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Pedestrian Test Mannequin Radar Cross-section Repeatability Evaluation

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This report documents identifying the repeatability of measuring the radar cross-section (RCS) of two pedestrian test mannequins (PTM), test surrogates designed to emulate an adult and a child pedestrian. The test methodology uses two measurement procedures from the International Organization for Standardization for surrogate devices that aided in calibration offset calculations and results. The resulting RCS measurements of adult and child PTMs are shown in both graphics and tables. Measurements demonstrate moderate variability of RCS profiles between measurement sessions. While present to some extent in measurements from both sensors and in all orientations, this variability is especially prominent in orientations where the stationary adult PTM longitudinally faces towards or faces away from the sensor. Less variability is observed in measurements where the adult PTM is facing perpendicular to the path of the sensor. Variability is observed throughout each child PTM orientation. The calculated calibration offsets remained consistent throughout the measurement series. Little calibration offset variation was seen between measurement sessions. While calculated calibration offsets were not a primary area of study in this series, the consistency across these values and, by extrapolation, calibration measurements of the trihedral corner reflector calibration subjects shows that the radar measurement system itself is consistent. It can be inferred that variability seen in the RCS of the PTMs is a result of the subjects themselves and not of the measurement process</td></tr>
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Abbreviations and Acronyms

AEB	automatic emergency braking
ADAS	advanced driver assistance systems
DRI	Dynamic Research, Inc.
ISO	International Organization for Standardization
PAEB	pedestrian automatic emergency braking
PTD	pedestrian test device
PTM	pedestrian test mannequin
RCS	radar cross-section

Executive Summary

This report identifies the repeatability of using advanced driver assistance system (ADAS) sensors to measure the radar cross-sections (RCS) of pedestrian test devices (PTD), included in a pedestrian test mannequin (PTM) mounted on a carrier system.

The work details the use of test equipment, including a mobile robotic cart, two radar sensors, two calibration objects, and the adult and child PTMs. There are illustrations of measurement locations and tabulations of environmental conditions.

The test methodology describes two measurement procedures that combine aspects of the International Organization for Standardization (ISO) 19206 series of documents on ADAS surrogate devices.

The resulting RCS measurements of adult and child PTMs demonstrate moderate variability of RCS profiles between measurement sessions. While present to some extent in measurements from both sensors, and in all orientations, this variability is especially prominent in orientations where the stationary adult PTM longitudinally faces towards or faces away from the sensor. Less variability is observed in measurements where the adult PTM is oriented perpendicular to the path of the sensor. Variability is observed throughout each child PTM orientation.

The calculated calibration offsets remained consistent throughout the measurement series. Little calibration offset variation is seen between measurement sessions. While calculated calibration offsets were not a primary area of study, the consistency across these values shows that the radar measurement system itself is consistent. Therefore, it can be inferred that variability seen in the RCS of the PTMs is a result of the subjects themselves and not of the measurement process.

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Introduction

Evaluating the performance of ADAS such as pedestrian automatic emergency braking often requires the use of a pedestrian surrogate to elicit a response from the vehicle under test. The pedestrian surrogate must appear like a real pedestrian to all sensors used by ADAS to ensure that the vehicle's response in a test is representative of its response to similar real-world interactions with pedestrians.

The work in this report identifies the repeatability of using ADAS sensors to measure the RCS of PTDs. A PTD has a PTM mounted on a carrier system. Radar measurements of adult and child PTMs were performed over several days and with several sensors to gain an accurate viewpoint of the appearance of the surrogates to automotive radar systems and to assess variability both in the measurement of PTM RCS and the variability present in the radar measurement system itself.

NHTSA identified the ISO 19206 series of documents to classify and verify strikable ADAS surrogates for use in AEB and PAEB testing (Zeits, 2025). Aspects of two documents were implemented in this series.

- ISO 19206-2:2018 (ISO, 2018) outlines requirements for pedestrian surrogates
- ISO 19206-3:2021 (ISO, 2021) outlines requirements for 3D passenger vehicle surrogates

This report details the test equipment and environment used, outlines the measurement and analysis procedures, and presents the results of the measurement series.

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Test Equipment

This section describes equipment used to perform the measurements in this research. All measurement sensors were mounted to a robotic cart with an attached inertial measurement unit for local positioning and tracking. This equipment also includes calibration objects used to correct the radar sensors' perceived RCS returns.

Radar Measurement Equipment

A robotic cart from Dynamic Research, Inc. (n.d.), called the ScanR, performed, processed, and displayed the radar measurements. The ScanR primarily had two automotive-grade radar sensors mounted to a height-adjustable bracket, an inertial measurement unit, and a self-propelled robotic cart that could be programmed to accurately approach the object being measured. Also included was a tablet with software used to calculate RCS values from the raw radar measurements, calculate and apply radar calibration factors, and to compare RCS magnitudes against a library of reference targets. Table 1 provides an overview of the radar sensors installed on the ScanR.

Table 1. Radar sensor technical specifications

Manufacturer	**Description**	**Model**	**Frequency (GHz)**	**Distance Range (m)**	**Horizontal Field of View (degrees)**	**Typical Measurement Rate (ms)**
Continental (2020)	Long-Range Radar Sensor	ARS 408-21	76-77	0.20 to 250	Near: ±60 Far: ±9	≈72 ms
Bosch (2020)	General Purpose Radar v1.0	MRRe14H BW	76-77	Up to 160	Near: ±42.6 Far: ±21.0	≈100 ms

To facilitate an accurate approach toward the object being measured, the ScanR uses an OxTS[1] RT3000 inertial navigation system with an inertial measurement unit and real-time kinematic GPS. Figure 1 shows the ScanR measurement cart along with the Continental and Bosch radar sensors.

[1] Oxford Technical Solutions, Bicester, United Kingdom; RT3000 series, specific model not stated.

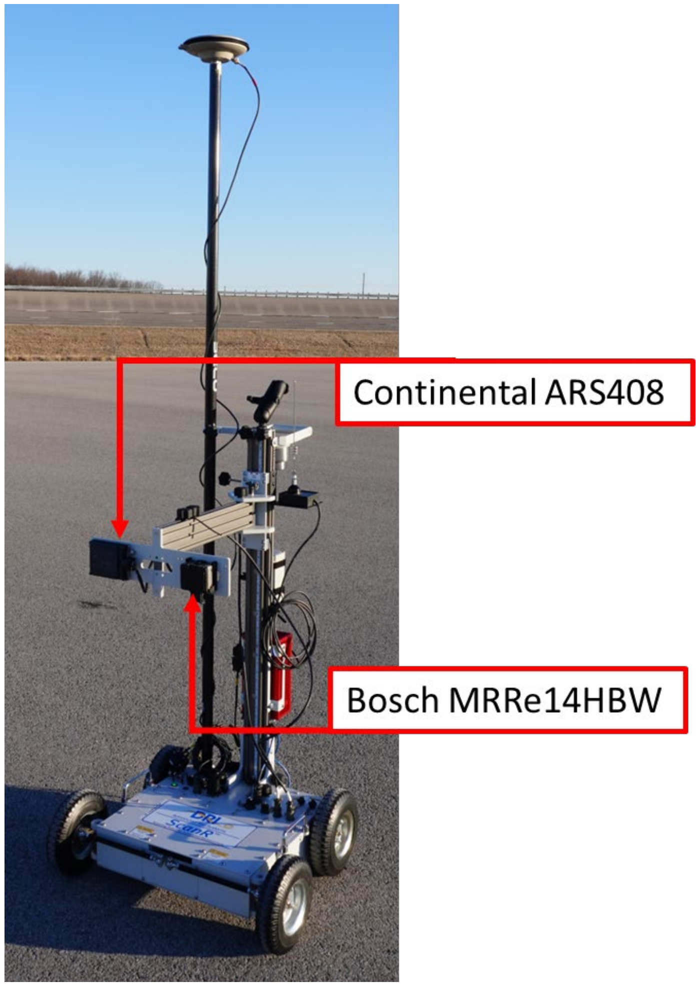


Figure 1. DRI ScanR measurement cart with radar sensors labelled

Trihedral Specifications (Calibration Targets)

Per ISO 19206-3:2021 recommendations, each radar sensor was calibrated by performing reference measurements using two objects of different sizes with known RCS characteristics. Two trihedral corner reflectors were used for calibration. Each was within one of two ranges specified in ISO 19206-3:2021: -20 dB-m^2 to 0 dB-m^2 for the smaller trihedral and 5 dB-m^2 to 20 dB-m^2 for the larger trihedral. Table 2 details the trihedrals used.

Table 2. Trihedral information

Manufacturer	Model	RCS at 77 GHz (dB-m^2)	Allowable Range* (dB-m^2)
Eravant (2024a)	SAJ-043-S1	10	5 to 20
Eravant (2024b)	SAJ-020-S1-1.97	-3.6	-20 to 0

*As defined in ISO 19206-3:2021 (ISO, 2021)

Each trihedral was mounted to a tripod and positioned with the outer face of the concave side vertically level and facing the radar sensors. The tripod was occluded using radar absorbent material (Mast MF11 reticulated foam with a nominal thickness of 12.7 mm) (MAST, n.d.). attached to an aluminum sheet and positioned as shown in Figure 2.

Figure 2. Example of trihedral corner reflector affixed to tripod masked with reticulate foam

Pedestrian Test Mannequins

A PTM was mounted on a carrier system. All radar measurements in this study were performed on stationary PTDs. One 4activePA-adult (v4v4) and one 4activePA-child (v3v3) PTM were evaluated in this measurement series (4activeSystems, n.d.). These mannequins are designed to meet the requirements of ISO 19206-2:2018 by replicating real pedestrians in both appearance and sensor response. Results comparing PTDs to real pedestrians are shown and referenced in ISO 19206-2:2018.

All mannequins began this measurement series in new condition. The adult mannequins, whose arms can be posed through rotation at the shoulder joint, were posed with the arms straight down at the sides for all measurements in this series. The arms of the child mannequin are fixed in position. Adult and child mannequins are capable of powered leg articulation at the hip joint; however, articulation was not activated at any point in this series as the PTD remained stationary throughout all measurements. Therefore, measurements were conducted with the legs straight down in a stationary standing position. Adjustable shrouds that line the bottom of the mannequins' feet to create the appearance of contact with the ground surface were placed to face the radar sensors. Removable battery packs for leg articulation power storage, typically installed inside the internal structure of the mannequins' lower backs, were installed but not connected to the articulation motors through the duration of this test series. The adult mannequin had stability tethers extending from the neck to magnetic couplings underneath the mannequin. These tethers were connected for all measurements in this series.

Each PTMs was mounted on a robotic carrier platform, the LaunchPad produced by Anthony Best Dynamics.[2] Unlike the mannequins, the robotic carrier platform had been previously used in testing and therefore did not begin the series in new condition. The platform was configured and positioned to correspond to the pedestrian mannequin orientation.

[2] Anthony Best Dynamics Limited, Bradford on Avon, England.

Figure 3 provides examples of adult and child PTDs as configured for measurements in this test series.

Figure 3. Adult (left) and child (right) PTDs

Test Environment

The following section covers where the measurements took place and the environmental conditions.

Test Facility

ISO 19206-3:2021 specifies the area around the radar sensor and measurement subject must be free of obstructions, buildings, or metallic objects that could lead to multipath propagation. Figure 4 shows the recommended area required for measurements, relative to the center of the test subject. To accommodate these requirements, all measurements were performed at the Transportation Research Center's SMARTCenter Urban East Roundabout.

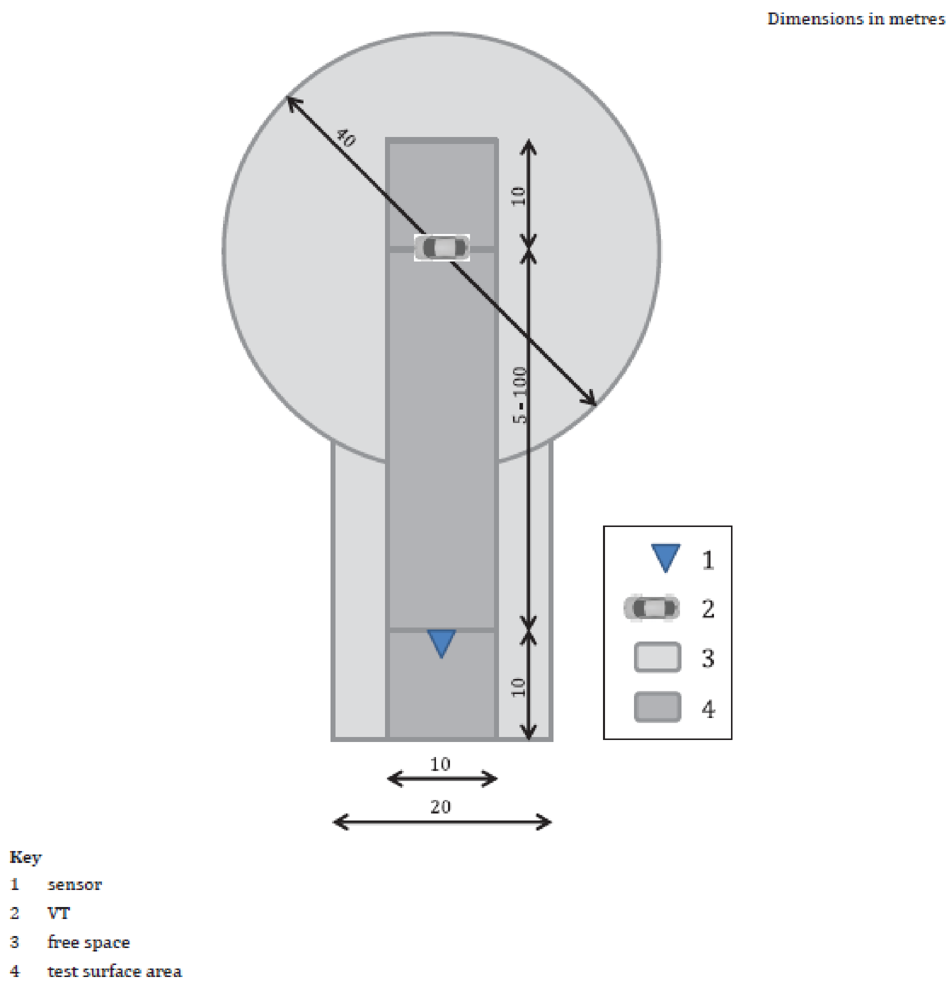


Figure 4. Test environment specified in ISO 19206-3:2021

Environmental Conditions

Radar measurements can be affected by environmental conditions; therefore ISO 19206-3:2021 states one environmental condition for test conduct, an ambient temperature from -5 °C to 40 °C. Rain can also cause radar signal degradation, so there was no active rain during all tests. Table 3 shows the environmental conditions that occurred during the testing timeline.

Table 3. Environmental conditions during testing

Environmental Condition	Criteria
Precipitation	None
Surface Wetness	Dry to damp (no standing water on test surface)
Ambient Temperature	0° C to 38° C
Wind	Up to 20 mph gusts

Test Methodology for Performing and Analyzing Measurements

This section discusses the performance, analysis, methodology, and calibration of PTD radar measurements.

Measurement Procedure

Adult and child PTD radar measurements were performed using two measurement procedures.

- The single-height measurement procedure drew many physical configuration parameters from ISO 19206-2:2018 but used many of the processing procedures outlined in ISO 19206-3:2021, such as the RCS compilation process and calibration offset calculations. ISO 19206-2:2018 does not include analysis procedures.
- The multi-height measurement procedure attempted to retrofit the procedure in ISO 19206-3:2021 for applicability in performing radar measurements of PTDs. Parameters taken from ISO 19206-3:2021 in this procedure include sensor heights, the number of approaches at each sensor height, and calibration target height. Parameters relevant to PTD analysis, such as measurement range, were taken from ISO 19206-2:2018. Like the single-height measurement procedure, processing procedures were taken from ISO 19206-3:2021.

Initially, only the single-height measurement procedure was planned. However, NHTSA later performed the multi-height measurements as well. Measurements were performed using the multi-height measurement procedure with the belief that incorporating measurements at several sensor heights could better mitigate potential effects caused by multipath propagation, a phenomenon where the radar signal returns to the sensor via several paths. This can be caused by reflections, refractions, or diffractions from objects or atmospheric conditions. A factor leading to this belief is that ISO 19206-3:2021 specifies several sensor heights and was published after 19206-2:2018, which only specifies a single sensor height.

As the multi-height procedure methods are considered more up to date and in line with other, more recently written procedures from the ISO 19206 series of documents, results from the multi-height procedure are only presented in this report. Appendix C lists the results from the single-height procedure.

Ten measurement sessions were planned for this series, with two measurement sessions performed per day. However, in some cases weather and time restrictions prevented this. The appendices detail the performance dates of each measurement session and tabulation.

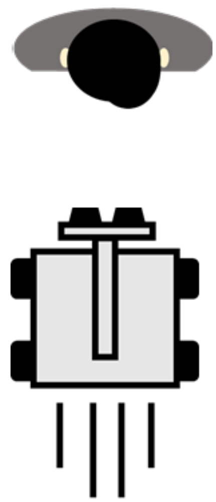
The ScanR and radar sensors were power-cycled between every measurement session in this series. The calibration targets, mounting hardware, and PTDs were disassembled and reassembled between every measurement session.

PTM Orientations

Radar measurements of both the adult and child PTMs were taken with the PTM in four rotational orientations relative to the ScanR, spaced 90° apart.

Table 4 illustrates the four PTM orientations analyzed in this series. The appendices show pictures of each PTM in each orientation from the sensors' point of view.

Table 4. PTM measurement orientations

Measurement Orientation:	0°	90°	180°	270°
Overhead Diagram:				

Measurement Approach Path

Figure 5 illustrates the approach path followed by the ScanR for both PTM radar measurements and calibration measurements. The ScanR travelled in a straight line over visually flat ground. Radar data was collected while the ScanR travelled forward from a range of 40 m to 4 m from the subject, with some run up and lead out at the beginning and end to mitigate the impact of potentially anomalous movement while the ScanR was starting and stopping.

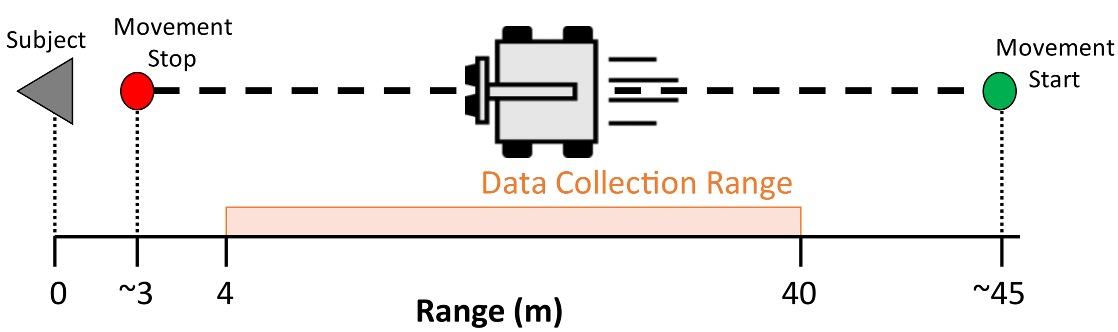


Figure 5. Measurement approach movement diagram

PTM Radar Measurements

Table 5 lists the parameters followed in the multi-height measurement procedure and its sources. Generally, the multi-height measurement procedure attempted to follow the procedure outlined in ISO 19206-3:2021 while retaining PTM-specific parameters from ISO 19206-2:2018.

Table 5. RCS multi-height measurement procedure

Parameter	Value	Source
Sensor Height From Ground (m)	0.23, 0.48, 0.90	ISO 19206-3:2021
Approaches per Sensor Height	1	ISO 19206-3:2021
Measurement Range (m)	4 to 40	ISO 19206-2:2018
ScanR Movement Speed (km/h)	3.9	ISO 19206-3:2021

Calibration Measurements

Each measurement session included radar measurements of two trihedral corner reflectors. The RCS returns of the trihedral corner reflectors were then used to calculate calibration offset values applied to all RCS measurements of PTMs collected in that session (see the Calibration Offset Calculations section). Table 6 outlines radar calibration measurement parameters used in this measurement series and their sources. Based on the calibration target RCS ranges listed in Table 6, -3.63 dB-m^2 and 10 dB-m^2 trihedral corner reflectors were used.

Table 6. RCS multi-height calibration procedures

Parameter	Value	Source
Number of Calibration Targets	2	ISO 19206-3:2021
Calibration Targets RCS Ranges (dB-m^2)	-20 to 0, 5 to 20	ISO 19206-3:2021
Corner Reflector Height (m)	0.48	ISO 19206-3:2021
Approach Range (m)	4 to 40	ISO 19206-2:2018
Sensor Height (m)	0.23, 0.48, 0.90	ISO 19206-3:2021
Approaches per Sensor Height	1	ISO 19206-3:2021

Analysis of Measurements

This section explores the processes of analyzing, calibrating, and evaluating raw measurement data.

Compilation of RCS Measurements

Figure 6 outlined the process of RCS datasets from approaches compiled into a single combined RCS dataset. The raw RCS datasets were processed according to the measurement procedure defined in Section C.3.3.2 of ISO 19206-3:2021. For this procedure, the raw RCS datasets from all approaches were filtered using a 5 m-wide sliding low-pass averaging window. The datasets were then combined into a single compilated dataset by averaging across the approaches. This combined data trace is considered the output of the RCS measurement process and is the trace against which RCS bounds are imposed.

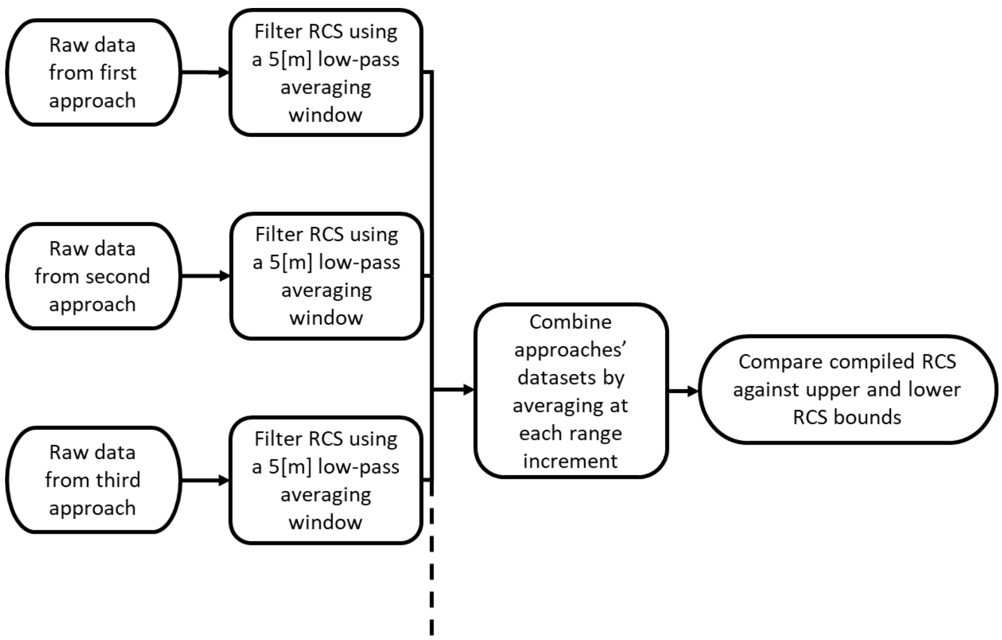


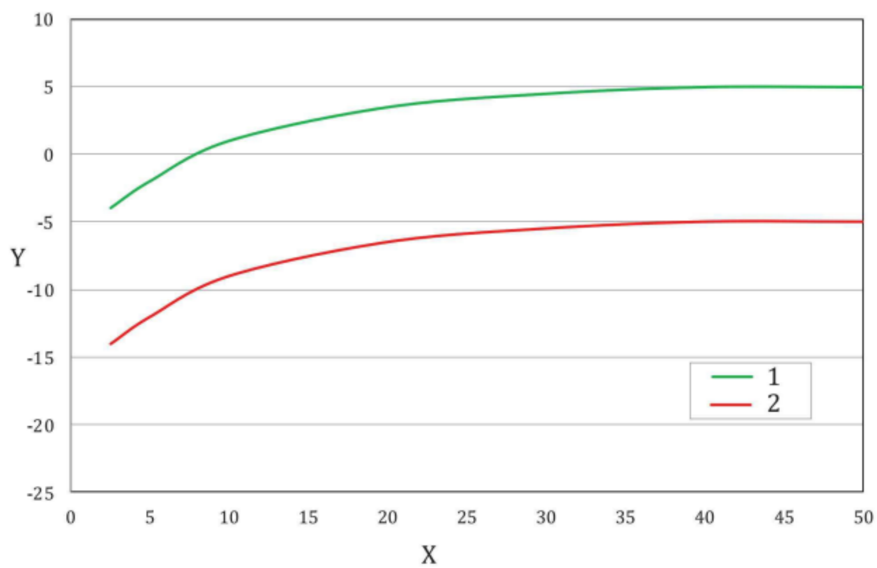
Figure 6. Compilation of RCS measurements process

RCS Bounds

ISO 19206-2:2018 describes the establishment of RCS upper and lower boundaries for PTM validation as a process dependent on collecting RCS data of real humans. The document suggests processes from which PTM RCS bounds can then be calculated from the RCS data of real humans. It is noted that these bounds should be individually determined for each radar sensor frequency and for each radar sensor model.

Figure 7 depicts sample PTM RCS upper and lower boundaries of a single, unspecified radar sensor, operating at 77 [GHz] is included in ISO 19206-2:2018. No formulas, values, or specifications of these boundaries besides graphics are provided in ISO 19206-2:2018.

These boundaries were recreated and used for reference as the RCS boundaries for all measurements in this test series.



Key
1 upper boundary RCS
2 lower boundary RCS
X distance (m)
Y RCS (dBsm)

Figure 7. Example PTM RCS boundaries from Figure B.5 in ISO 19206-2:2018

Calibration Offset Calculations

For each measurement session, a calibration offset was calculated using the two trihedral corner reflector measurements performed in that session. The calculation of the calibration offset was performed following the process outlined in Section C.3.4 of ISO 19206-3:2021. For this process, RCS data from the fixed-angle measurements taken at the three sensor heights are converted to units of m^2 and then bin-averaged using a bin size of 1 m. The median of the bin-averaged RCS is used to calculate the calibration factor, K.

Formula 1:

$$K_{n,A} = \frac{P_{cal}}{P_{meas}}$$

Formula 2:

$$K_{n,D} = 10log_{10}\left(\frac{P_{cal}}{P_{meas}}\right)$$

Where:

$K_{n,A}$ is the calibration factor for object *n* in units of area (m^2).

$K_{n,A}$ is the calibration factor for object *n* in units of decibel area (dBm^2).

$K_{n,A}$ is the known RCS in m^2 of the calibration object.

$K_{n,A}$ is the measured RCS in m^2 of the calibration object.

This calculation process was performed separately for the two trihedral measurements, then the final calibration offset factor was calculated by averaging the two results together.

Results

This section describes the results from the radar measurements of PTMs and the radar calibration offset calculations.

PTM RCS Results

The following shows the results of the PTM radar measurements using the multi-height procedure. The results of adult and child PTM radar measurements are shown in plots of overlaid PTM combined RCS vs range. Each figure shows results plotted by sensor and subject orientation. Sample upper and lower RCS bounds from ISO 19206-2:2018 (Figure 7) are shown on each plot in dotted black lines.

Figure 8 shows the results of radar measurement of the adult PTM using the multi-height measurement procedure in plots of overlaid combined RCS vs range.

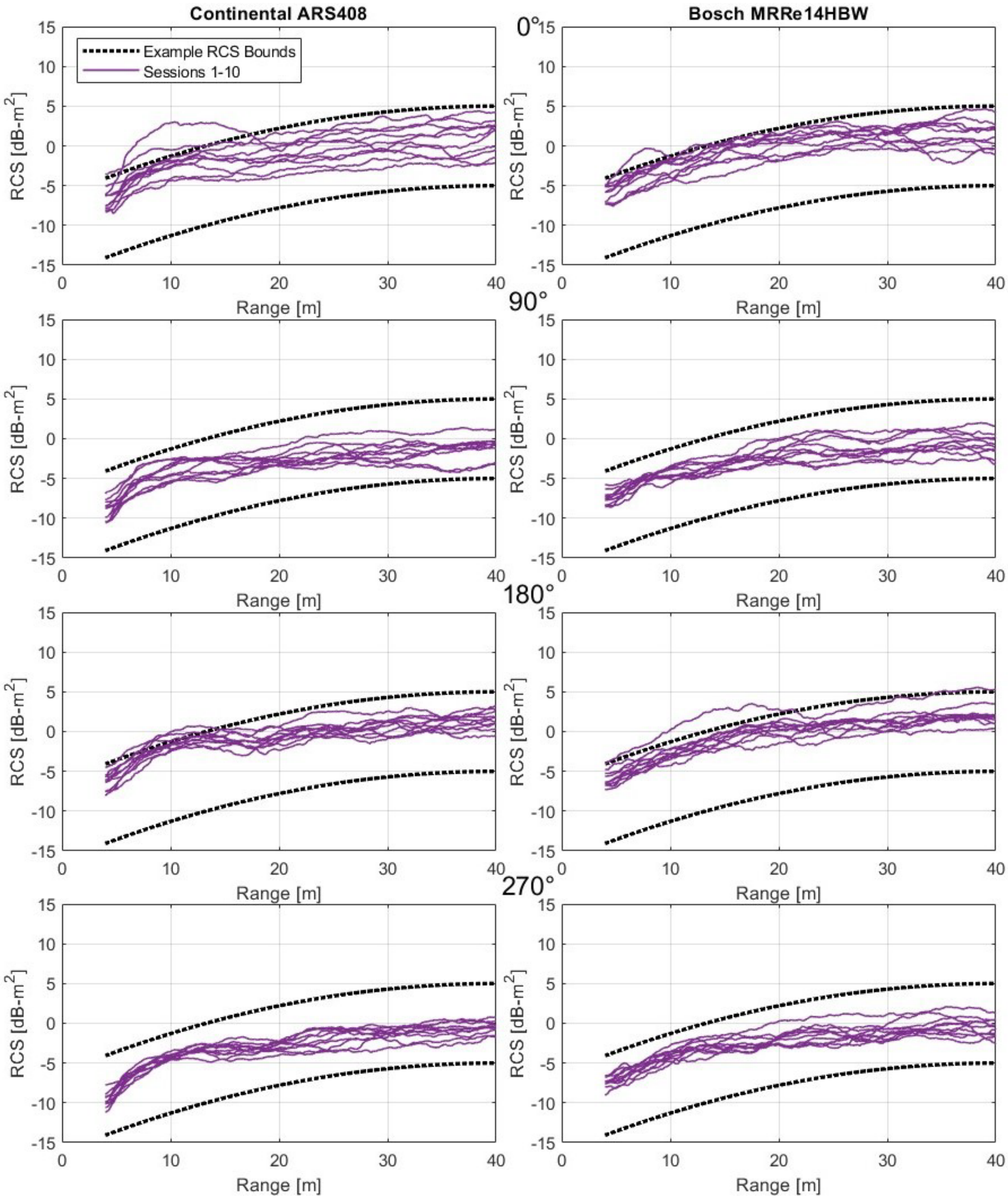


Figure 8. Adult PTM RCS repeatability results - height procedure

Figure 9 shows the results of radar measurement of the child PTM using the multi-height measurement procedure in plots of overlaid combined RCS vs range.

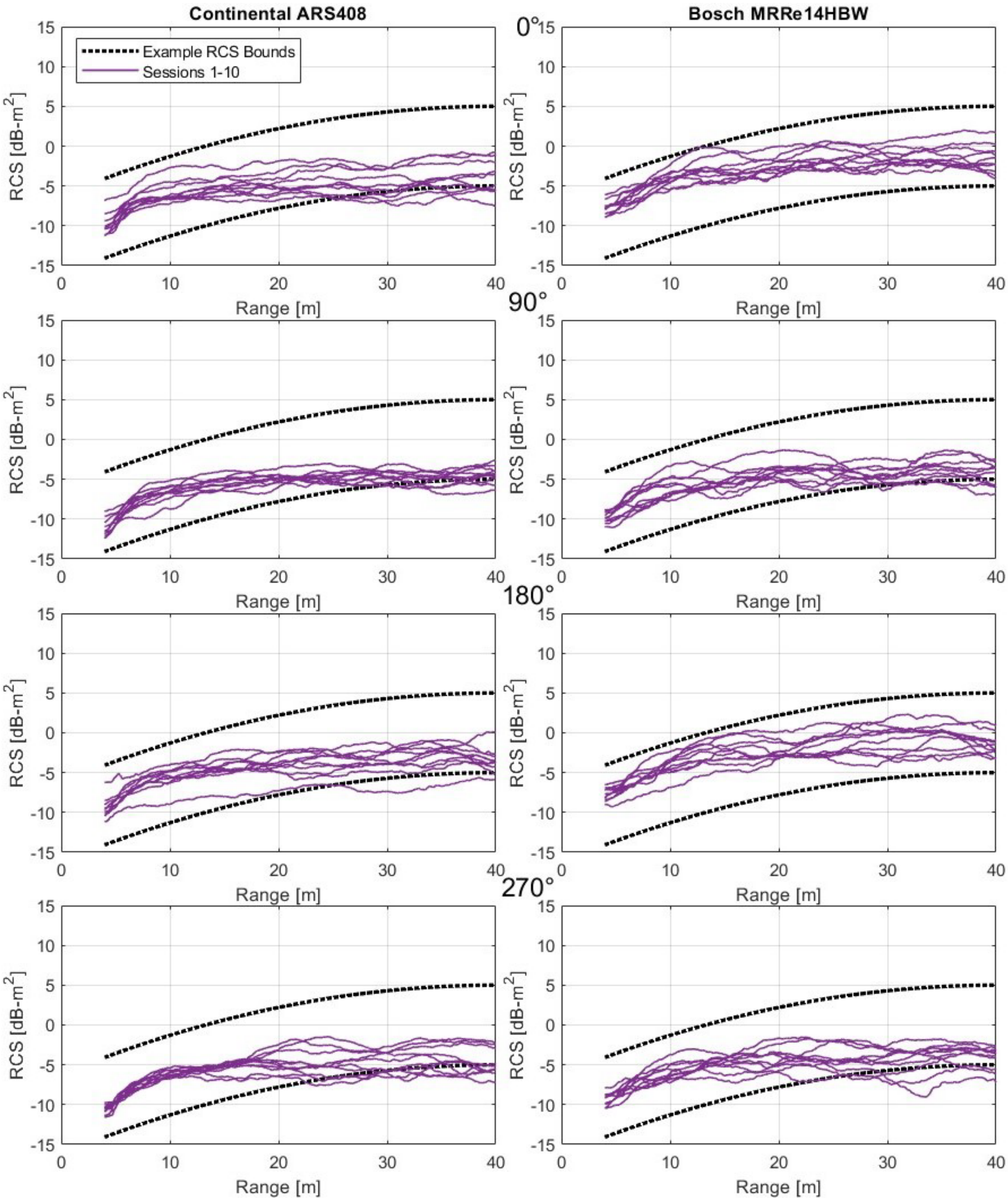


Figure 9. Child PTM RCS repeatability results - height procedure

RCS Calibration Results

Figure 10 shows the final radar calibration offsets calculated from radar measurements of calibrated trihedral corner reflectors. The values plotted are the final calibration offsets resulting from averaging the calibration offsets calculated individually from measurements of the -3.63 and 10 dB-m^2 trihedral corner reflectors. The PTM RCS Results section presents these final calibration offsets applied to the combined RCS datasets as magnitude shifts. Tables listing values for each calibration offset are shown in Appendix A.

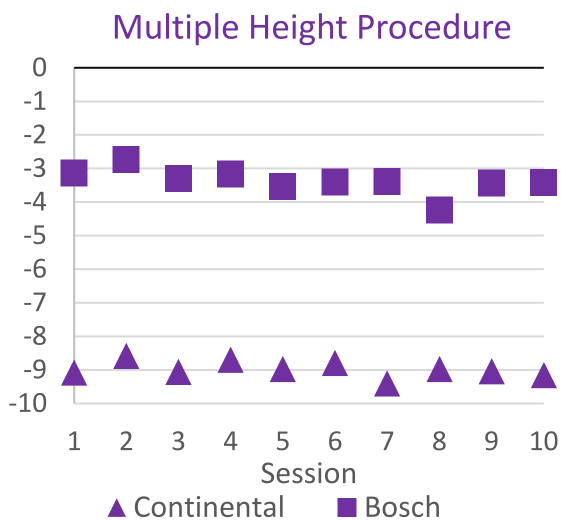


Figure 10. Radar calibration offsets – multi-height procedure

Conclusions and Observations

The following conclusions and observations can be made from the results of the measurement series.

- The resulting RCS measurements of the adult PTM demonstrates moderate variability of RCS profiles between measurement sessions. While present to some extent in measurements from both sensors, and in all orientations, this variability is especially prominent in the adult 180° and 0° orientations where the stationary PTM respectively faces towards or away from the sensor. Less variability is observed in measurements where the adult PTM is oriented at 90° and 270°, facing perpendicular to the path of the sensor.
- RCS measurements of the child PTM demonstrate moderate variability of RCS profiles between measurement sessions and in all orientations.
- The calculated calibration offsets remained consistent throughout the measurement series. Little calibration offset variation was seen between measurement sessions. While calculated calibration offsets were not a primary area of study in this series, the consistency across these values and, by extrapolation, calibration measurements of the trihedral corner reflector calibration subjects shows that the radar measurement system itself is consistent. It can be inferred that variability seen in the RCS of the PTMs is a result of the subjects themselves and not of the measurement process.

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Appendix A: Additional Measurement Session Data

Table 7. Measurement Session Dates - Single-Height Measurement Procedure

Measurement Session	Date
1	10-31-2023
2	10-31-2023
3	11-01-2023
4	11-01-2023
5	11-02-2023
6	11-02-2023
7	11-06-2023
8	11-06-2023
9	11-07-2023
10	11-07-2023

Table 8. Measurement Session Dates - Multi-Height Measurement Procedure

Measurement Session	**Date**
1	11-13-2023
2	11-15-2023
3	11-20-2023
4	11-20-2023
5	11-27-2023
6	11-27-2023
7	11-28-2023
8	11-28-2023
9	11-29-2023
10	11-29-2023

Table 9. Individual RCS Calibration Offsets - Single-Height Procedure

	Continental ARS408		**Bosch MRRe14HBW**	
Calibration Target RCS [dB-m^2]:	**-3.63**	**10**	**-3.63**	**10**
Session 1	-8.23	-6.89	-3.03	-0.71
Session 2	-8.84	-6.8	-2.58	-1.26
Session 3	-9.57	-7.10	-3.69	-1.20
Session 4	-8.24	-6.97	-2.43	-0.75
Session 5	-8.92	-7.02	-3.70	-1.68
Session 6	-8.32	-6.83	-3.43	-1.21
Session 7	-8.52	-6.83	-2.44	-0.75
Session 8	-8.41	-6.88	-3.38	-1.22
Session 9	-8.74	-6.87	-3.25	-0.60
Session 10	-8.43	-6.48	-3.75	-0.74

Table 10. Individual RCS Calibration Offsets - Multi-Height Procedure

	Continental ARS408		Bosch MRRe14HBW	
Calibration Target RCS [dB-m^2]:	**-3.63**	**10**	**-3.63**	**10**
Session 1	-9.80	-8.47	-5.31	-1.70
Session 2	-9.08	-8.13	-4.01	-1.76
Session 3	-9.69	-8.50	-4.90	-2.14
Session 4	-9.17	-8.28	-4.27	-2.29
Session 5	-9.64	-8.39	-5.52	-2.19
Session 6	-9.03	-8.55	-4.92	-2.29
Session 7	-10.34	-8.63	-4.72	-2.38
Session 8	-9.48	-8.51	-4.24	-2.26
Session 9	-9.54	-8.59	-4.89	-2.35
Session 10	-9.99	-8.45	-4.94	-2.30

Table 11. Combined RCS Calibration Offsets - Single-Height Procedure

	Continental ARS408	**Bosch MRRe14HBW**
Session 1	-7.50	-1.71
Session 2	-7.70	-1.87
Session 3	-8.16	-2.27
Session 4	-7.56	-1.51
Session 5	-7.86	-2.57
Session 6	-7.51	-2.18
Session 7	-7.59	-1.51
Session 8	-7.58	-2.17
Session 9	-7.70	-1.73
Session 10	-7.35	-1.99

Table 12. Combined RCS Calibration Offsets - Multi-Height Procedure

	Continental ARS408	**Bosch MRRe14HBW**
Session 1	-9.08	-3.14
Session 2	-8.58	-2.74
Session 3	-9.06	-3.30
Session 4	-8.70	-3.17
Session 5	-8.97	-3.54
Session 6	-8.79	-3.41
Session 7	-9.40	-3.40
Session 8	-8.97	-4.24
Session 9	-9.04	-3.44
Session 10	-9.15	-3.42

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Appendix B: Single-Height Measurement Procedure Test Methodology

Parameters followed in the single-height measurement procedure and its sources are listed in the following tables. Generally, the single-height measurement procedure attempted to broadly follow the procedure specified in ISO 19206-2:2018.

Table 13. RCS Single-Height Measurement Procedure

Parameter	Value	Source
Sensor Height from Ground (m)	0.50	ISO 19206-2:2018
Approaches per Sensor Height	5	ISO 19206-2:2018
Measurement Range (m)	4 to 40	ISO 19206-2:2018
ScanR Movement Speed (km/h)	3.9	ISO 19206-3:2021

Table 14. RCS Single-Height Calibration Procedures

Parameter	Value	Source
Calibration Targets	2	ISO 19206-3:2021
Calibration Targets RCS Ranges (dB-m^2)	-20 to 0, 5 to 20	ISO 19206-3:2021
Corner Reflector Height (m)	1	ISO 19206-2:2018
Approach Range (m)	4 to 40	ISO 19206-2:2018
Sensor Height (m)	0.5	ISO 19206-2:2018
Approaches per Sensor Height	5	ISO 19206-2:2018

Appendix C: Single-Height Measurement Procedure Test Results

Figure 11 shows the results of radar measurement of the adult PTM using the single-height measurement procedure in plots of overlaid combined RCS vs range.

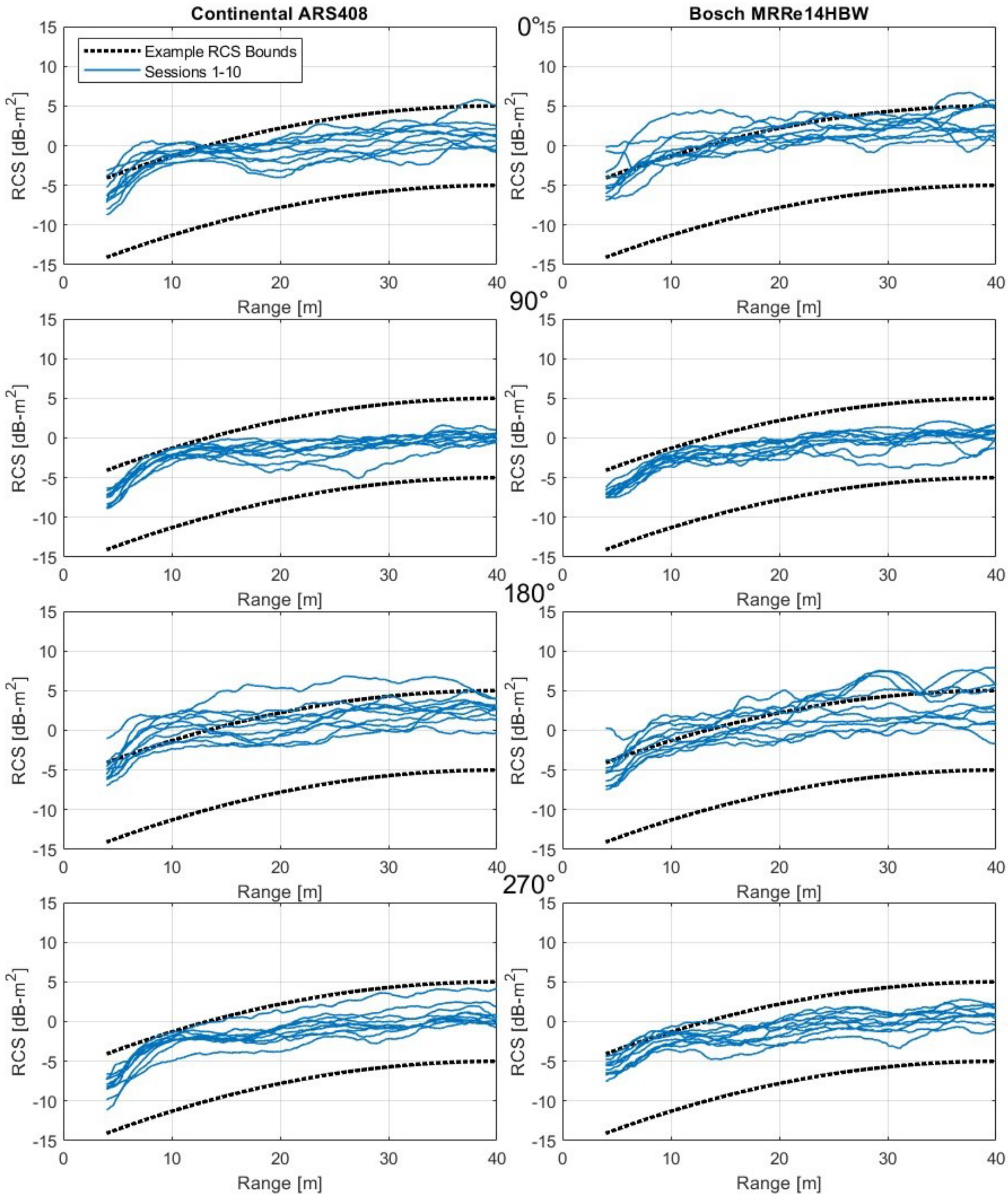

Figure 11. Adult PTM RCS Repeatability Results - Single-Height Procedure

Figure 12 shows the results of radar measurement of the child PTM using the single-height measurement procedure in plots of overlaid combined RCS vs range.

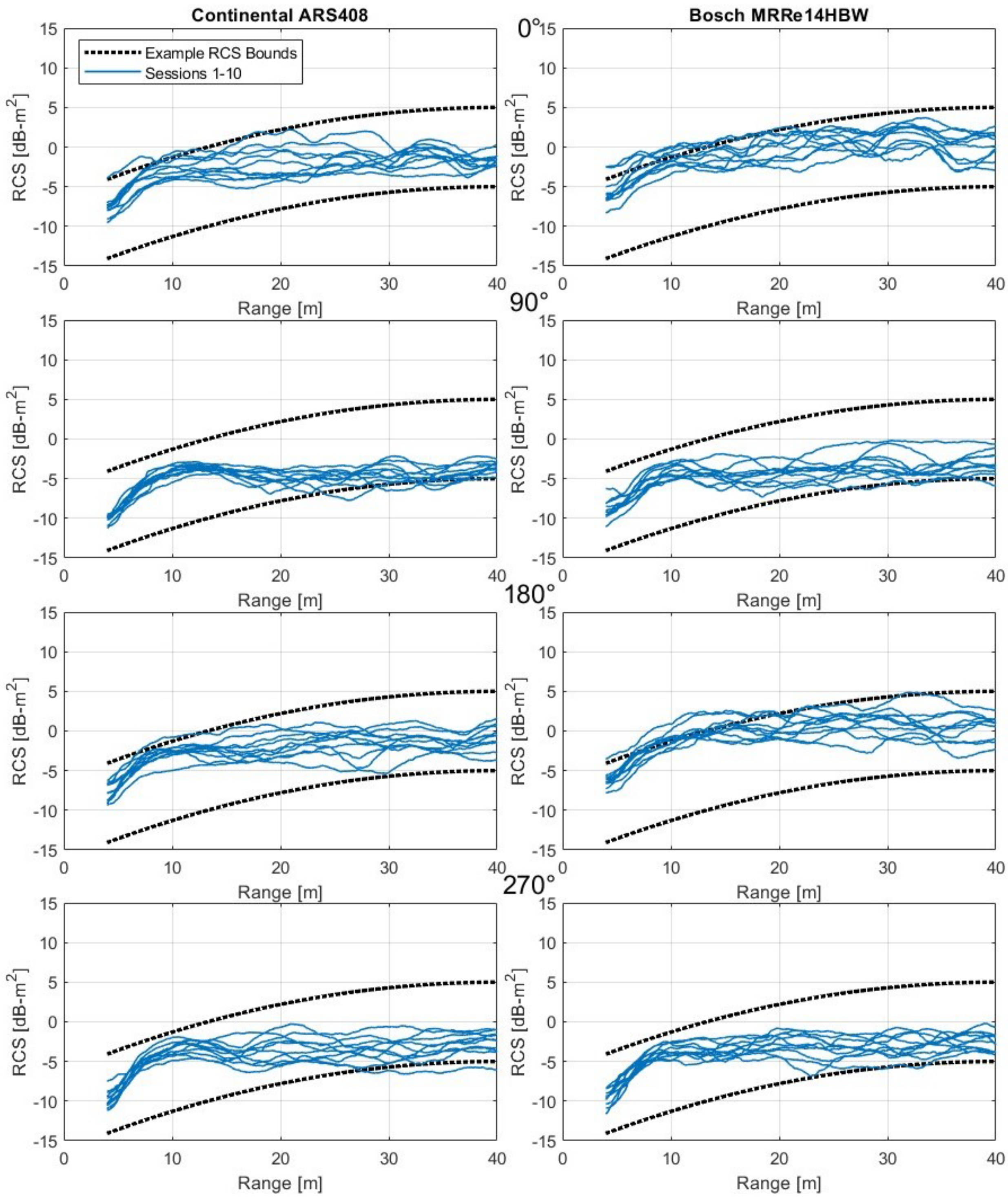

Figure 12. Child PTM RCS Repeatability Results - Single-Height Procedure

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Appendix D: PTM In-Bounds Percentage Tables

In most cases, the ISO 19206 series of documents do specify a percentage in which the combined RCS dataset should fall within the RCS boundary lines, however, ISO 19206-2:2018 does not specify a percentage. For reference purposes, the percentage of the combined RCS dataset within the example upper and lower RCS bounds shown in ISO 19206-2:2018 is tabulated for each measurement below. Tables are separated by measurement procedure.

Table 15. Percentage of PTM RCS Between Example Bounds – Single-Height Procedure

	Adult PTM								**Child PTM**							
	Continental ARS408				**Bosch MRRe14HBW**				**Continental ARS408**				**Bosch MRRe14HBW**			
Orientation:	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**
Session 1	83	99	9	100	83	100	7	99	100	100	85	65	100	100	47	100
Session 2	100	100	42	100	88	100	18	100	87	67	100	100	100	86	91	100
Session 3	81	100	96	100	38	100	100	100	88	96	100	100	68	100	100	100
Session 4	75	100	77	100	42	100	79	84	100	100	100	100	98	100	83	100
Session 5	100	100	80	100	93	100	100	91	97	83	100	100	81	88	90	100
Session 6	97	100	71	100	72	100	58	100	100	100	100	100	100	100	88	100
Session 7	99	100	100	100	90	100	100	89	100	100	100	100	100	100	65	100
Session 8	83	100	100	99	24	100	100	100	100	87	100	100	67	100	96	91
Session 9	85	100	60	100	97	100	9	100	95	100	100	100	68	100	97	100
Session 10	83	100	68	100	90	100	36	100	100	100	100	99	100	100	76	100

Table 16. Percentage of PTM RCS Between Example Bounds – Multi-Height Procedure

	Adult PTM								**Child PTM**							
	Continental ARS408				**Bosch MRRe14HBW**				**Continental ARS408**				**Bosch MRRe14HBW**			
Orientation:	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**
Session 1	100	100	100	100	100	100	100	100	62	100	100	93	100	96	100	100
Session 2	100	100	81	100	100	100	35	100	98	87	100	100	100	99	100	100
Session 3	100	100	100	100	84	100	100	100	87	100	100	60	100	100	100	70
Session 4	100	100	100	100	97	100	100	100	100	84	100	88	99	100	100	90
Session 5	67	100	84	100	100	100	100	100	91	78	100	81	100	73	100	100
Session 6	100	100	100	100	100	100	100	100	100	74	100	74	100	83	100	100
Session 7	100	100	93	100	100	100	100	100	90	94	61	70	100	94	100	57
Session 8	100	100	98	100	100	100	100	100	58	97	99	100	100	100	100	100
Session 9	100	100	83	100	93	100	100	100	100	100	100	76	100	100	100	81
Session 10	75	100	100	100	100	100	100	100	85	100	100	100	100	100	100	100

Appendix E: PTM Pictures

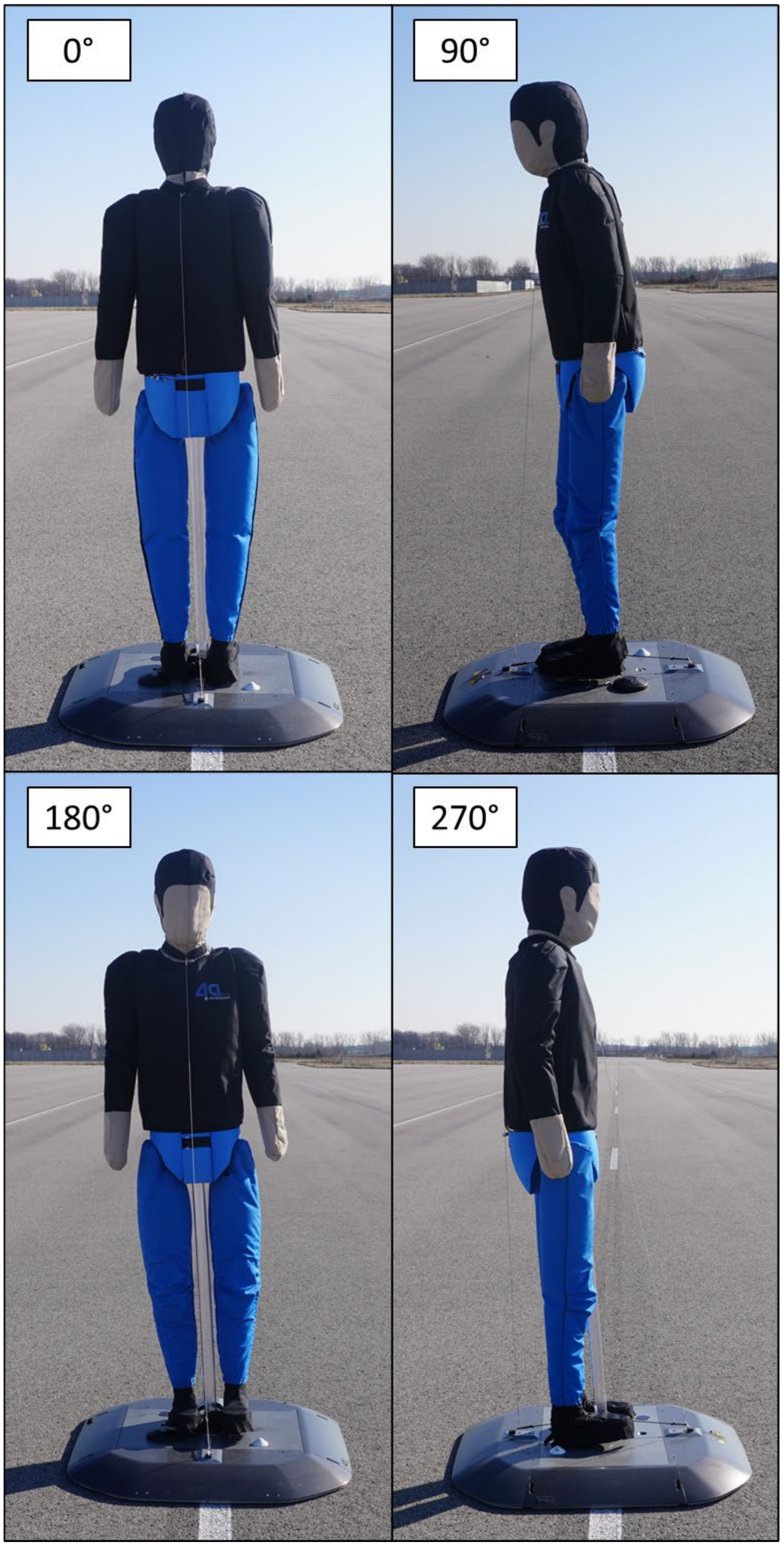

Figure 13. Adult PTM at Labelled Orientations From Sensors' Point of View

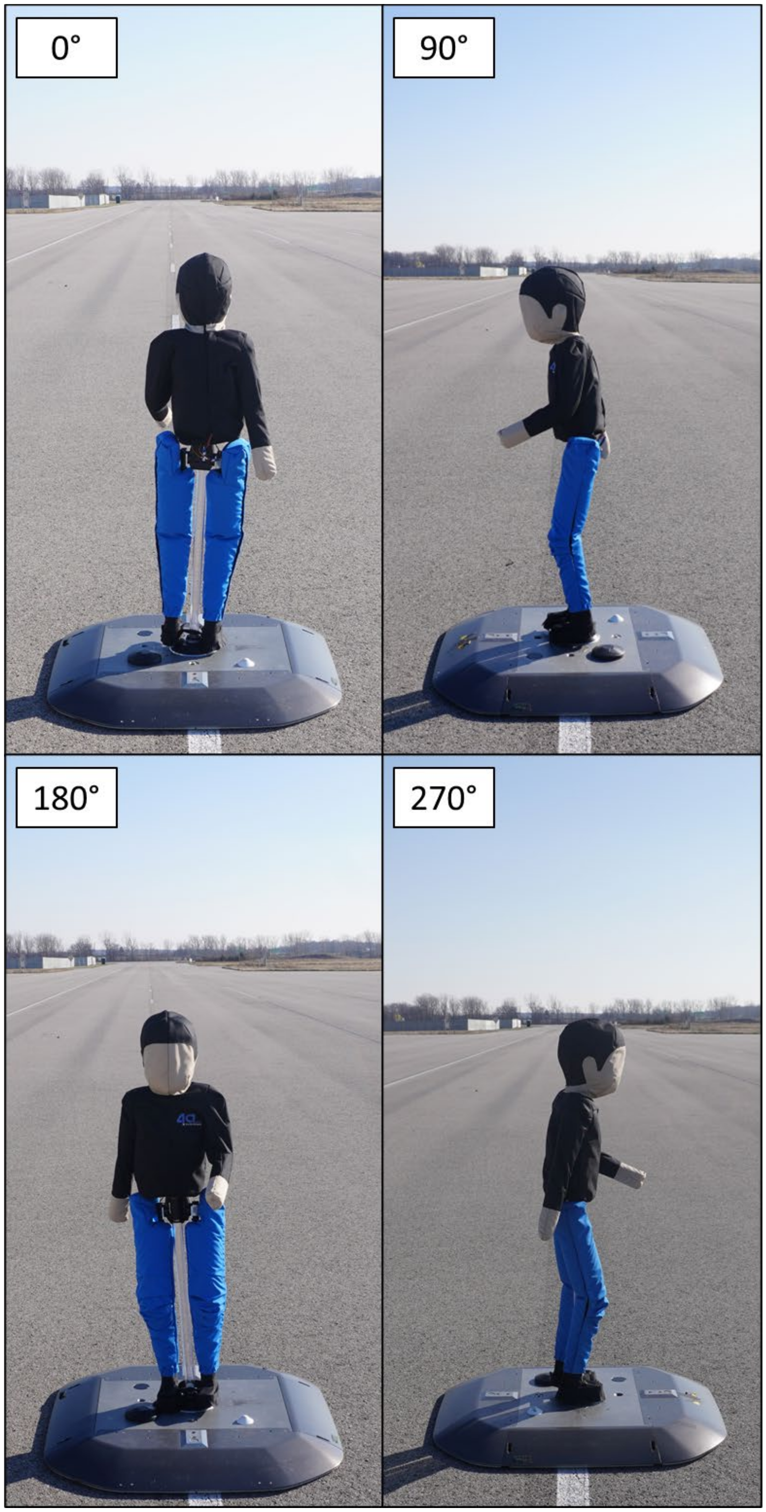

Figure 14. Child PTM at Labelled Orientations From Sensors' Point of View

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