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Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions —

Part 4: Requirements for bicyclist targets

Véhicules routiers — Dispositifs d'essai pour véhicules cibles, usagers de la route vulnérables et autres objets, pour l'évaluation de fonctions de sécurité active —

Partie 4: Exigences pour cibles de cyclistes

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22 *Road vehicles*, Subcommittee SC 33 *Vehicle dynamics and chassis components*.

A list of all parts in the ISO 19206 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

ADAS (Advanced Driver Assistance Systems) and active safety systems are designed to support decision-making for the driver, extend the driver's awareness of the traffic situation with advanced warnings, improve the behaviour of the vehicle, and even take over vehicle control in an emergency situation. The goal is to completely avoid an accident or at least reduce the severity of an accident.

The surrogate target is an essential component in the evaluation of ADAS/active safety functions and different levels of automated driving systems, in all situations where a collision with the target may occur.

The characteristics of targets need to be trustworthy and a vehicle target needs to be recognized as a real vehicle by the various sensing technologies.

This document addresses the specification of bicyclist test targets. The bicyclist targets specified are representative of adult and child sizes.

A bicyclist test target needs to represent the characteristics of the rider and bicycle yet provide safety for the subject vehicle and test operators in the event that contact is made between the tested vehicle and the bicyclist target. Crashworthiness and durability requirements for the bicyclist target require that the material and construction of the bicyclist target are adapted to fit the purposes.

Test cases usually address both stationary and moving targets and, as such, the physical construction of the target may accommodate a target carrier system capable of mimicking realistic motions. This document includes requirements on the target carrier system as applicable.

Targets described in the ISO 19206 series can be used for system development or applied in conjunction with existing standards, or standards under development, for assessment of ADAS and active safety functions of vehicles.

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Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions —

Part 4: Requirements for bicyclist targets

1 Scope

This document specifies the properties and performance requirements of a bicyclist target (BT) that represents a human bicyclist in terms of shape, movement, reflection properties, etc. for testing purposes. The BT is used to assess the system detection and activation performance of active safety systems.

This document establishes the detection requirements for a BT in terms of sensing technologies commonly in use at the time of publication of this document, and where possible, anticipated future sensing technologies. It also establishes methodologies to verify the target response properties to these sensors, as well as some performance requirements for the target carrier.

The BT according to this document is also representative for electrically assisted pedal bicycles (pedal electric cycle, pedelec).

This document does not address the test procedures in terms of speeds, positions, or timing of events. Performance criteria for the active safety system being tested are also not addressed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8855, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

ISO 8608, *Mechanical vibration — Road surface profiles — Reporting of measured data*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
subject vehicle
SV
vehicle with active safety system to be tested

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3.2
bicyclist target
BT
test device representing a bicyclist on a bicycle used to test active safety systems

3.2.1
BT bicycle
part of the *bicyclist target* (3.2) consisting of the bicycle only

3.2.2
BT rider
part of the *bicyclist target* (3.2) consisting of the rider only

3.3
target carrier
mechanical or electro-mechanical system used to move the target according to a test protocol

Note 1 to entry: Target carrier can be self-contained within, or supporting the target structure or external devices connected with cables, beams, or similar structures. It can also be a self-propelled carrier.

Note 2 to entry: Target structure fixation is included in the target carrier. A commonly used fixation interface is shown in Annex G.

3.4
measurement equipment
equipment used to record the position of the *bicyclist target* (3.2) relative to the *subject vehicle* (3.1) to ensure that the test protocol is followed within prescribed tolerances and record data documenting the function of the active safety system and allowing its performance to be assessed

4 Abbreviated terms

BT	bicyclist target
CCD	charge-coupled device
CMOS	complementary metal oxide semiconductor
FIR	far infrared
LIDAR	light detection and ranging
NIR	near infrared
PMD	photonic mixer device
RCS	radar cross section
SV	subject vehicle

5 Bicyclist target specifications

5.1 Bicyclist target size

The bicyclist targets specified in this document are representative for adult and child sizes. References for subsequent requirements are based on sample measurements of different demographics and compiled into categories. The following human bicyclist sizes are relevant for this document:

— adult: 50-percentile male;

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— child: 6-7 year old.

5.2 Dimensions of the BT rider

Annex A, Tables A.1 and A.2 provide the information for a 50-percentile male adult and a 6-7 year old child.

5.3 Safety considerations

Drivers of the subject vehicle shall not be exposed to any substantial risk of personal injury resulting from impact of the BT by the SV. The BT and its components should not cause more than cosmetic damage to the subject vehicle when struck at a relative velocity of 60 km/h. The conditions specified by the test procedure application shall be taken into consideration.

NOTE Test procedures for specific applications typically indicate what measures are taken to reduce the risk of injury and vehicle damage. These measures can include instructions to disable subject vehicle systems such as supplementary occupant restraints, seatbelt pre-tensioners, vulnerable user protection systems, etc.

5.4 Repairability and robustness

The BT should be easily reassembled or repaired after contacts up to a relative speed of 60 km/h. Field repairs should be possible with hand tools. After repair, the target body and/or target carrier system shall be verified according to 6.5.

NOTE The repairability requirement does not apply to disposable targets.

After a collision, the correctness of the BT posture and dimension shall be verified before start of a new test.

5.5 Environmental conditions

The BT shall fulfil all requirements in a temperature range of -5 °C to +40 °C. The BT shall not deteriorate under storage temperatures in the range of -20 °C to +80 °C when properly stored.

NOTE The specified temperature range recognises that there can be substantial technical challenges achieving a cost-effective target fulfilling the requirements at lower temperatures than -5 °C.

5.6 Postures and articulation

5.6.1 General

The BT described in this document represents an average human bicyclist (adult and child versions) on an average utility bicycle (Figure 1) in relation to the vulnerable road users (VRU) detection sensors used in vehicles. The requirements relate, unless not specified otherwise, to the BT including a target carrier.

The BT shall be a full 3D representation of a human bicyclist with bicycle and shall have rotating wheels (synchronized to speed) or other means of producing the 3D visual and micro-Doppler effects as described in 6.3.4 and Annex D.

BT rider postures can be of static (non-pedalling type) or articulated (pedalling type). Both variants are recognised according to this document.

5.6.2 Static posture

The torso angles shall be implemented according to Table A.1 and Table A.2 (10° and 30°). Optional torso angles may be implemented using a range of 0° to 50°.

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Figure 1 — Bicyclist target with different BT rider torso angles

6 Bicyclist target response to sensing technologies

6.1 General

Requirements related to sensing technologies commonly in use at the time of publication of this document are listed in 6.2, 6.3 and 6.4. A BT intended for use with a specific set of sensing technologies needs only to meet the requirements of those technologies.

6.2 Optical requirements

6.2.1 General

Sensors operating on optical principles include charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) camera sensors, stereo camera sensors, photonic mixing devices (PMD) and light detection and ranging (LIDAR). These systems cover visible and near infrared light frequency spectra. PMD and LIDAR are more reliant on infrared reflectivity of the target surface.

6.2.2 Reference measurements

When technology-specific measurements are required, information of the type of sensor used, environmental conditions during measurements, and date of measurement shall be provided with the description of the BT. The version of the BT and the target carrier shall be traceable to manufacturing drawings or supplier specifications. Measurements of the IR reflectivity shall follow the requirements in C.2.

6.2.3 Colours and clothing

Skin surface parts of BT rider shall be non-reflective and skin-coloured. Hair may be represented by a securely attached hairpiece or integrated in the head design by other means.

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It is recommended to use long-sleeved t-shirt and trousers in different non-reflective colours. A black t-shirt and blue jeans are recommended. Clothing shall be loose fitting, but fluttering shall be avoided. Specific requirements given in B.2 shall be followed.

6.3 Radar requirements

6.3.1 General

At the time of publication of this document, automotive applications of radar are using 24 GHz and 76 GHz – 81 GHz.

6.3.2 Reference measurements

When technology-specific measurements are required, information of the type of sensor used, environmental conditions during measurements, and date of measurement shall be provided with the description of the reference subject(s). The version of the BT and the target carrier shall be traceable to manufacturing drawings or supplier specifications. Reference radar measurement setups for human bicyclist subjects that shall be used for verification are provided in C.3.

6.3.3 Radar cross section measurement of BT

The radar reflective characteristics of the BT should be comparable to a human bicyclist of the same size. Requirements and recommendations on the radar properties are given in B.3.

For every radar frequency relevant for the BT, a set of radar cross-section measurements shall be made. The main steps are as follows:

1) measurement of human bicyclist reference subjects and radar cross section (RCS) reference targets,

2) establishment of boundaries, and

3) verification that the BT RCS measurements are within the boundaries.

The following scenario is described in C.3.3:

— static BT approached by moving vehicle or moving fixture, to check for inconsistencies at different distances and at different BT orientation angles.

An example of the results of this process is illustrated in Figure 2, showing RCS measurements on human bicyclist reference subjects and two BT versions at 77 GHz (static measurements).

Annex E provides RCS measurement data on real bicyclists and BTs for different viewing angles.

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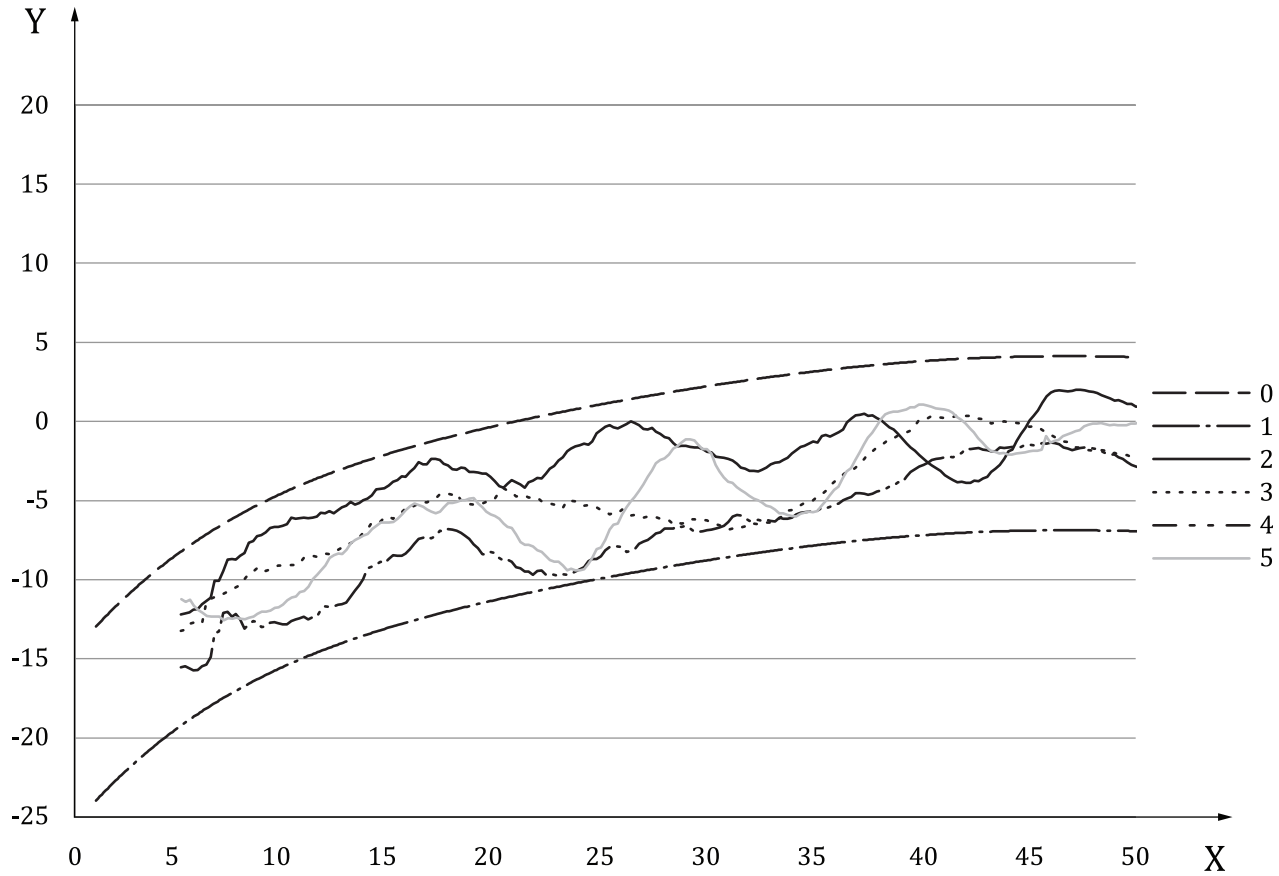

Key

X distance [m]

Y RCS [dBsm]

0 upper boundary RCS

1 lower boundary RCS

2 average RCS real GAZELLE 180°

3 average RCS real KTM 180°

4 average RCS commercially available BT A 180°

5 average RCS commercially available BT B 180°

NOTE Boundary definitions are given in B.3.

Figure 2 — Radar cross-section measurement, example for human adult bicyclists and BTs

6.3.4 Micro-Doppler effect for rotating wheels and pedalling of the BT

To identify a bicyclist, state of the art radar sensor technology can detect and measure the relative velocities of rotating wheels and pedalling legs on the bicyclist, referred to as the micro-Doppler effect. Rotating wheels shall thus be realized in a manner that provides a realistic micro-Doppler representation of the BT. The articulation requirements in Annex D shall be followed to obtain this.

Real bicyclists may or may not be pedalling while moving, this property is optional for articulated BTs. If implemented, the pedalling shall be realized in a manner that realistically represents that of a real bicyclist.

Figure 3 shows an example of the distribution of relative velocities for a transversal moving human bicyclist, measured by radar (77 GHz sensor, 1 GHz bandwidth).

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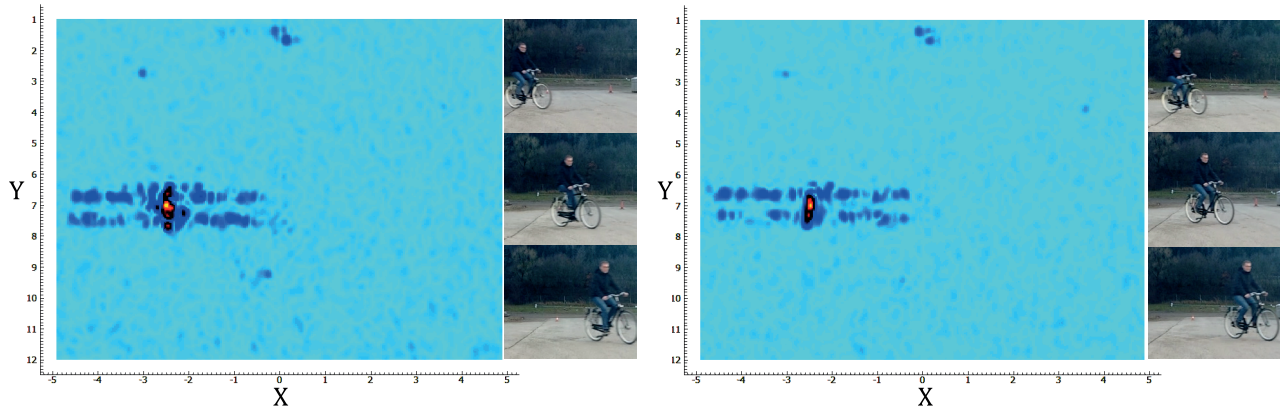
The plot shows a snapshot at a distinct time from the approach. Due to the chosen reference coordinate system, relative speeds show negative values (approach towards sensor). A typical H-shape of relative velocities is depicted, with reflections in the centre emerging from non-rotating parts (travel speed of bicycle), and two horizontal lines representing the two rotating wheels (double the travel speed of bicycle for upper parts of wheels, zero relative velocity for part of wheels touching ground). The pedalling motion shows additional relative speed information minor to the rotating wheels.



Key

X relative velocity [m/s]

Y radial distance [m]

Figure 3 — Micro-Doppler effect example for pedalling (left) and non-pedalling (right) human bicyclist

6.4 Thermal requirements for far IR vision systems

6.4.1 General

Inclusion of passive thermal sensor requirements is optional.

Far infrared (FIR) vision systems can provide information to active safety systems in conditions of low light or otherwise limited visibility. A thermal camera detects far-infrared electromagnetic radiation with a wavelength in the range of 8 µm to 14 µm. Imaging is provided by means of an appropriate camera.

6.4.2 Reference measurements

When technology-specific measurements are required, information of the type of sensor used, environmental conditions during measurements and date of measurement shall be provided with the description of the reference subject(s). The version of the BT and the target carrier system shall be traceable to manufacturing drawings or supplier specifications.

6.4.3 Thermal characteristics

BTs commonly in use at the time of publication of this document do not feature human-specific FIR characteristics. Developers of BT that incorporate such characteristics should ensure that the characteristics of the BT are comparable to a human bicyclist of the same size.

Characterization of these properties should follow the same main steps used to characterizing RCS:

1) measurement of human bicyclist reference subjects,

2) establishment of boundaries, and

3) verification that the BT FIR measurements are within the boundaries.

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6.5 Calibration and verification

The BT manufacturer shall provide a certificate detailing which test information has been used to verify the product performance and which sensor technologies it conforms to.

Calibration shall be based on representative characteristics of the applied detection technology as described in 6.2, 6.3 and Annex C.

For field verification of BT functionality, see Annex F.

7 Motion and positioning during test for BT including target carrier system

7.1 General requirements

The most relevant BT parameters are defined in Tables A.1 and A.2 and shall be maintained under typical test conditions including wind and acceleration.

The target carrier system shall be capable of positioning the target within tolerances required by the applicable test procedures. Repeatable test performance requires that subject vehicle and BT relative speed and position shall be consistent between test repetitions. Unless more stringent requirements are needed by a specific test procedure, the positioning requirements outlined in this clause are the minimum requirements for the BT. Recommended specifications for measurement equipment are given in C.1.

The following requirements and recommendations apply to the target carrier system.

— All visible parts of the target carrier system should be transparent or coloured to minimize the contrast with background, for example grey, to approximate the test area road surface. In case of a uniform background the colour shade of the background can be used.

— Visible parts of the target carrier system should be non-reflective to light sources, for example headlamps during low natural light conditions.

— The target carrier system and resulting motion of the BT shall minimally affect target characteristics (radar, optical signature, etc). Design measures, for example radar absorbing material, shall be used at the BT mounting to ensure that the BT carrier provides minimal radar reflections.

— No deformations of target structure shall occur that influence the sensor response.

— The outer circumference of the wheels of the BT shall be physically and/or visually in contact with the road surface. If not in contact with the road surface the lower most point on the circumference shall be no more than 25 mm above the surface.

— The mounting of the BT on the target carrier system shall be secure and not permit the target body and target carrier system to separate during any positioning sequence, within the limits specified in 7.2 through 7.4.

— An attachment system used to secure the BT to the carrier system shall be capable of releasing BT immediately before or upon impact, to prevent/reduce severe damage by the collision.

— The target carrier shall accelerate and decelerate in a smooth manner, except for actions intended to avoid impact or damage. The BT shall not show unnatural changes of posture or movement during acceleration or deceleration.

The positioning requirements in 7.2 through 7.4 are with reference to a coordinate system oriented with the target. The longitudinal axis is parallel with the direction of travel. The face of the dummy is oriented in the direction of travel.

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7.2 Longitudinal positioning

7.2.1 Speed range for operation

Maximum speed shall be at least 25 km/h (7 m/s). The speed control accuracy shall be ±0,18 km/h (±0,05 m/s).

7.2.2 Accelerations

Accelerations between -5 m/s^2 (stopping) and +3 m/s^2 (speedup) shall be possible.

7.3 Lateral positioning

7.3.1 General

The BT shall meet the lateral positioning requirements in 7.3.2 and 7.3.3 while operating in the speed range defined in 7.2.1 over a smooth road surface no rougher than road class A according to ISO 8608.

In addition to the values mentioned in the Tables A.1 and A.2, a lateral (relative to moving direction of BT) oscillation shall be prevented, with roll tolerances ±5°.

7.3.2 Heading angle

The BT shall be capable of maintaining a heading angle within ±2° of the direction of travel.

7.3.3 Lateral position

During straight line manoeuvres, the BT should not drift laterally more than ±0,05 m relative to the intended trajectory.

7.4 Vertical positioning

7.4.1 General

The BT shall meet the vertical positioning requirements in 7.4.2 and 7.4.3 while operating in the speed range defined in 7.2.1 over a smooth road surface no rougher than road class A according to ISO 8608.

7.4.2 Pitch angle

For straight line motions at constant speed, the pitch angle of the BT shall not change by more than ±2°.

7.4.3 Vertical motions

The BT should not vibrate or bounce more than 15 mm when operating in the speed range defined in 7.2.1 over a smooth road surface no rougher than road class A according to ISO 8608.

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Annex A
(normative)

Adult and child bicyclist target dimensions and postures

A.1 Adult BT dimensions

The dimensions of the adult BT bicycle are based on an average Dutch utility bicycle for average male according to data from TU Delft, with additional dimensions taken from a standard Dutch utility bicycle (Gazelle Paris Pure male size 57) to complete the dimension specifications. Alternative European bicycles have also been taken into account.

The adult BT bicycle is based on a standard utility bicycle and has a double triangle frame shape. Typical dimensions include those indicated in Figure A.1.

The centre of the bottom bracket (crank shaft) of the BT bicycle (red point in Figure A.1) is used as reference 0-point in X-direction and the ground level as reference 0-point in Z-direction.

Figure A.1 and Table A.1 provide the information for the adult BT bicycle.

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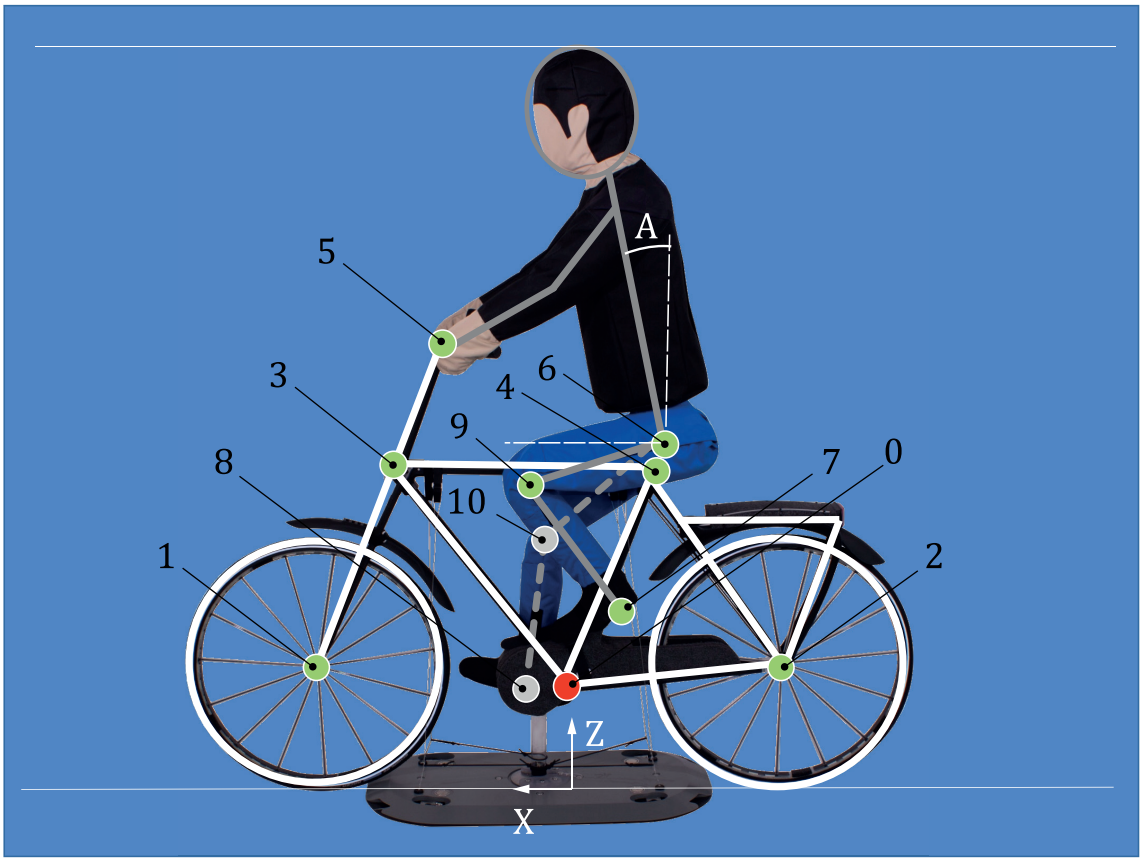

Key

0 centre of bottom bracket of BT bicycle
1 centre axis front wheel
2 centre axis rear wheel
3 front top frame
4 rear top frame
5 handlebar
6 saddle
7 lower edge left foot
8 lower edge right foot
9 knee point left
10 knee point right
A torso angle (city)

Figure A.1 — Adult BT bicycle dimensions and dummy posture

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