for 'Start Height' verification, in place of a requirement to undertake absolute accuracy measurements.

5.2 Verification Procedures

5.2.1 Firmware Revision Level

An AMRT with connected display, will show the firmware revision level for three seconds immediately after the application of power.

5.2.2 Operational Sequence

For this procedure, the AMRT has to be supplied with power, a command signal input and a means of monitoring the "motor run"/"stop" signal that is supplied to the ESC. A display module must be connected.

Whilst this procedure is applicable to a complete aircraft installation, for reasons of safety and when verifying an AMRT, it should be removed from the aircraft and tested independently.
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The procedure is as follows:

- (a) With the command signal at Motor Off, apply power to the AMRT. After the initial display of the firmware revision level, the display will show either a previously recorded 'Start Height' or a sequence of dashes. The ESC signal will be in the "motor stop" state.
- (b) If a sequence of dashes is shown the first time power is applied, it will be necessary to perform steps (c) and (d) to establish a 'Start Height'
- (c) Apply a Motor On command and raise the AMRT to a low height. After a short time period, apply a Motor Off command. The display will show a sequence of dashes from the time of the Motor On command to 10 seconds after the Motor Off command. During this sequence the ESC signal follows the command signal.
- (d) After the 10 seconds has elapsed, the display will show a low value height reading.
Note: The value displayed may be influenced by local air movement.
- (e) Remove power. Wait for approximately 30 seconds and then, with the Motor Off Command, selected, re-apply power. After the display of the firmware revision level, the same low level height reading as recorded in (d) will be displayed.
- (f) Apply and maintain a Motor On command. Immediately the display will show a sequence of dashes and the ESC signal becomes "motor run".
- (g) 30 seconds after the Motor On command, the ESC signal will change to "motor stop". Immediately raise the AMRT to a low height for approximately two seconds to simulate a peak height.
- (h) 10 seconds after the ESC signal became "motor stop", the display will show a low height value.
- (i) Apply a Motor Off command.
- (j) Whilst maintaining power, apply a further Motor On command. The ESC signal will remain in the "motor stop" condition and the AMRT will remain in the same state.
- (k) Repeat steps (e) to (h), but instead of waiting for 30 seconds at step (g), apply a Motor Off command after about 10 seconds which will cause the ESC signal to become "motor stop". The result of the "motor stop" should be as (h) and (j).

5.2.3 'Start Height' Detection

Verification of the measured 'Start Height' value requires the use of a 'vacuum' chamber. Such a chamber comprises an airtight container from which air can be extracted to create a pressure reduction. Air equivalent to approximately 3% of the chamber capacity has to be extracted in 15 to 20 seconds in order to simulate a typical model climb. On completion of the climb simulation, a slight increase in pressure is required in order to emulate the transition to gliding flight.

For verification purposes it is only necessary to perform tests starting at local ambient pressure. Slight air leakage of the chamber is acceptable and aids the gliding flight simulation.

Within the chamber, facilities are required to provide power and simultaneous command signals to a number of AMRTs.

A known, good AMRT (preferably with a certificated calibration) is used as the reference standard against which other AMRTs are compared.

The procedure is as follows.

- (a) Place the device(s) to be tested in the chamber together with the reference device.
- (b) Readout display(s) may be attached either before or after the pressure change has been applied.
- (c) Close the chamber and allow a short period for the pressure to stabilise. (Some variation may occur due to temperature differences introduced by handling).
- (d) With the Motor Command set to "motor off", apply power to the AMRTs. This causes the zero height reference to be detected by the AMRT(s).
- (e) Apply a Motor Run command.
- (f) Reduce the chamber pressure at an appropriate rate to simulate a climb to approximately 150 metres.

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- (g) Apply a Motor Stop command and immediately allow the pressure to begin increasing to simulate a descent of gliding flight.
- (h) Wait for a minimum of 10 seconds.
- (i) Observe 'Start Height' readings for all AMRTs.
- (j) Analyse the results by comparison with the known, good AMRT.

Any AMRT that deviates by more than plus or minus 1.25 metre from the monitoring AMRT should be subject to further investigation.

Note: The overall tolerance for absolute accuracy specified in Section 2 is the worst case figure when all possible discrepancies are taken into consideration.

(The 1.25 metre figure may be subject to revision when more experience has been gained in the competition environment).

Repeat the procedure simulating other climb heights as considered necessary.

6.0 GUIDANCE FOR COMPETITION ORGANISERS ON THE USE OF MONITORING AMRTS

Competition rules allow competition organisers to carry out random checks on competitors' equipment at any time during a competition. One aspect of this could be the use of a monitoring AMRT to be fitted in a competitor's aircraft for a competition flight. Item 4.1.9 defines that the appropriate connectors in an aircraft must be accessible.

6.1 Use of Monitoring AMRT in Competitors' Aircraft

6.1.1 A monitoring AMRT may be fitted at the command signal input of an AMRT by means of a Y connection lead. This permits the monitoring AMRT to respond to the motor command signals and take its own 'Start Height' measurement of a flight.

The rating and quality of the Y lead must be such that it does not degrade the performance of the competitor's own installation.

6.1.2 The 'Start Height', as determined by the monitoring AMRT should be in close agreement with the reading taken by the competitor's own AMRT.

Allowing for variations in pressure distribution within the aircraft, agreement within plus or minus 2.0 metre is considered acceptable.

Note: The 2.0 metre figure may be subject to revision when more experience has been gained in the competition environment.

7.0 APPROVAL PROCEDURES

7.1 Check list of features to be verified when evaluating compliance

- (a) Display of firmware revision level
- (b) Operational sequence (as in 5.2.2)
- (c) Retention of Start Height reading when power removed
- (d) Accuracy of Motor On pulse sensing
- (e) Accuracy of timing of motor run
- (f) Accuracy of 10 second period after motor cut
- (g) Accuracy of ISA calculation across full ambient pressure range
- (h) Accuracy of Start Height determination across range of Start Heights
- (i) Dynamic response of Start Height determination
- (j) Affect of temperature variations on Start Height accuracy
- (k) Prevention of motor restart
- (l) Clarity and legibility of readout
- (m) Verification that any additional features not required by the specification (e.g. buttons on the display, flight logging) do not affect the essential operation of the device

7.2 Submission of AMRTs for Approval

The CIAM is establishing a committee to assume responsibility for the approval process. The services of a technical expert may be used to undertake the practical testing on behalf of the committee.

Further details will be advised in due course, together with the specific requirements concerning the presentation of devices for approval.

Devices submitted for approval must be to normal production standard and must incorporate firmware at the revision level that is to be evaluated.

Supporting documentation shall include the sensor manufacturer's data sheet on the pressure sensor device with particular reference to long term drift and temperature variation characteristics.

Additional supporting information may be required at the request of the technical expert undertaking the evaluation on behalf of the CIAM committee.

Approval, when granted, will relate to a specific hardware/firmware combination. Any subsequent modification to hardware or firmware must be notified to the CIAM committee and advice will be provided concerning any requirements for upgrading the previously granted approval.

7.3 Withdrawal of Approved Status

- 7.3.1 An approved AMRT may have its Approved Status withdrawn if inconsistencies of performance are found in further examples of the AMRT.
- 7.3.2 If, subsequent to the granting of an approval status, the rules of the competition are amended in a manner that affects the technical specification of the AMRT, the validity of all AMRTs on the Approved List will be subject to review.

APPENDIX A

List of Approved AMRTs/Firmware

Manufacturer	
AMRT Type	Firmware Revision Level
Display Readout	Firmware Revision Level (where applicable)
Approval Date	

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