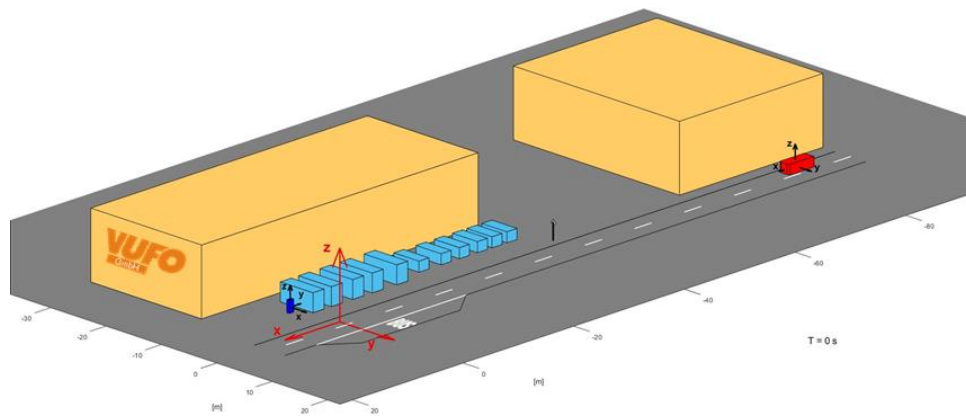


Pre-Crash-Matrix (PCM)

Format Specification v5.0

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Legal Framework

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Preface – What is PCM?

WHAT IS PCM?

PCM is the abbreviation for Pre-Crash-Matrix, and is a specified format to describe the phase of a traffic accident prior to the collision (the so-called pre-crash phase). It describes participants, its dynamics as well as the environment.

Initially the VUFO (Institute for Traffic Accident Research at Dresden University of Technology) developed the format in 2011 to provide pre-crash data for accidents investigated within the German In-Depth Accident Study (GIDAS). In January 2019, the format was defined in a more general way. Since then, it is applicable for any accident or scenario database and publicly accessible.

As it does not describe further data regarding the accident / scenario (e.g. accident description, accident type, injury severities, et al.), specific analyses should always refer to the linked accident / scenario database.

PCM STRUCTURE

Figure 1 shows the PCM structure including all tables in their hierarchic definitions. Attached to some environment tables there are property tables (containing meta data) and library tables which refer to country-specific definitions. The completion as well as the extension on other country-specific libraries is possible and one of the intended objectives for the future PCM development process.

CREATION AND SPECIFIC PCM DATABASE

A PCM case can be created by simulation methods (e.g. accident reconstruction) as well as data recording (e.g. from Event Data Recorders (EDR), Naturalistic Driving Study (NDS), Field Operational Test (FOT), ...). The resulting database contains a set of accidents / scenarios in PCM format.

The standard file format is a Microsoft Access database (mdb). As there exists the 2GB limit on a 32-bit operating system an alternative will be discussed for a future format release.

The name of the resulting PCM database should always refer to the linked database, e.g. "GIDAS-PCM".

EXAMPLE CASE

An example case is available for download on our website <https://www.vufo.de/>.

FURTHER DEVELOPEMENT

PCM is a "living format" that will evolve in cooperation with their users and partners. Send suggestions for format extensions, new or missing objects (OBJTYPE), mistakes in the specification and especially further libraries (e.g. with your countries specific characteristics) directly to VUFO via pcm@vufo.de. In order to provide uniform definitions for all users the extensions can then be included in the next release.

Description of tables and variables

The following chapters describe the variables in the respective tables as well as their unit and data type. In general, if any information is unknown use the value 99999.

The following abbreviations are used:

- COS – Coordinate system (3-dimensional, cartesian)
- COG – Center Of Gravity
- GPS – Global Positioning System (according to WGS 84)

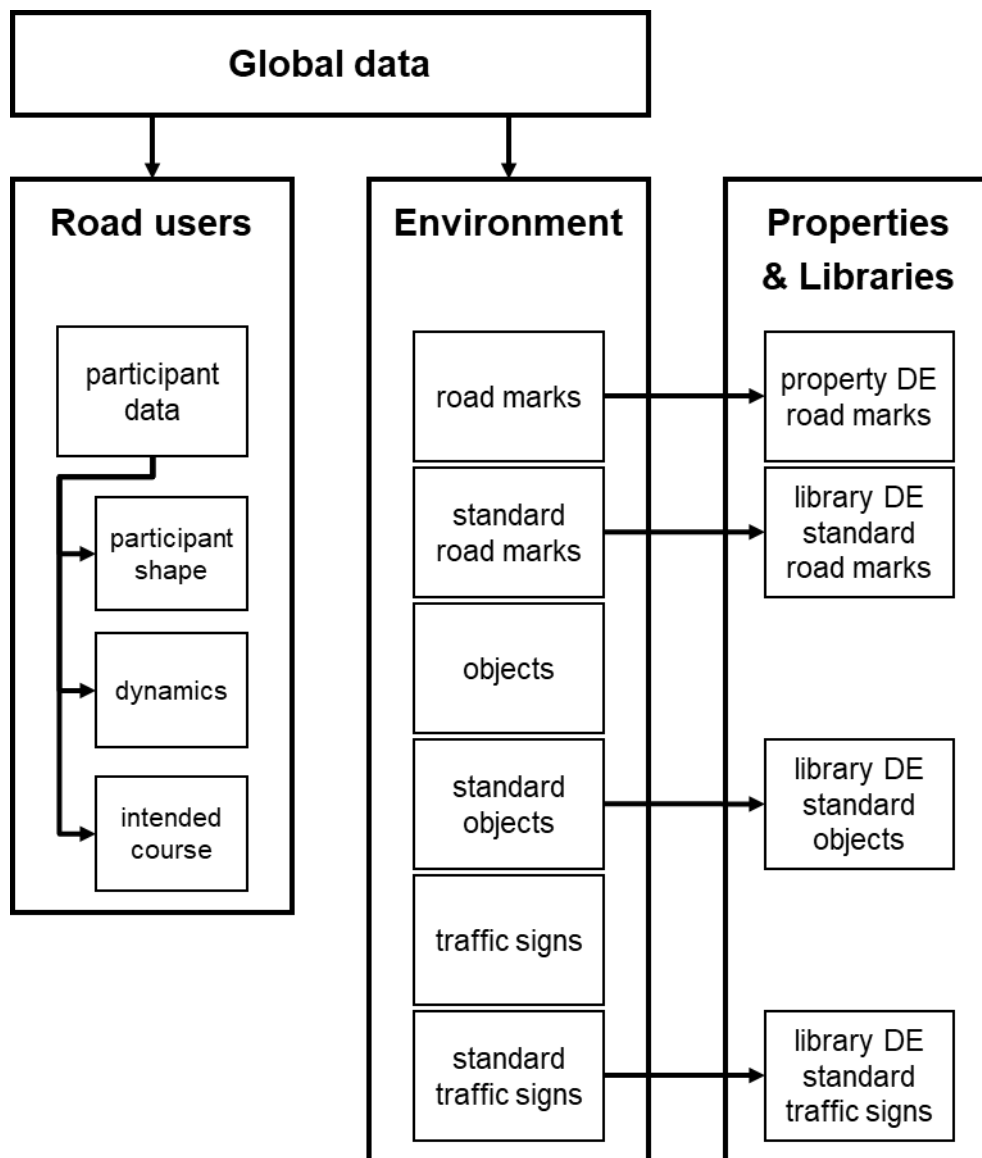


Figure 1: Hierarchical structure of PCM

Global data

Table: global_data

Description: The table global_data provides general information about the accident / scenario.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
DATETIME	Date and time expressed according to ISO 8601:2004 This represents the global zero for all TIME values. Unknown digits may be omitted or expressed by "9" Example: 2019-01-31T11:11:11.111+00:00	[]	Short text
PARTICIP	Number of involved participants	[]	Long int.
SOLVER	Used solver for vehicle dynamics 1 – IPG CarMaker 2 – DSD PC-Crash 3 – AnalyzerPro 4 – Virtual Crash 5 – IPG TruckMaker 6 – IPG MotorcycleMaker 7 – Mechanical Simulation™ CarSim® 8 – Mechanical Simulation™ TruckSim® 9 – Mechanical Simulation™ BikeSim® 10 – Tass International PreScan 11 – dSPACE Automotive Simulation Models (ASM) 12 – TESIS DYNA4 13 – Pro Impact 88888 – other	[]	Long int.
GPSLAT	GPS latitude of global COS according to WGS 84 (decimal, e.g. 51.034186)	[°]	Double
GPSLON	GPS longitude of global COS according to WGS 84 (decimal, e.g. 13.744801)	[°]	Double
GPSELE	Elevation of global COS according to WGS84 reference system (ellipsoidal height)	[m]	Double

Road users

Table: participant_data

Description: The table participant_data contains relevant variables to parametrise participants. This data can be used to model the geometry and further attributes. The variable PARTID is the participant identifier. Consider the table participant_shape to model the participant geometry in detail. The variable PARTTYPE describes the type of road user.

It is recommended to use a local reference COS according to ISO 8855 with the COG as origin.

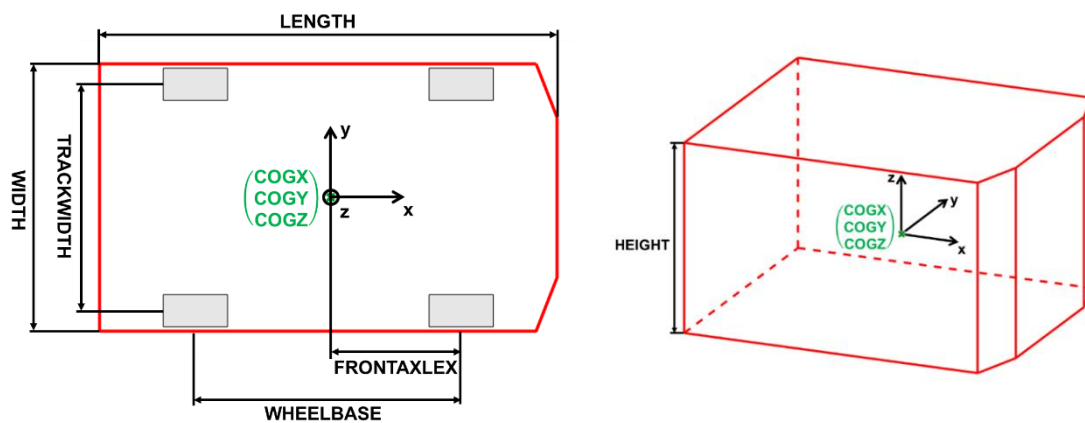


Figure 2: participant definitions

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
PARTID	Participant identifier per CASEID	[]	Long int.
PARTTYPE	Participant type: 0 – passenger car 1 – pedestrian 2 – motorbike 3 – bicycle 4 – truck 5 – bus 6 – tram/train 7 – trailer 8 – camper 9 – agricultural vehicle 10 – construction vehicle	[]	Long int.

	11 – emergency vehicle 12 – large animal 13 – small animal 88888 – other		
LENGTH	Length	[m]	Double
WIDTH	Width	[m]	Double
HEIGHT	Height	[m]	Double
TRACKWIDTH	Track width	[m]	Double
WHEELBASE	Wheelbase	[m]	Double
FRONTAXLEX	Position of front axle in x-direction in reference to participant local coordinate system (participant shape)	[m]	Double
WEIGHT	Weight	[kg]	Double
COGX	x-coordinate of COG in reference to participant local coordinate system (participant shape)	[m]	Double
COGY	y-coordinate of COG in reference to participant local coordinate system (participant shape)	[m]	Double
COGZ	z-coordinate of COG in reference to participant local coordinate system (participant shape)	[m]	Double
IXX	Moment of inertia around x-axis in reference to COG	[kgm ²]	Double
IYY	Moment of inertia around y-axis in reference to COG	[kgm ²]	Double
IZZ	Moment of inertia around z-axis in reference to COG	[kgm ²]	Double

Table: participant_shape

Description: The table participant_shape defines the geometrical shape for each participant by surfaces. Each surface contour is defined by points. Each point is defined by its position $(x \ y \ z)^T$ in reference to the participants local COS.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
PARTID	Participant identifier per CASEID	[]	Long int.
SURFID	Surface identifier per PARTID	[]	Long int.
POINTID	Point identifier per SURFID	[]	Long int.
X	Local x-coordinate	[m]	Double
Y	Local y-coordinate	[m]	Double
Z	Local z-coordinate	[m]	Double

Examples for participant shapes:

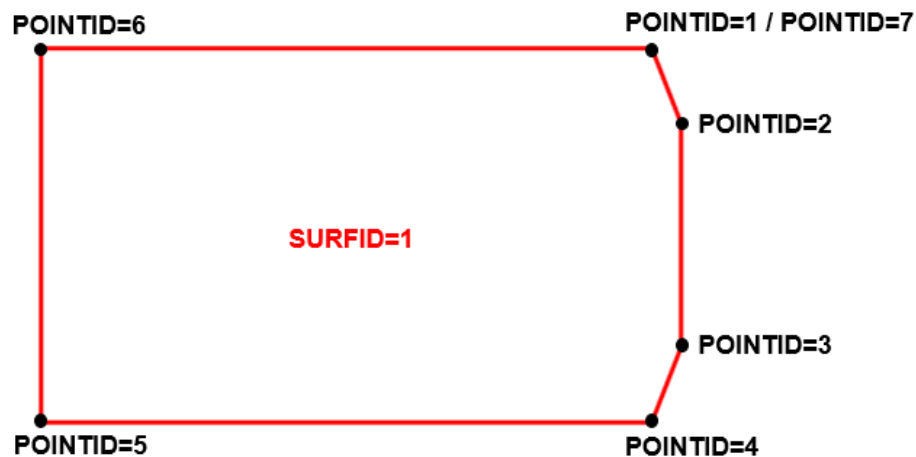


Figure 3: Example for 2D vehicle shape definition of a passenger car

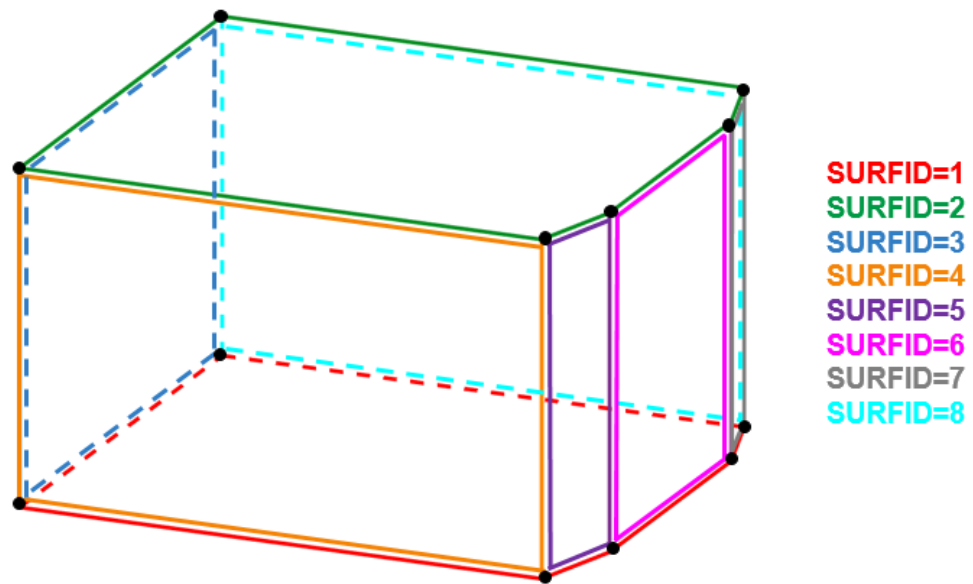


Figure 4: Example for 3D vehicle shape definition of a passenger car

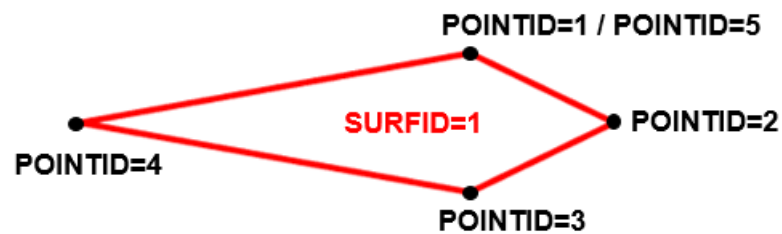


Figure 5: Example for 2D vehicle shape definition of a motorcycle/ bicycle

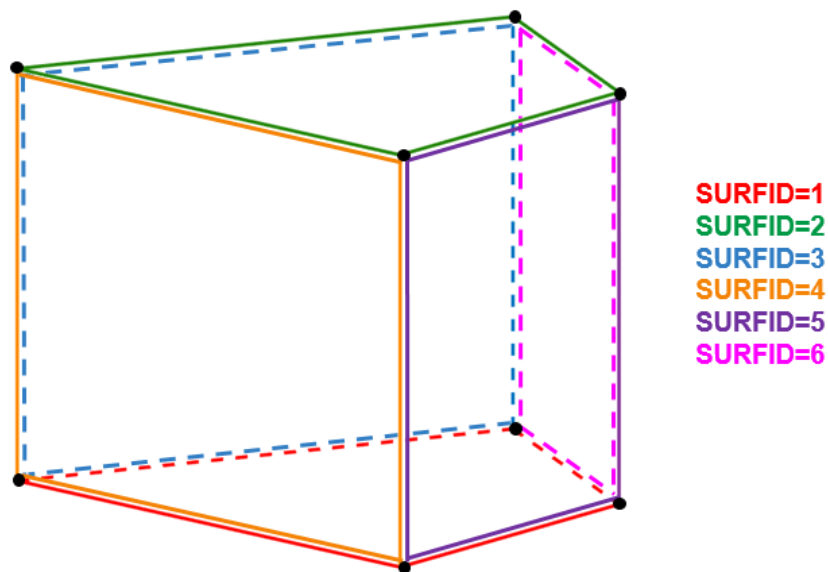


Figure 6: Example for 3D vehicle shape definition of a motorcycle/ bicycle



Figure 7: Example for 2D pedestrian shape definition

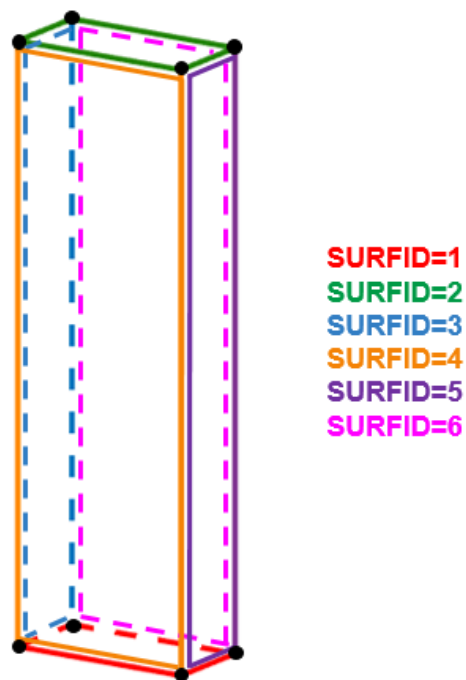


Figure 8: Example for 3D pedestrian shape definition

Table: dynamics

Description: The table dynamics defines the global position of participants $(x \ y \ z \ \Phi \ \Theta \ \Psi)^T$ according to the global COS as well as velocity and acceleration of the participants COG according to the local COS at each time step of the simulation (see Figure 9).

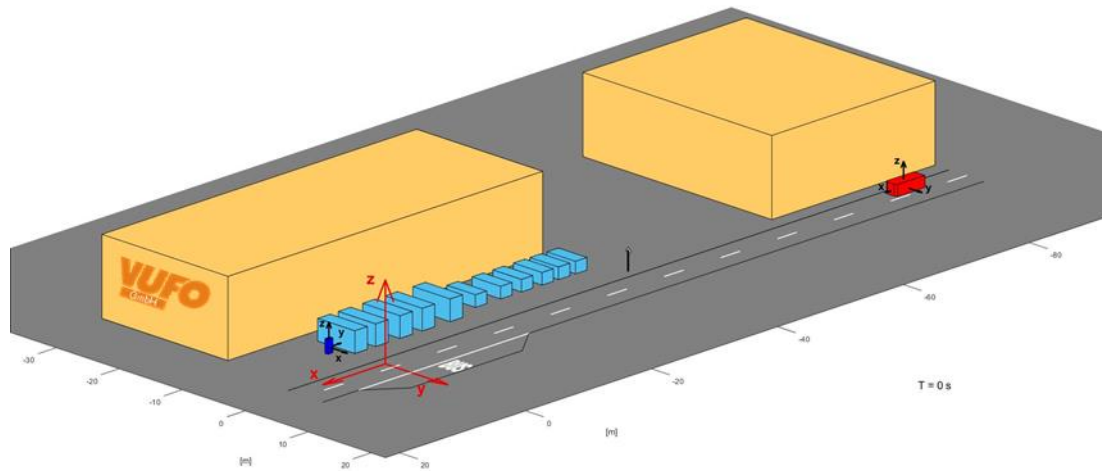


Figure 9: Global (red) and local (black) coordinate systems

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
PARTID	Participant identifier per CASEID	[]	Long int.
VARIATIONID	Variation identifier per PARTID 0 – original accident / scenario ≥ 1 – simulation variation, like additional braking or other	[]	Long int.
TIME	Time step	[s]	Double
POSX	Global x-position of COG	[m]	Double
POSY	Global y-position of COG	[m]	Double
POSZ	Global z-position of COG	[m]	Double
POSPHI	Global roll angle Φ of COG (cardan angles)	[rad]	Double
POSTHETA	Global pitch angle Θ of COG (cardan angles)	[rad]	Double
POSPSI	Global yaw angle Ψ of COG (cardan angles)	[rad]	Double
VX	Velocity of COG in local x-direction	[m/s]	Double
VY	Velocity of COG in local y-direction	[m/s]	Double

VZ	Velocity of COG in local z-direction	[m/s]	Double
AX	Acceleration of COG in local x-direction	[m/s ²]	Double
AY	Acceleration of COG in local y-direction	[m/s ²]	Double
AZ	Acceleration of COG in local z-direction	[m/s ²]	Double
MUE	Coefficient of friction	[]	Double
REC	Reconstruction / data recording availability for the given time step 1 – Values based on reconstruction / data recording 0 – Values based on extension of reconstruction / data recording	[]	Long int.

Table: **intended_course**

Description: The table intended_course defines the course the participant initially intended to follow. The POINTID determines the points with their global position $(x \ y \ z)^T$.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
PARTID	Participant identifier per CASEID	[]	Long int.
VARIATIONID	Variation identifier per PARTID 0 – original accident / scenario ≥ 1 – variation	[]	Long int.
POINTID	Point identifier per VARIATIONID	[]	Long int.
POSX	Global x-coordinate	[m]	Double
POSY	Global y-coordinate	[m]	Double
POSZ	Global z-coordinate	[m]	Double

Environment

Several tables and their link to a respective library or property describe the accident / scenario's environment.

Table: road_marks

Description: The table road_marks is part of the environment description. It defines the relevant boundaries and markings of the road as objects, each with an OBJID as identifier and consisting of points with their position $(x \ y \ z)^T$ in reference to global COS. These are no 3D objects, but they can be positioned in 3D.

The variable OBJTYPE defines the kind of road boundary or marking. The list of possible OBJTYPEs and their definition is given in the table property_DE_road_marks (example for Germany).

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
OBJID	Object identifier per CASEID	[]	Long int.
POINTID	Point identifier per OBJID	[]	Long int.
OBJTYPE	Type of object	[]	Long int.
X	Global x-coordinate	[m]	Double
Y	Global y-coordinate	[m]	Double
Z	Global z-coordinate	[m]	Double

Table: standard_road_marks

Description: The table standard_road_marks is part of the environment description. It defines frequently existing road markings (e.g. turning arrow, bicycle path, “BUS” symbol) each with an OBJID as identifier. The advantage of standard road marks is that they are defined only once and can be used for multiple cases, which saves storage space in the database.

The variable OBJTYPE defines the kind of road mark. The list of possible OBJTYPES and their definition is given in the table library_DE_standard_road_marks (example for Germany).

These are no 3D objects, but can be positioned and scaled in 3D to global COS through its reference point and the scaling factors. See also Appendix A: Advices for positioning objects.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
OBJID	Object identifier per CASEID	[]	Long int.
OBJTYPE	Type of object	[]	Long int.
REFX	Global x-coordinate of reference point	[m]	Double
REFY	Global y-coordinate of reference point	[m]	Double
REFZ	Global z-coordinate of reference point	[m]	Double
REFROTX	Rotation angle around x-axis at reference point (cardan angles)	[rad]	Double
REFROTY	Rotation angle around y-axis at reference point (cardan angles)	[rad]	Double
REFROTZ	Rotation angle around z-axis at reference point (cardan angles)	[rad]	Double
SCALEX	Scaling factor in x-direction at reference point	[]	Double
SCALEY	Scaling factor in y-direction at reference point	[]	Double
SCALEZ	Scaling factor in z-direction at reference point	[]	Double

Table: objects

Description: The table is part of the environment description. It defines the geometrical shape of relevant stationary objects by surfaces. Each surface contour is defined by points. Each point is defined by its position $(x \ y \ z)^T$ in reference to global COS.

The variable OBJTYPE defines the kind of object. The list of possible OBJTYPES is given in the table below.

Comments: In order to provide a uniform table for all users, it is recommended to forward extensions to pcm@vufo.de. The extensions can then be included in a new release.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
OBJID	Object identifier per CASEID	[]	Long int.
SURFID	Surface identifier per OBJID	[]	Long int.
POINTID	Point identifier per SURFID	[]	Long int.
OBJTYPE	Type of object	[]	Long int.
X	Global x-coordinate	[m]	Double
Y	Global y-coordinate	[m]	Double
Z	Global z-coordinate	[m]	Double

List of OBJTYPES:

OBJTYPE	Description
520	Traffic barrier (steel)
521	Traffic barrier (concrete)
522	Traffic barrier (not specified)
523	Traffic pole for guidance, warning and barriers
524	House wall, bridge pier
525	Game fence, wooden fence
526	Bush, hedge
527	Railing
528	Group of trees
529	Railway gate
530	Traffic cone

531	Bus Stop
532	Taxi rank
533	Speed bump
534	Bridge
535	Tunnel
536	Garbage bin / waste basket
537	Earth wall
538	Embankment
549	Other areal objects
599	Objects – not specified

Table: standard_objects

Description: The table standard_objects is part of the environment description. It defines frequently existing stationary objects (e.g. trees, parking vehicles), each with an OBJID as identifier. The advantage of standard objects is that they are defined only once and can be used for multiple cases, which saves storage space in the database.

The variable OBJTYPE defines the kind of object. The list of possible OBJTYPES and their definition is given in the table library_DE_standard_objects (example for Germany).

Each object can be positioned and scaled in 3D to global COS through its reference point and the scaling factors. See also Appendix A: Advices for positioning objects.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
OBJID	Object identifier per CASEID	[]	Long int.
OBJTYPE	Type of object	[]	Long int.
REFX	Global x-Coordinate of reference point	[m]	Double
REFY	Global y-Coordinate of reference point	[m]	Double
REFZ	Global z-Coordinate of reference point	[m]	Double
REFROTX	Global rotation angle around x-axis at reference point (cardan angles)	[rad]	Double
REFROTY	Global rotation angle around y-axis at reference point (cardan angles)	[rad]	Double
REFROTZ	Global rotation angle around z-axis at reference point (cardan angles)	[rad]	Double
SCALEX	Scaling factor in x-direction at reference point	[]	Double
SCALEY	Scaling factor in y-direction at reference point	[]	Double
SCALEZ	Scaling factor in z-direction at reference point	[]	Double

Table: traffic_signs

Description: The table traffic_signs is part of the environment description. It defines the geometrical shape of arbitrary traffic signs by surfaces (be aware of standard traffic signs). Each surface contour is defined by points. Each point is defined by its position $(x \ y \ z)^T$ in reference to global COS.

The variable OBJTYPE defines the kind of object. There is currently no list of possible OBJTYPES beyond the library_DE_standard_traffic_signs.

Comments: In order to provide a uniform table for all users, it is recommended to forward extensions to pcm@vufo.de. The extensions can then be included in a new release.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
OBJID	Object identifier per CASEID	[]	Long int.
SURFID	Surface identifier per OBJID	[]	Long int.
POINTID	Point identifier per SURFID	[]	Long int.
OBJTYPE	Type of object	[]	Long int.
X	Global x-coordinate	[m]	Double
Y	Global y-coordinate	[m]	Double
Z	Global z-coordinate	[m]	Double

Table: standard_traffic_signs

Description: The table standard_traffic_signs is part of the environment description. It defines frequently existing traffic signs, each with an OBJID as identifier. The advantage of standard traffic signs is that they are defined only once and can be used for multiple cases, which saves storage space in the database.

The variable OBJTYPE defines the kind of object. The list of possible OBJTYPES and their definition is given in the table library_DE_standard_traffic_signs (example for Germany).

Each object can be positioned and scaled in 3D to global COS through its reference point and the scaling factors. See also Appendix A: Advices for positioning objects.

Variable	Description	Unit	Type
CASEID	Unique case identifier	[]	Short text
OBJID	Object identifier per CASEID	[]	Long int.
OBJTYPE	Type of object	[]	Long int.
REFX	Global x-coordinate of reference point	[m]	Double
REFY	Global y-coordinate of reference point	[m]	Double
REFZ	Global z-coordinate of reference point	[m]	Double
REFROTX	Rotation angle around x-axis at reference point (cardan angles)	[rad]	Double
REFROTY	Rotation angle around y-axis at reference point (cardan angles)	[rad]	Double
REFROTZ	Rotation angle around z-axis at reference point (cardan angles)	[rad]	Double
SCALEX	Scaling factor in x-direction at reference point	[]	Double
SCALEY	Scaling factor in y-direction at reference point	[]	Double
SCALEZ	Scaling factor in z-direction at reference point	[]	Double

Properties and Libraries

Table: property_DE_road_marks

Description: The table property_DE_road_marks is referred to by table road_marks through OBJTYPE. It defines the width, length and gap of a line and can be used to visualize the various road boundaries and markings.

Comments: Countries-specific road boundaries and markings may be required. Additional properties can be added for this purpose. The format of the library must remain the same. The name of the library should be changed according to the ISO3166 Alpha-2 code.

Example:

Germany: "property_DE_road_marks"

China: "property_CN_road_marks"

...

In order to provide a uniform table for all users, it is recommended to forward extensions to pcm@vufo.de. The extensions can then be included in a new release.

Variable	Description	Unit	Type
OBJTYPE	Type of object	[]	Long int.
DESCRIPTION	Description object	[]	Short text
WIDTH	Width of the line	[m]	Double
LENGTH	Length of line	[m]	Double
GAP	Length of gap	[m]	Double

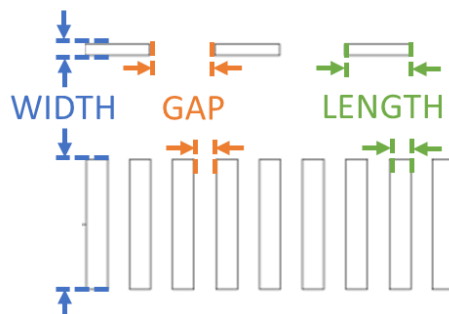


Figure 10: Examples for road marks

Table: library_DE_standard_road_marks

Description: The table library_DE_standard_road_marks defines the general shape of standard road marks (e.g. turning arrow, bicycle path, "BUS" symbol) in Germany and is referred to by standard_road_marks through OBJTYPE.

The variable OBJTYPE defines the kind of road mark. The list of possible OBJTYPES is given in the table below (for Germany). Each OBJTYPE consists of one or several surfaces, each consisting of points with their position $(x \ y \ z)^T$ in reference to local COS (always SURFID = 1, POINTID = 1).

These are no 3D objects, but can be positioned and scaled in 3D to global COS through its reference point and the scaling factors. See also Appendix A: Advices for positioning objects.

Comments: Countries-specific standard road marks may be required. Additional libraries can be added for this purpose. The format of the library must remain the same. The name of the library should be changed according to the ISO3166 Alpha-2 code,

Example:

Germany: "library_DE_standard_road_marks"

China: "library_CN_standard_road_marks"

...

In order to provide a uniform table for all users, it is recommended to forward extensions to pcm@vufo.de. The extensions can then be included in a new release.

Variable	Description	Unit	Type
OBJTYPE	Type of object	[]	Long int.
SURFID	Surface identifier per OBJTYPE	[]	Long int.
POINTID	Point identifier per SURFID	[]	Long int.
X	Local x-coordinate	[m]	Double
Y	Local y-coordinate	[m]	Double
Z	Local z-coordinate	[m]	Double

Table: library_DE_standard_objects

Description: The table library_DE_standard_objects defines the general shape of frequently existing stationary objects in Germany (e.g. trees, parking vehicles) and is referred to by standard_objects through OBJTYPE.

The variable OBJTYPE defines the kind of road mark. The list of possible OBJTYPEs is given in the table below (for Germany). Each OBJTYPE consists of one or several surfaces, each consisting of points with their position $(x \ y \ z)^T$ in reference to local COS (always SURFID = 1, POINTID = 1).

They can be positioned and scaled in 3D in reference to global COS through its reference point and the scaling factors. See also Appendix A: Advices for positioning objects.

Comments: Countries-specific standard road marks may be required. Additional libraries can be added for this purpose. The format of the library must remain the same. The name of the library should be changed according to the ISO3166 Alpha-2 code,

Example:

Germany: "library_DE_standard_objects"

China: "library_CN_standard_objects"

...

In order to provide a uniform table for all users, it is recommended to forward extensions to pcm@vufo.de. The extensions can then be included in a new release.

Variable	Description	Unit	Type
OBJTYPE	Type of object	[]	Long int.
SURFID	Surface identifier per OBJTYPE	[]	Long int.
POINTID	Point identifier per SURFID	[]	Long int.
X	Local x-coordinate	[m]	Double
Y	Local y-coordinate	[m]	Double
Z	Local z-coordinate	[m]	Double

Table: library_DE_standard_traffic_signs

Description: The table library_DE_standard_traffic_signs defines the general shape of frequently existing traffic signs in Germany and is referred to by standard_traffic_signs through OBJTYPE.

The variable OBJTYPE defines the kind of road mark. The list of possible OBJTYPES is given in the table below (for Germany). Each OBJTYPE consists of one or several surfaces, each consisting of points with their position $(x \ y \ z)^T$ in reference to local COS (always SURFID = 1, POINTID = 1).

They can be positioned and scaled in 3D in reference to global COS through its reference point and the scaling factors. See also Appendix A: Advices for positioning objects.

Comments: Countries-specific standard road marks may be required. Additional libraries can be added for this purpose. The format of the library must remain the same. The name of the library should be changed according to the ISO3166 Alpha-2 code,

Example:

Germany: "library_DE_standard_traffic_signs"

China: "library_CN_standard_traffic_signs"

...

In order to provide a uniform table for all users, it is recommended to forward extensions to pcm@vufo.de. The extensions can then be included in a new release.

Variable	Description	Unit	Type
OBJTYPE	Type of object	[]	Long int.
SURFID	Surface identifier per OBJTYPE	[]	Long int.
POINTID	Point identifier per SURFID	[]	Long int.
X	Local x-coordinate	[m]	Double
Y	Local y-coordinate	[m]	Double
Z	Local z-coordinate	[m]	Double

Appendix A: Advices for positioning objects

SCALING

- Take x-, y-, and z-coordinates from library for concerning OBJID (e.g. library_DE_standard_objects) and multiply by scaling factor 'SCALEX', 'SCALEY', 'SCALEZ':

$$x_{sijk} = SCALEX_i \cdot x_{ijk} ,$$

$$y_{sijk} = SCALEY_i \cdot y_{ijk} ,$$

$$z_{sijk} = SCALEZ_i \cdot z_{ijk} ,$$

for all $i \in OBJID$, $j \in SURFNO$, $k \in POINTNO$

ROTATION

- Define matrix R_x for rotation around the x-axis by 'REFROTX':

$$R_x(\alpha_i) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos \alpha_i & -\sin \alpha_i \\ 0 & \sin \alpha_i & \cos \alpha_i \end{pmatrix} , \text{ where } \alpha_i = \text{REFROTX}_i$$

- Define matrix R_y for rotation around the y-axis by 'REFROTY':

$$R_y(\beta_i) = \begin{pmatrix} \cos \beta_i & 0 & \sin \beta_i \\ 0 & 1 & 0 \\ -\sin \beta_i & 0 & \cos \beta_i \end{pmatrix} , \text{ where } \beta_i = \text{REFROTY}_i$$

- Define matrix R_z for rotation around the z-axis by 'REFROTZ':

$$R_z(\gamma_i) = \begin{pmatrix} \cos \gamma_i & -\sin \gamma_i & 0 \\ \sin \gamma_i & \cos \gamma_i & 0 \\ 0 & 0 & 1 \end{pmatrix} , \text{ where } \gamma_i = \text{REFROTZ}_i$$

The rotation is composed of the rotation matrices multiplied by the x-, y-, z-coordinates.

$$\begin{pmatrix} x_{rijk}, y_{rijk}, z_{rijk} \end{pmatrix}^T = R_z(\gamma_i) \cdot R_y(\beta_i) \cdot R_x(\alpha_i) \cdot \begin{pmatrix} x_{sijk}, y_{sijk}, z_{sijk} \end{pmatrix}^T$$

for all $i \in OBJID$, $j \in SURFNO$, $k \in POINTNO$

TRANSLATION

- Translate x-, y-, z-coordinates by vector ('REFX', 'REFY', 'REFZ'):

$$\begin{pmatrix} x_{tijk}, y_{tijk}, z_{tijk} \end{pmatrix} = \begin{pmatrix} x_{rijk}, y_{rijk}, z_{rijk} \end{pmatrix} + \begin{pmatrix} x_{ref_i}, y_{ref_i}, z_{ref_i} \end{pmatrix} ,$$

for all $i \in OBJID$, $j \in SURFNO$, $k \in POINTNO$

Appendix B: List of object types (OBJTYPES)

Table: property_DE_road_marks

List of OBJTYPE:

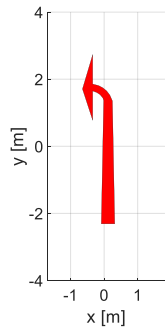
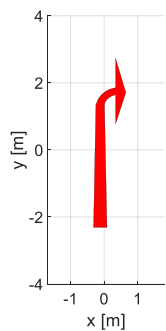
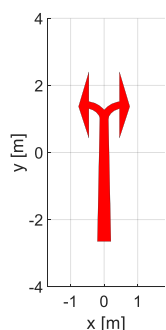
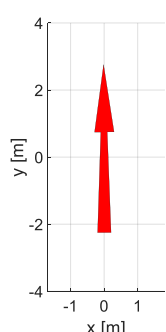
OBJTYPE	DESCRIPTION	WIDTH	LENGTH	GAP
<i>General</i>				
101	Roadside (e.g. curb)	-	-	-
102	Continuous to indicate stopping restriction (e.g. zigzag pattern)	0.12	-	-
103	Continuous for barred areas	0.5	-	-
104	Continuous for cyclists	0.25	-	-
105	Interrupted for cyclists	0.25	1	2
106	Interrupted for cyclists	0.25	0.5	0.5
107	Lateral, interrupted for cyclists	0.25	0.5	0.2
108	Lateral, continuous for stopping traffic (e.g. at stop signs, traffic lights, railway crossing signs)	0.5	-	-
109	Lateral, interrupted for turning events	0.5	0.5	0.25
110	Lateral, interrupted for pedestrians (e.g. at traffic lights)	0.12	0.5	0.2
111	Lateral, interrupted for pedestrians (crosswalk)	3	0.5	0.5
112	Railway tracks	-	-	-
114	Parking lot	-	-	-
115	Interrupted for cyclists	0.12	1	1
116	Lane Marking without white marking (e.g. with stones for parking spaces or bus stops)	-	-	-
196	Former marks continuous	-	-	-
197	Former marks of the road edge	-	-	-
198	Former marks interrupted short	-	-	-
199	Former marks interrupted long	-	-	-
<i>Urban</i>				
201	Continuous road edge	0.25	-	-
202	Interrupted road edge (no junction)	0.25	1	0.5

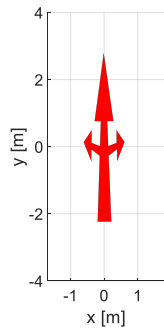
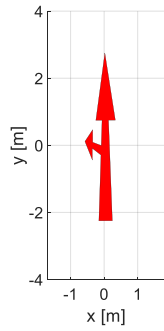
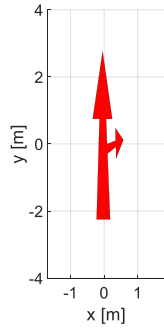
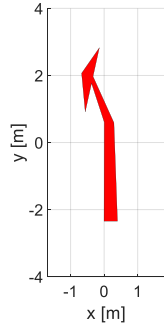
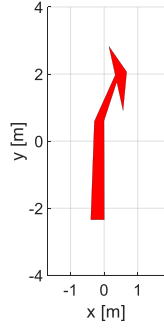
203	Interrupted road edge (junction area)	0.25	3	3
204	Interrupted road edge (close to junction area)	0.25	1.5	1.5
205	Continuous lane marking	0.12	-	-
206	Guiding marks (no junction)	0.12	3	6
207	Guiding marks (in general)	0.12	3	1.5
208	Guiding marks (junction area)	0.12	3	3
209	Interrupted road edge (junction area)	0.12	1.5	1.5
<i>Extra urban</i>				
221	Continuous road edge	0.25	-	-
222	Interrupted road edge (junction area)	0.25	3	3
223	Interrupted road edge (close to junction area)	0.25	1.5	1.5
224	Continuous lane marking	0.12	-	-
225	Guiding marks (no junction)	0.12	4	8
226	Guiding marks (in general)	0.12	4	2
227	Guiding marks (junction area)	0.12	3	3
<i>Motorway</i>				
241	Continuous road edge	0.3	-	-
242	Interrupted road edge (junction area)	0.3	6	6
243	Continuous lane marking	0.15	-	-
244	Guiding marks (no junction)	0.15	6	12
245	Guiding marks (in general)	0.15	6	3
246	Guiding marks (connecting ramp, adjunct lane)	0.15	6	6
<i>Construction site</i>				
261	Continuous road edge	0.25	-	-
262	Interrupted road edge (close to junction) – urban	0.25	1.5	1.5
263	Interrupted road edge (junction area) – extra urban	0.25	3	3
264	Interrupted road edge (junction area) – motorway	0.3	6	6
265	Guiding marks (no junction) – urban	0.12	3	6
266	Guiding marks (junction area) – urban	0.12	3	3

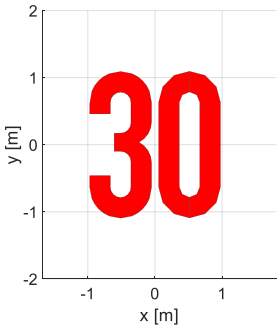
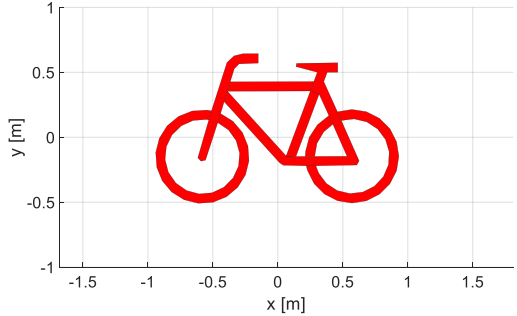
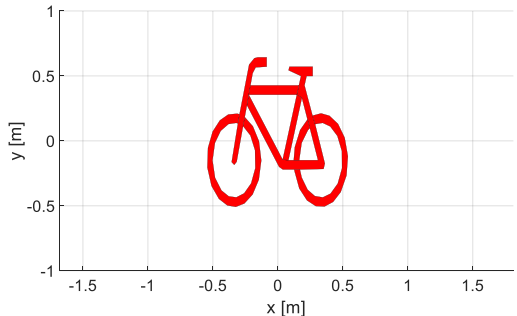
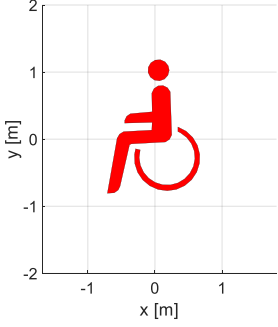
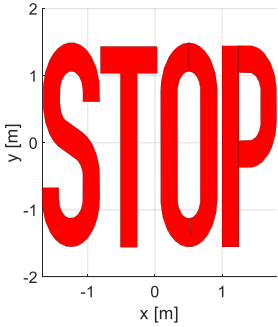
267	Guiding marks (no junction) – extra urban	0.12	4	8
268	Guiding marks (no junction) – motorway	0.15	6	12
269	Interrupted marks for bicycle / pedestrian passage	0.25	0.5	0.2
270	Lateral, continuous for stopping traffic (e.g. at stop signs, traffic lights, railway crossing signs)	0.5	-	-
271	not specified	-	-	-
<i>Roadside</i>				
401	Pavement	-	-	-
402	Bicycle path	-	-	-
405	Combined bicycle pedestrian path	-	-	-

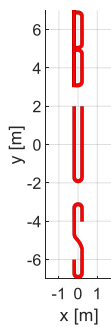
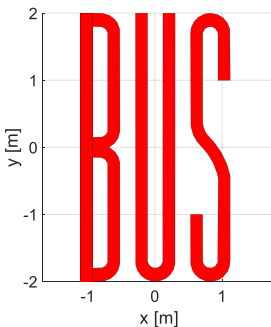
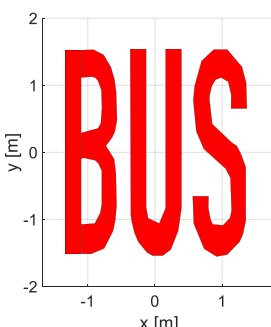
Table: library_DE_standard_road_marks

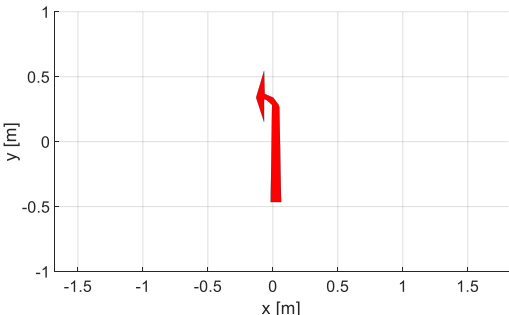
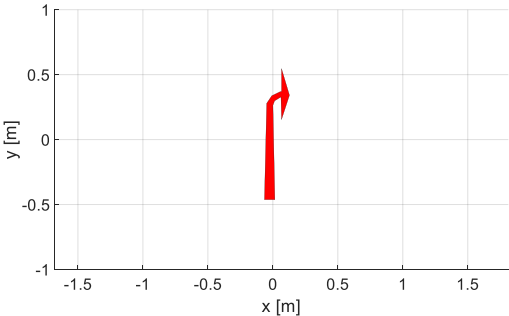
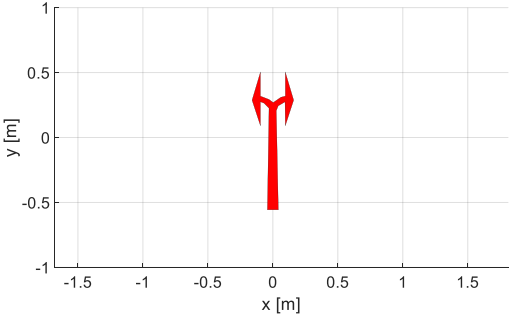
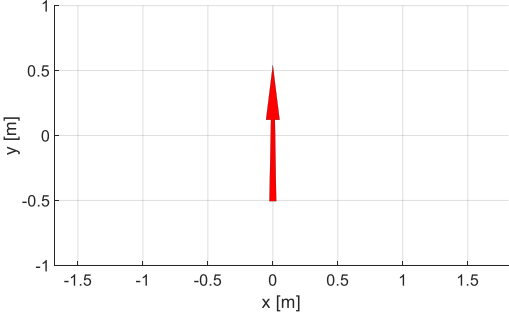
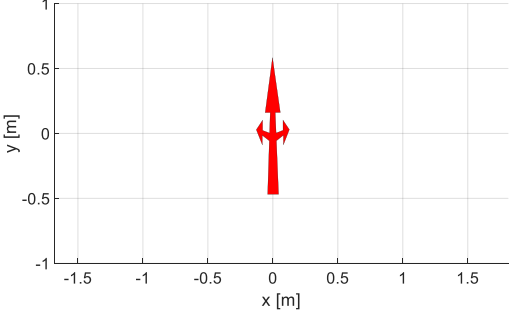
List of OBJTYPE:

OBJTYPE	Description	Pictogram
301	Arrow to turn left	 A red arrow pointing upwards from the bottom center (0, -2) to (0, 2), then curving 90 degrees to the left to point towards (-1, 2). The coordinate system has x and y axes from -1 to 1 and -4 to 4 respectively.
302	Arrow to turn right	 A red arrow pointing upwards from the bottom center (0, -2) to (0, 2), then curving 90 degrees to the right to point towards (1, 2). The coordinate system has x and y axes from -1 to 1 and -4 to 4 respectively.
303	Arrow to turn left and right	 A red arrow pointing upwards from the bottom center (0, -2) to (0, 2), then splitting into two branches: one curving 90 degrees to the left to point towards (-1, 2) and the other curving 90 degrees to the right to point towards (1, 2). The coordinate system has x and y axes from -1 to 1 and -4 to 4 respectively.
304	Arrow to go straight	 A red arrow pointing straight upwards from the bottom center (0, -2) to (0, 2). The coordinate system has x and y axes from -1 to 1 and -4 to 4 respectively.

305	Arrow to go straight and to turn left and right	
306	Arrow to go straight and turn left	
307	Arrow to go straight and turn right	
308	Preliminary arrow to turn left	
309	Preliminary arrow to turn right	
310	Pictogram velocity 20	

311	Pictogram velocity 30	
312	Pictogram velocity 50	
313	Pictogram bikeway 1	
314	Pictogram bikeway 2	
315	Pictogram wheelchair	
316	Pictogram STOP	

317	Pictogram BUS 1	
318	Pictogram BUS 2	
319	Pictogram BUS 3	

320	Bicycle arrow to turn left	
321	Bicycle arrow to turn right	
322	Bicycle arrow to turn left and right	
323	Bicycle arrow to go straight	
324	Bicycle arrow to go straight and to turn left and right	

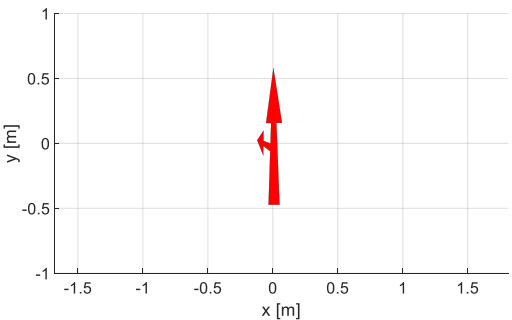
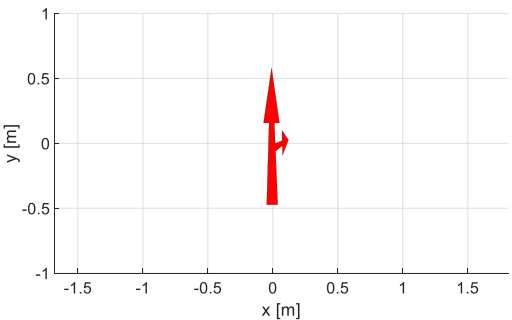
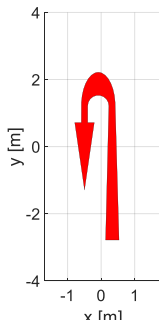
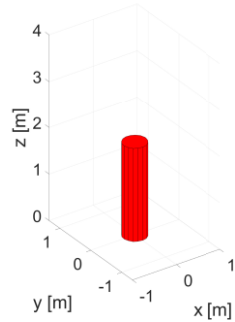
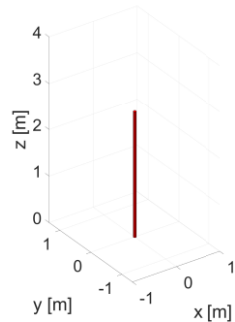
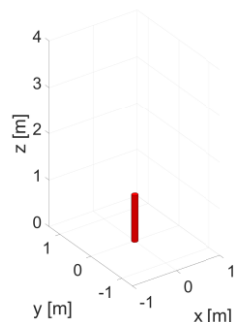
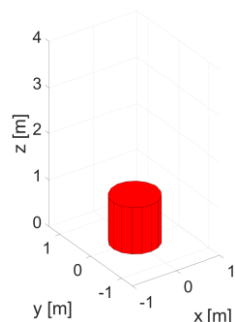
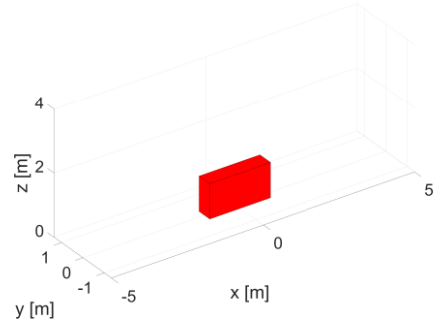
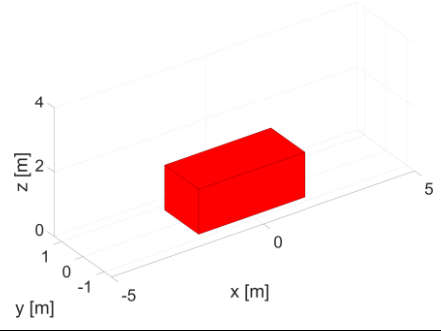
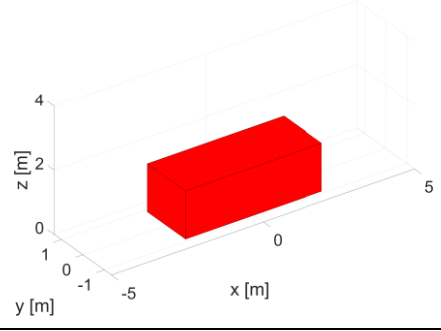
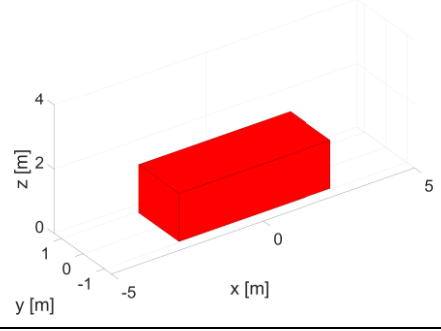
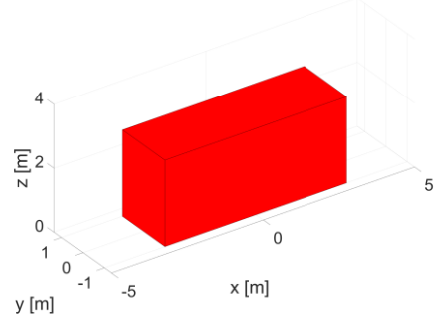
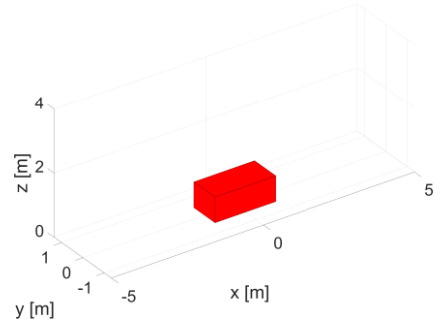
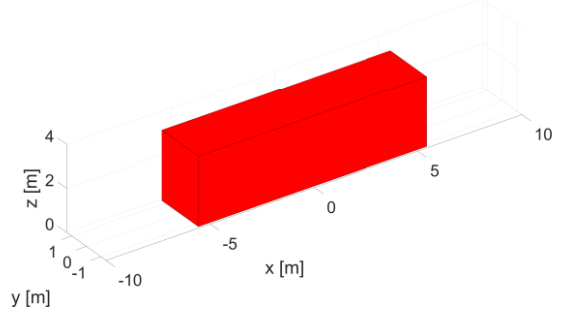
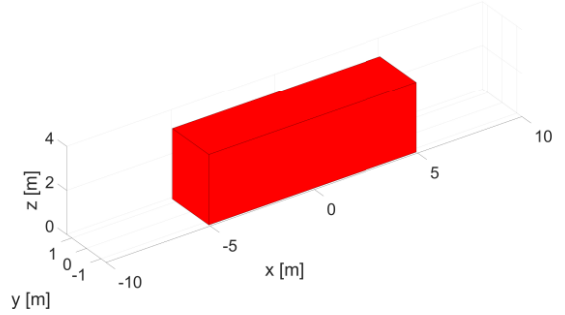
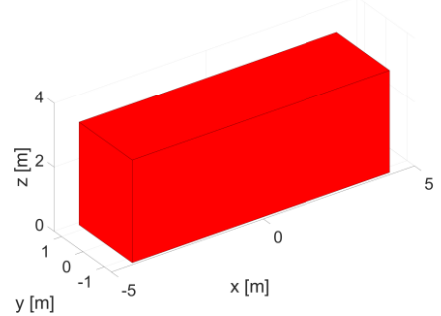
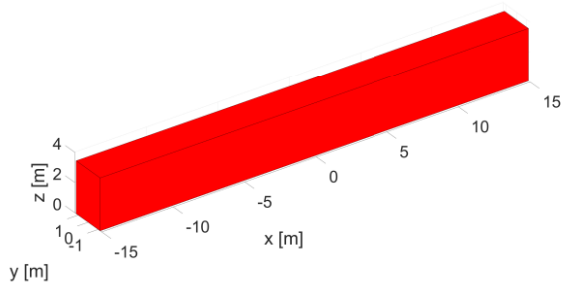
325	Bicycle arrow to go straight and turn left	 <p>A red arrow pointing straight up from y = -0.5 to y = 0.5 on the y-axis (x = 0). At y = 0.5, the arrow turns 90 degrees to the left, pointing towards x = -0.5. The plot has x and y axes ranging from -1.5 to 1.5 with grid lines every 0.5 units.</p>
326	Bicycle arrow to go straight and turn right	 <p>A red arrow pointing straight up from y = -0.5 to y = 0.5 on the y-axis (x = 0). At y = 0.5, the arrow turns 90 degrees to the right, pointing towards x = 0.5. The plot has x and y axes ranging from -1.5 to 1.5 with grid lines every 0.5 units.</p>
327	Arrow to turn around	 <p>A red arrow pointing straight down from y = 2 to y = -3 on the y-axis (x = 0). At y = -3, the arrow turns 180 degrees, pointing straight up to y = 2. The plot has x and y axes ranging from -1 to 1 with grid lines every 1 unit.</p>

Table: library_DE_standard_objects

List of OBJTYPE:

OBJTYPE	Description	Pictogram
501	Tree trunk (w/o crown)	 A 3D coordinate system with x, y, and z axes ranging from -1 to 1. A red cylinder representing a tree trunk is positioned at the origin (0,0,0), extending vertically along the z-axis from approximately z=0.5 to z=1.5.
502	Pole of wood, concrete or steel	 A 3D coordinate system with x, y, and z axes ranging from -1 to 1. A thin red vertical line representing a pole is positioned at the origin (0,0,0), extending along the z-axis from approximately z=0.5 to z=2.5.
503	Reflector post	 A 3D coordinate system with x, y, and z axes ranging from -1 to 1. A short red vertical line representing a reflector post is positioned at the origin (0,0,0), extending along the z-axis from approximately z=0.5 to z=0.8.
519	Other round objects	 A 3D coordinate system with x, y, and z axes ranging from -1 to 1. A red cylinder representing a round object is positioned at the origin (0,0,0), extending vertically along the z-axis from approximately z=0.5 to z=1.5.

550	Standing motorcycle	 A 3D coordinate system with x, y, and z axes. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. A small red rectangular bounding box is positioned at approximately x=[-1, 1], y=[0, 0], and z=[1, 2].
551	Standing passenger car - small	 A 3D coordinate system with x, y, and z axes. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. A red rectangular bounding box is positioned at approximately x=[-1, 2], y=[0, 0], and z=[1, 3].
552	Standing passenger car - medium	 A 3D coordinate system with x, y, and z axes. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. A red rectangular bounding box is positioned at approximately x=[-1, 3], y=[0, 0], and z=[1, 3.5].
553	Standing passenger car - large	 A 3D coordinate system with x, y, and z axes. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. A red rectangular bounding box is positioned at approximately x=[-1, 3.5], y=[0, 0], and z=[1, 3.5].
554	Standing transporter	 A 3D coordinate system with x, y, and z axes. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. A large red rectangular bounding box is positioned at approximately x=[-1, 4], y=[0, 0], and z=[1, 4].

555	Standing trailer	 <p>A 3D plot showing a small red rectangular prism representing a standing trailer. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. The prism is positioned at approximately x=0, y=0, and z=1.</p>
556	Standing bus	 <p>A 3D plot showing a red rectangular prism representing a standing bus. The x-axis ranges from -10 to 10, the y-axis from -1 to 1, and the z-axis from 0 to 4. The prism is positioned at approximately x=0, y=0, and z=1.</p>
557	Standing truck	 <p>A 3D plot showing a red rectangular prism representing a standing truck. The x-axis ranges from -10 to 10, the y-axis from -1 to 1, and the z-axis from 0 to 4. The prism is positioned at approximately x=0, y=0, and z=1.</p>
558	Standing truck trailer	 <p>A 3D plot showing a red rectangular prism representing a standing truck trailer. The x-axis ranges from -5 to 5, the y-axis from -1 to 1, and the z-axis from 0 to 4. The prism is positioned at approximately x=0, y=0, and z=1.</p>
559	Standing tram Dresden	 <p>A 3D plot showing a red rectangular prism representing a standing tram. The x-axis ranges from -15 to 15, the y-axis from -1 to 1, and the z-axis from 0 to 4. The prism is positioned at approximately x=0, y=0, and z=1.</p>

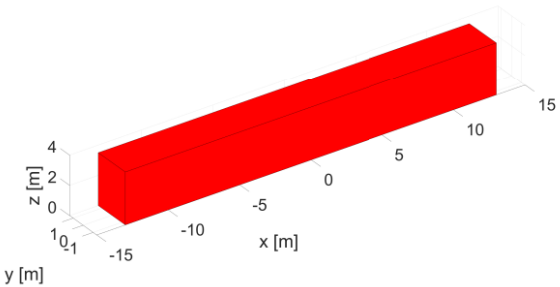
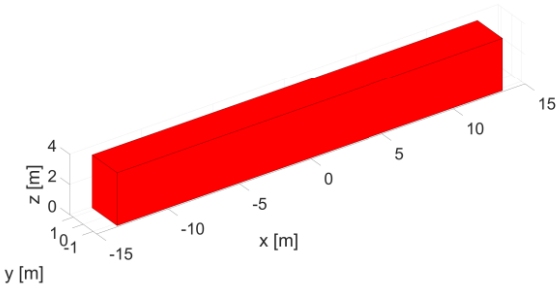
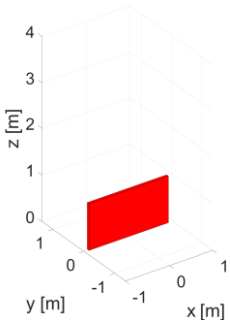
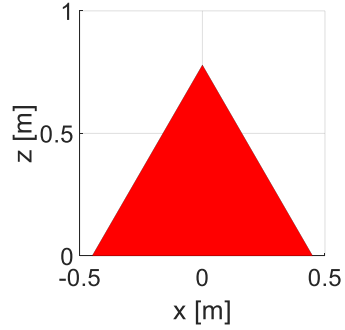
560	Standing tram Hanover 1	
561	Standing tram Hanover 2	
562	Standing bicycle	

Table: library_DE_standard_traffic_signs

Description: The library of German standard traffic signs is based on the specifications of the Bundesanstalt für Straßenwesen (Status: 2019). For an assignment of the official number, see:

https://www.bast.de/BAST_2017/DE/Verkehrstechnik/Fachthemen/v1-verkehrszeichen/vz-download.html?nn=1817946

List of OBJTYPE:

OBJTYPE	Description / Official no.*	Pictogram
1001	101	
1002	101-10	
1003	101-11	
1004	101-12	
1005	101-13	
1006	101-14	
1007	101-15	
1008	101-20	
1009	101-21	
1010	101-22	

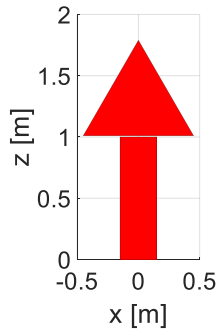
1011	101-23	
1012	101-24	
1013	101-25	
1014	101-51	
1015	101-52	
1016	101-53	
1017	101-54	
1018	101-55	
1019	102	
1020	103-10	
1021	103-20	
1022	105-10	
1023	105-20	
1024	108-4	

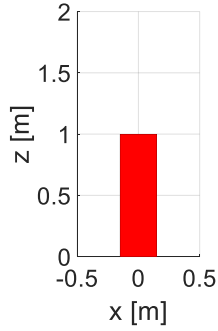
1025	108-5	
1026	108-6	
1027	108-7	
1028	108-8	
1029	108-9	
1030	108-10	
1031	108-11	
1032	108-12	
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1034	108-14	
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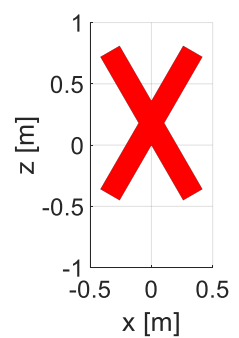
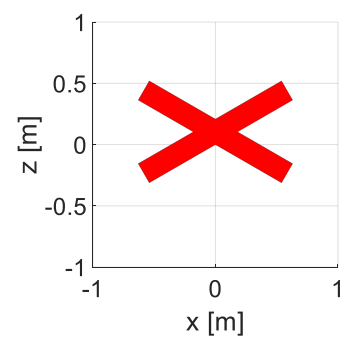
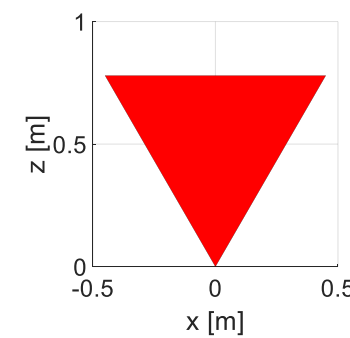
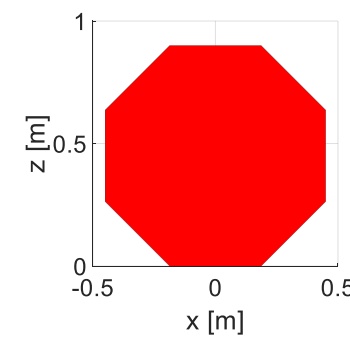
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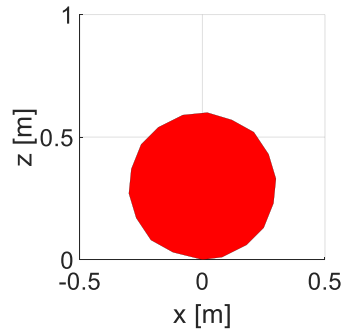
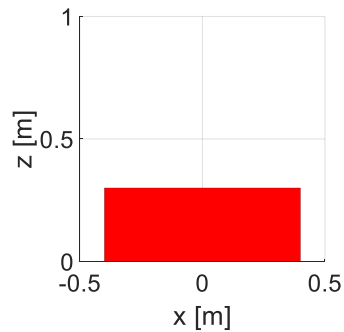
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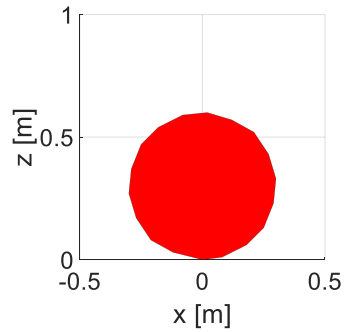
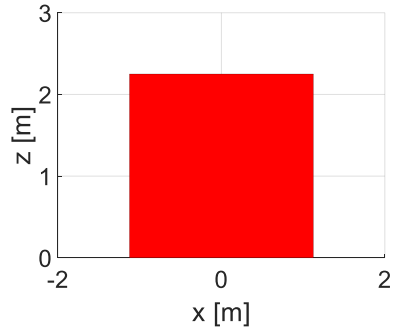
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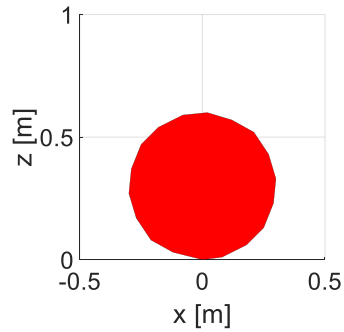
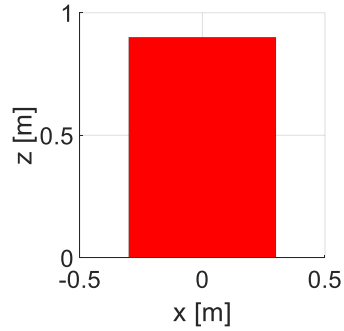
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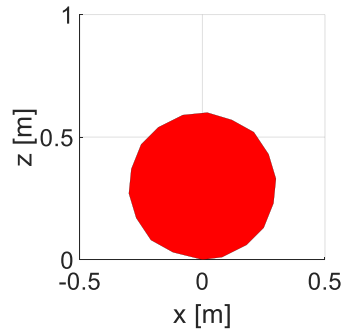
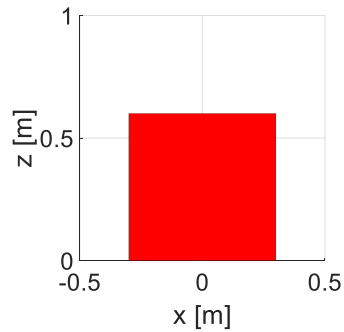
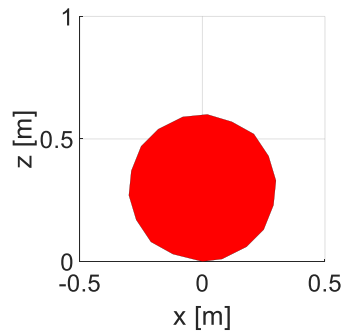
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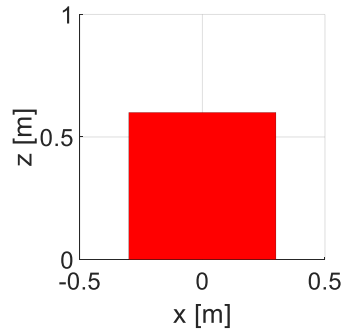
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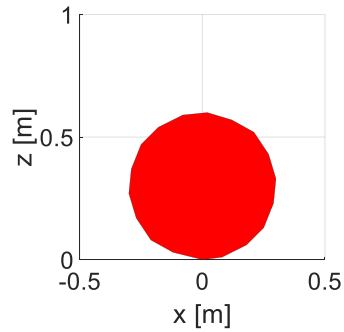
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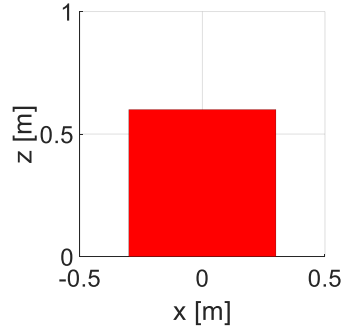
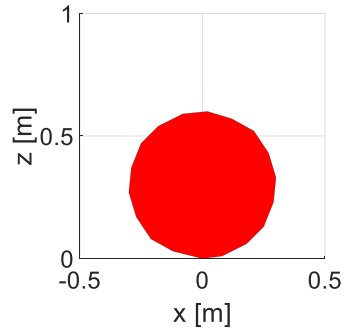
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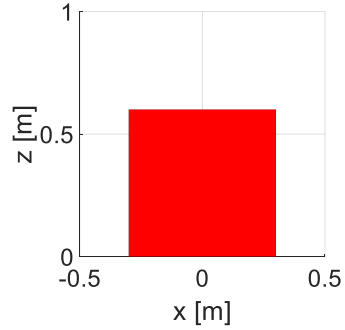
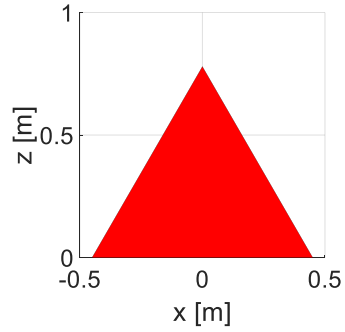
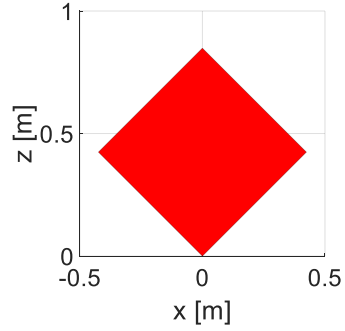
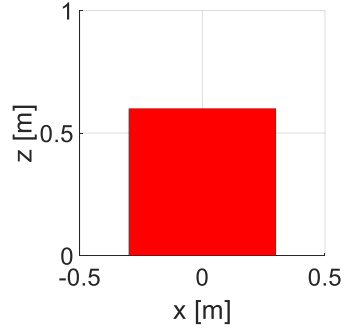
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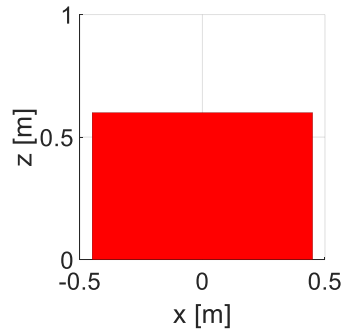
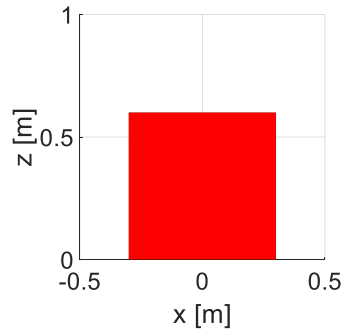
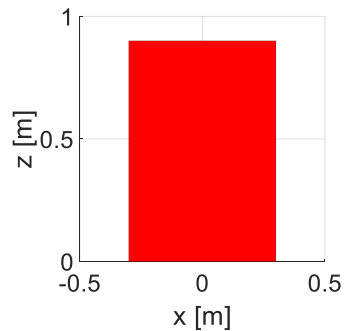
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1208	274.1-41	
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1210	274.2-20	
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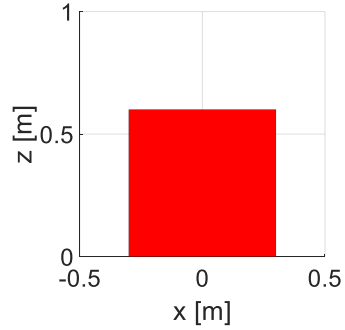
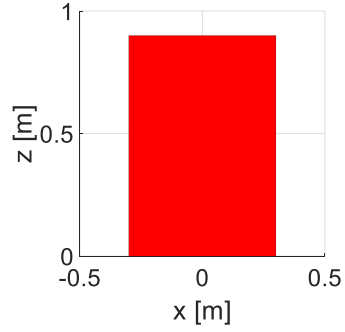
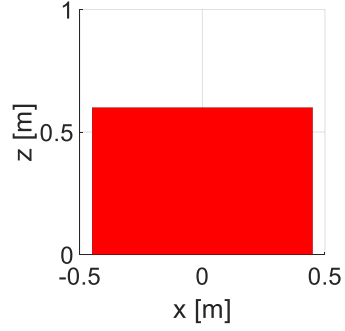
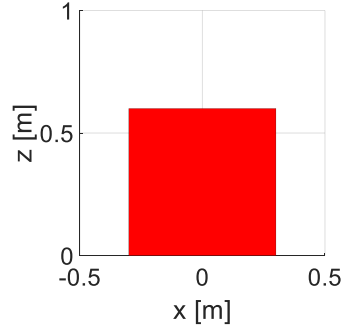
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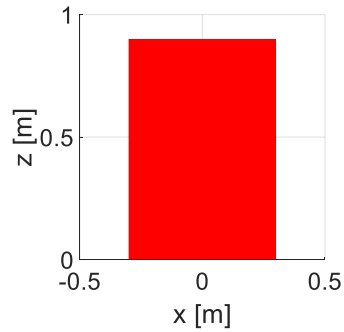
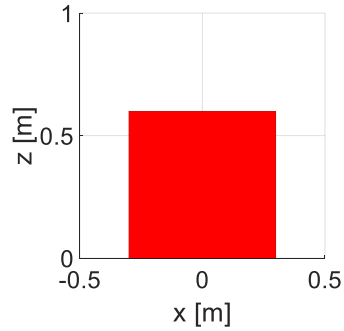
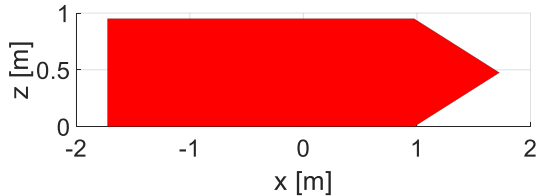
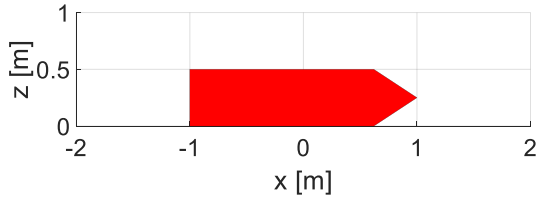
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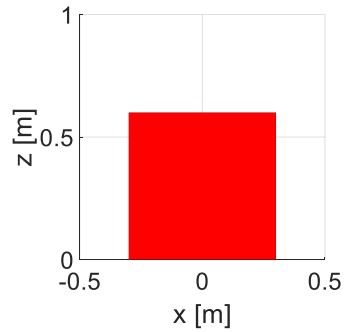
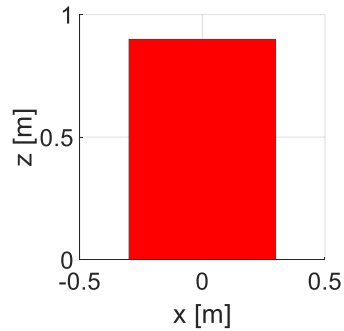
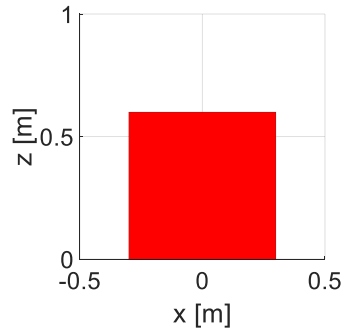
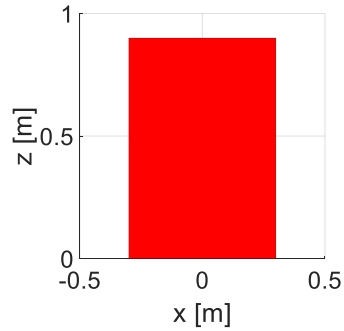
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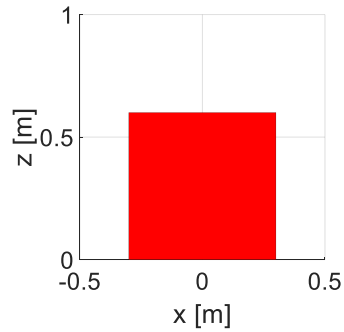
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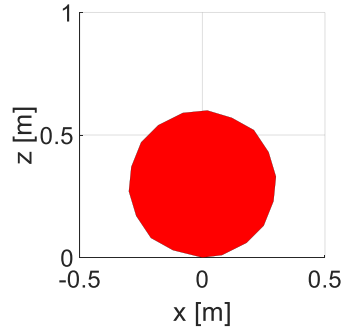
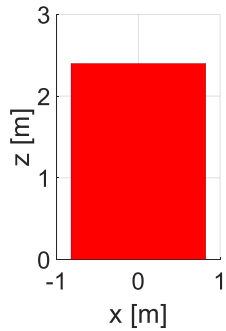
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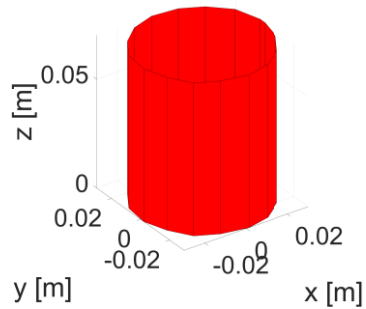
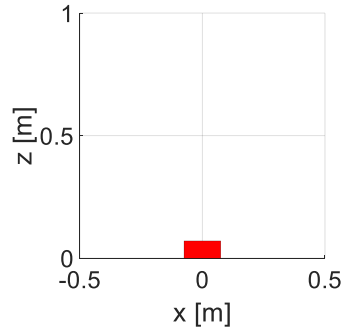
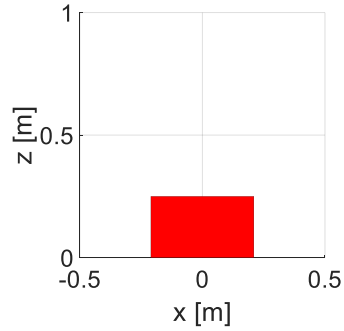
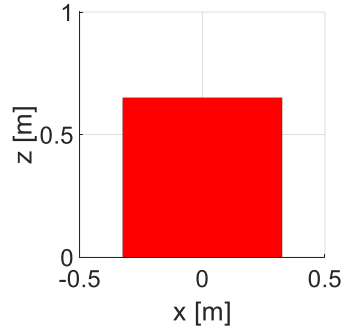
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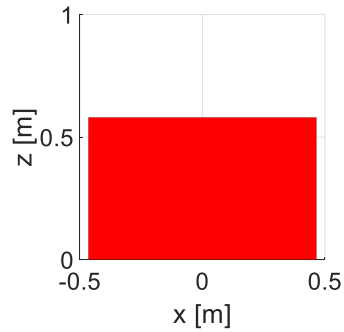
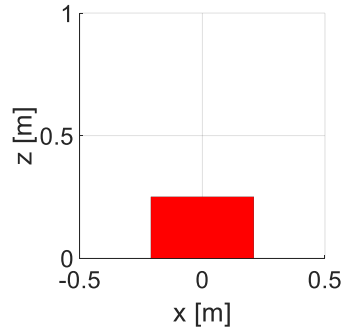
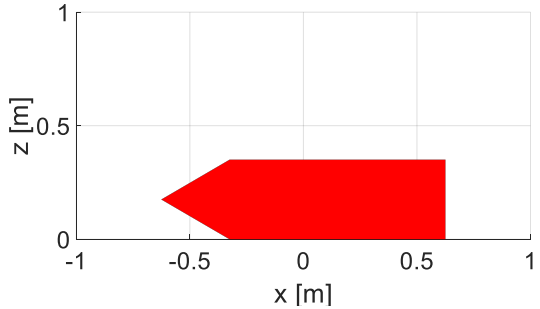
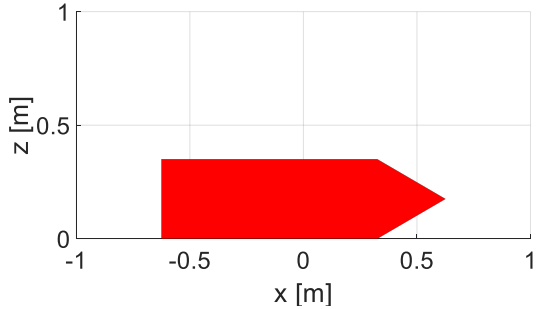
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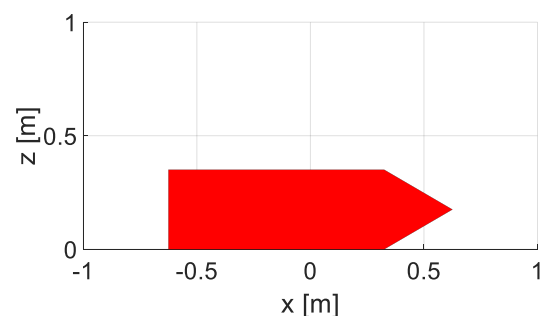
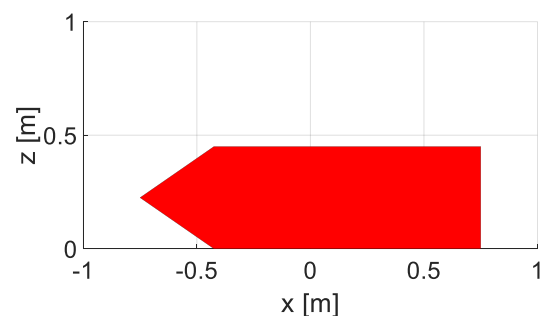
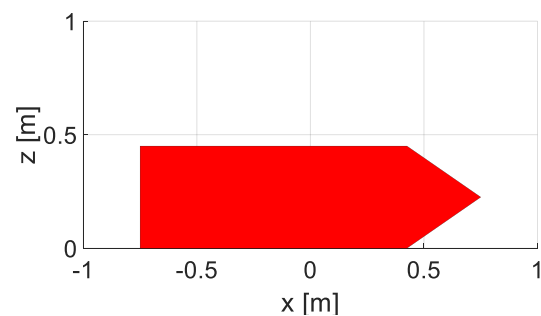
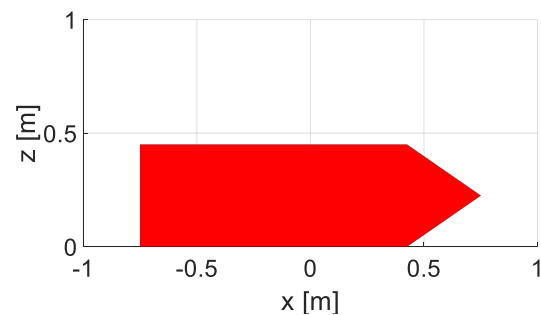
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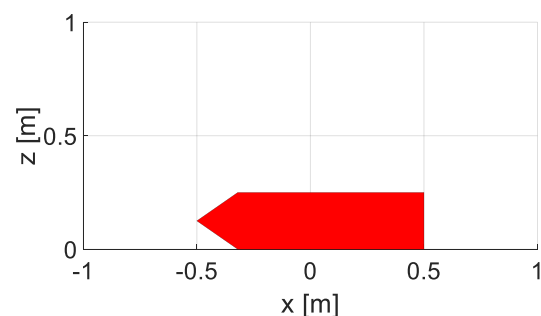
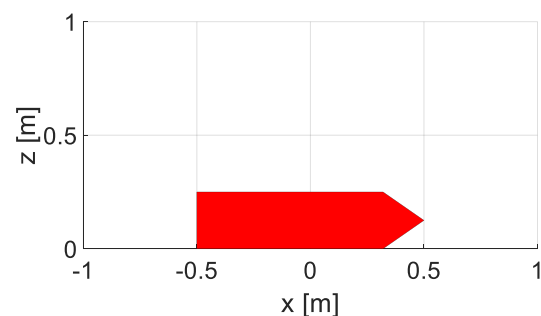
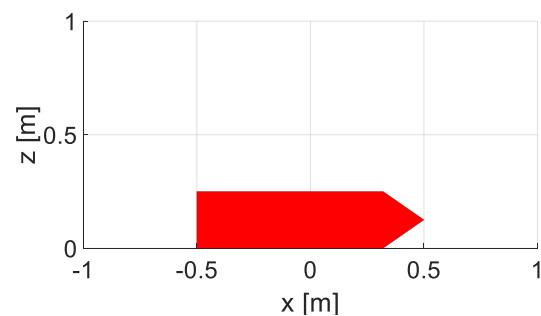
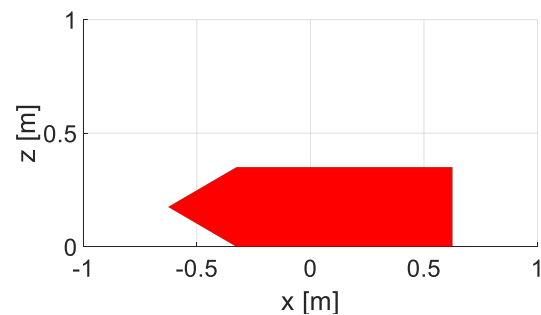
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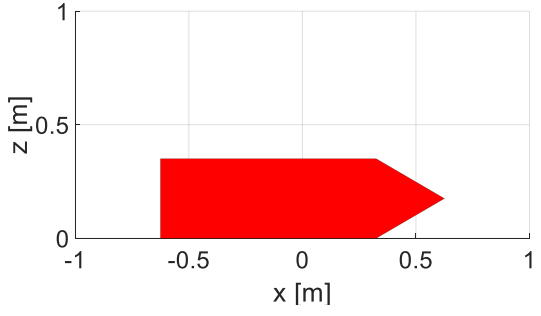
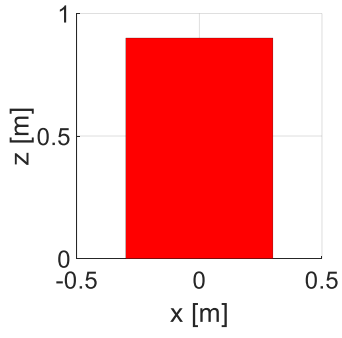
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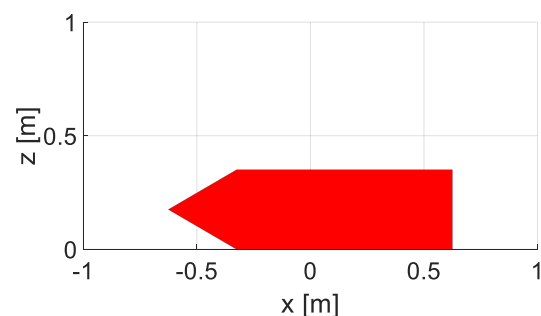
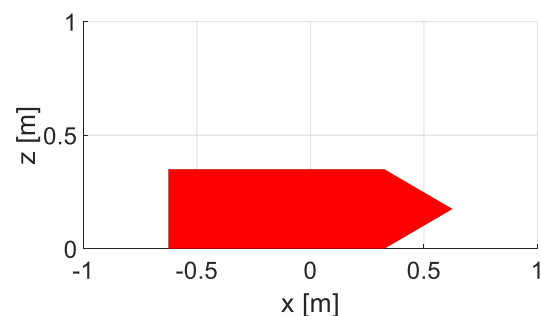
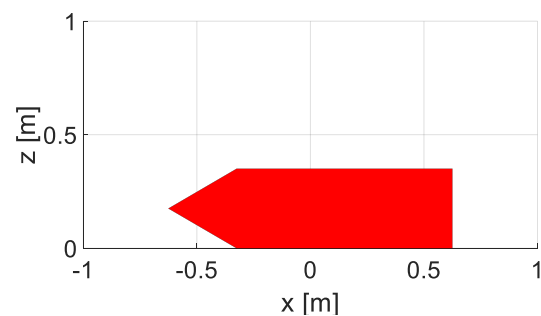
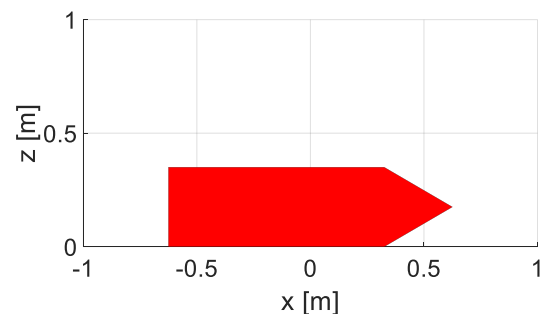
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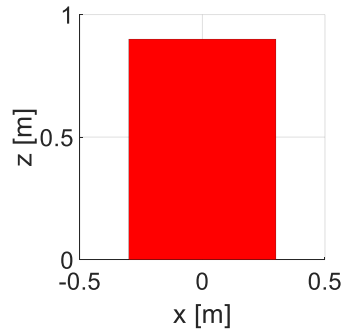
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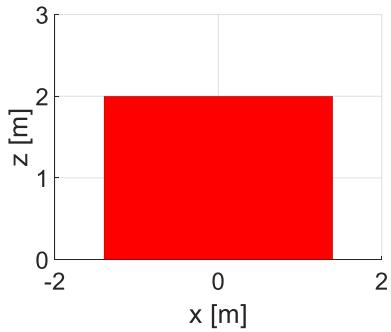
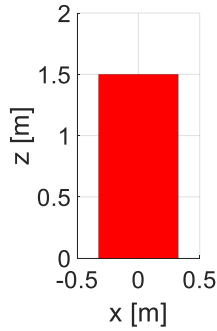
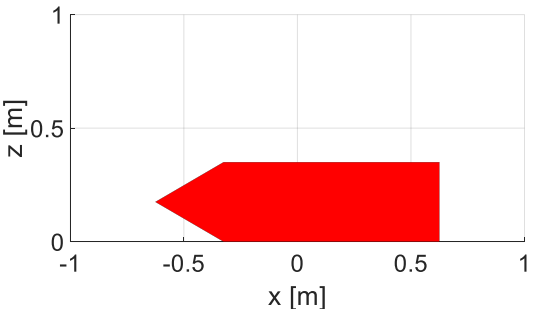
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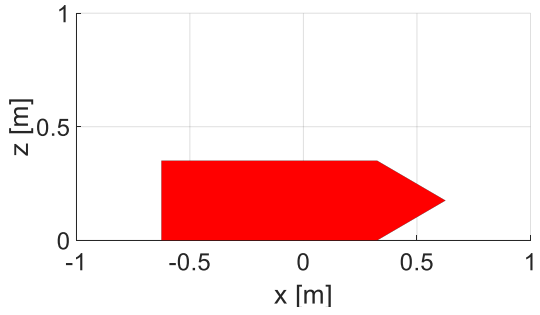
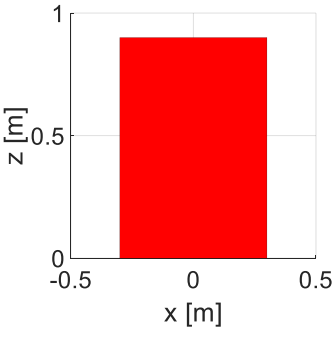
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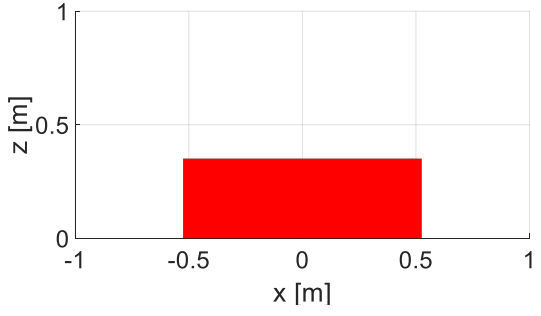
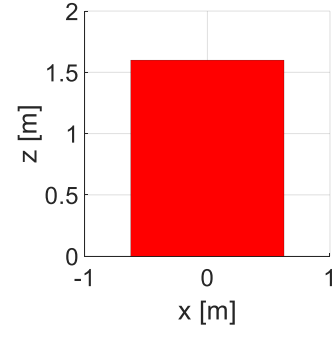
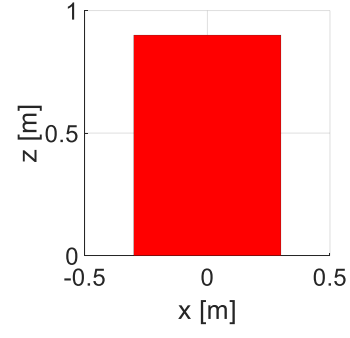
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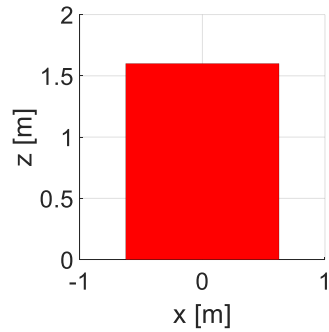
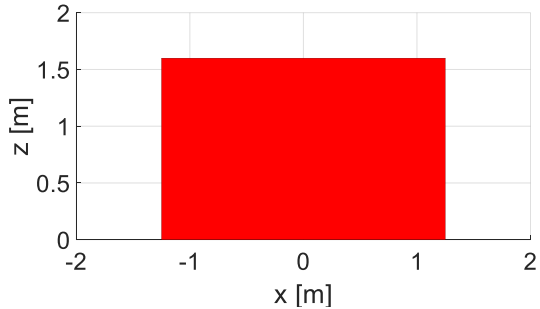
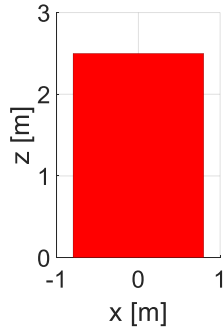
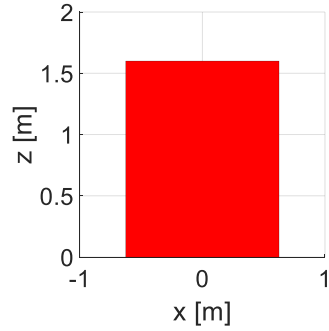
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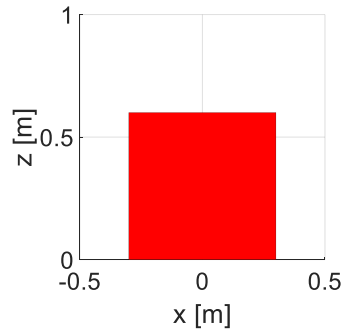
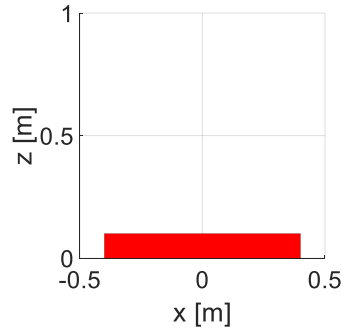
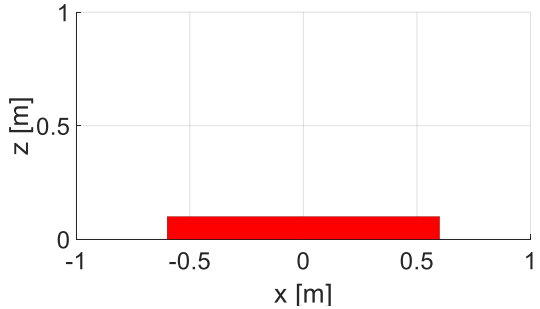
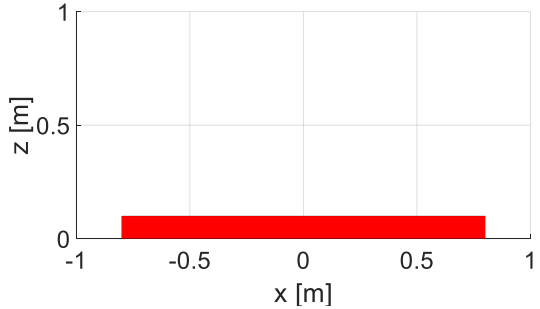
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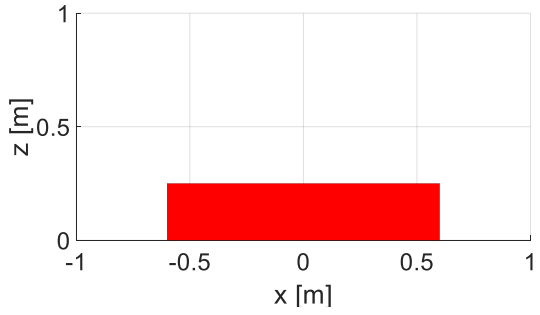
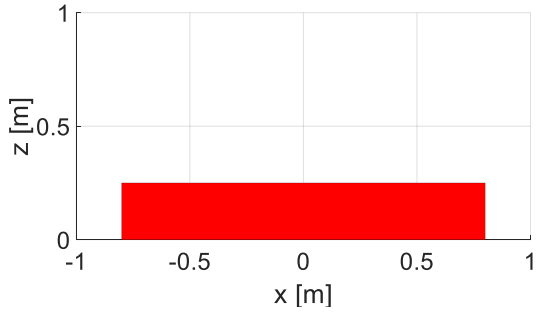
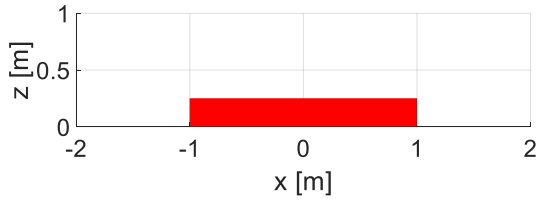
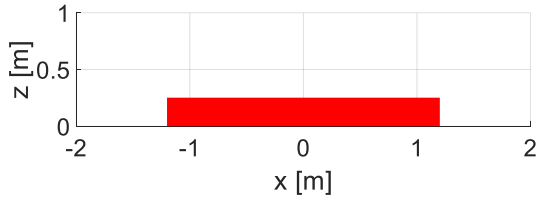
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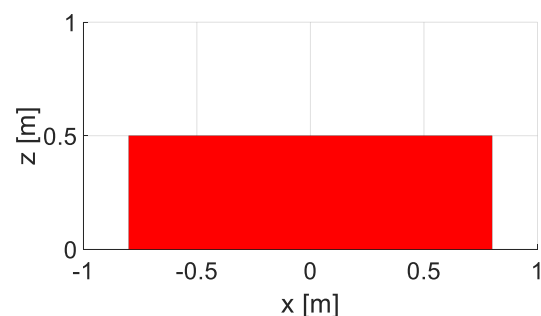
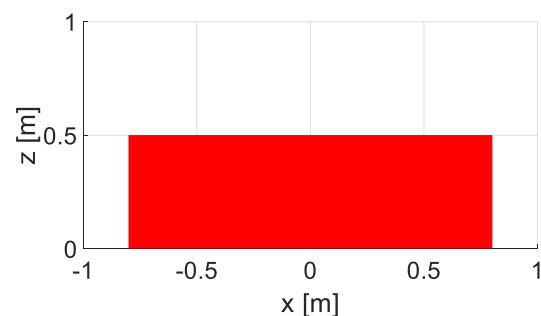
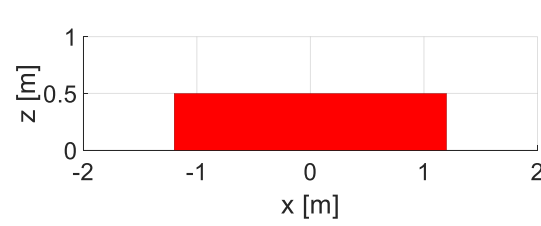
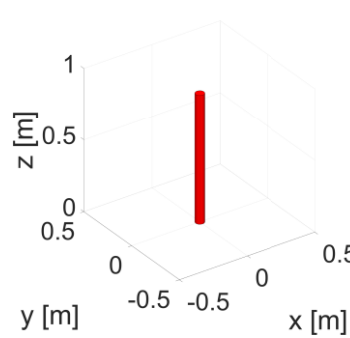
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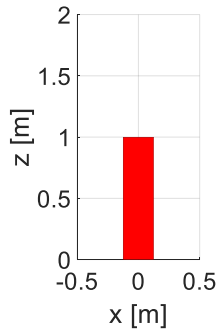
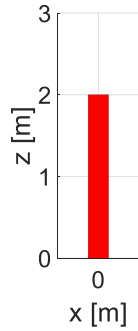
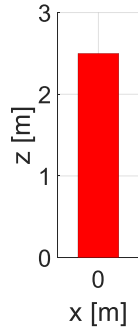
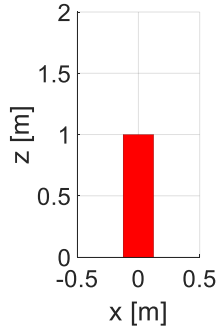
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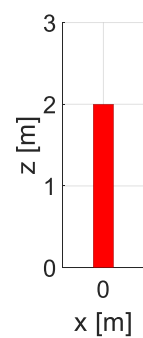
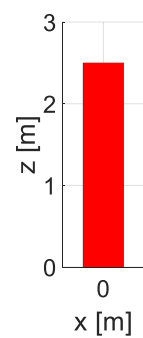
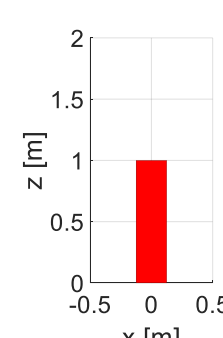
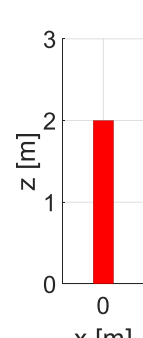
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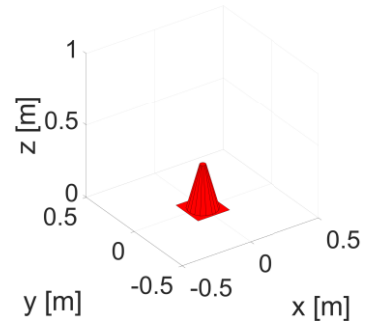
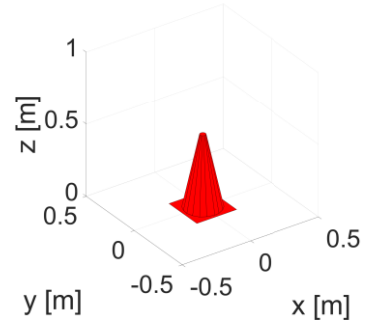
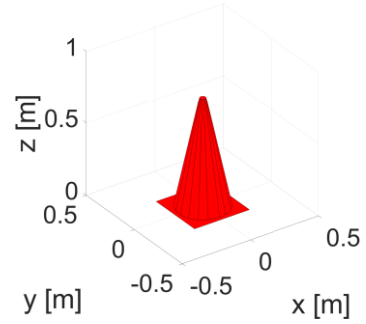
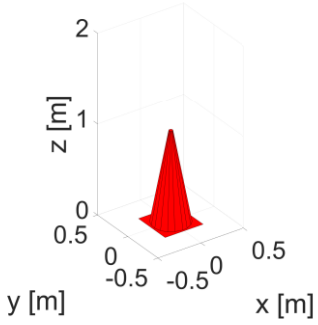
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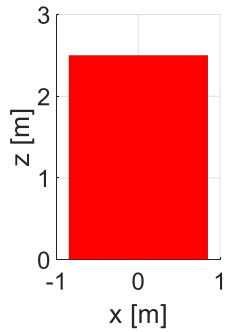
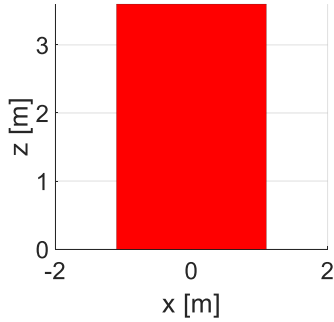
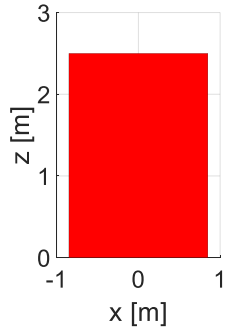
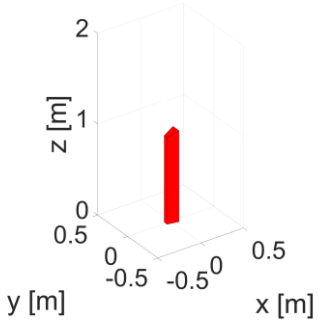
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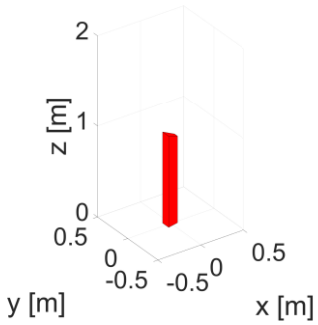
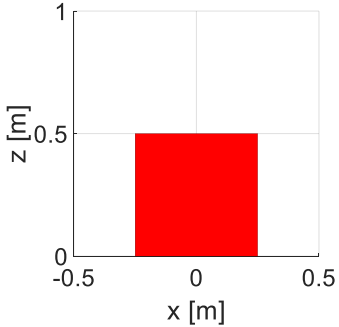
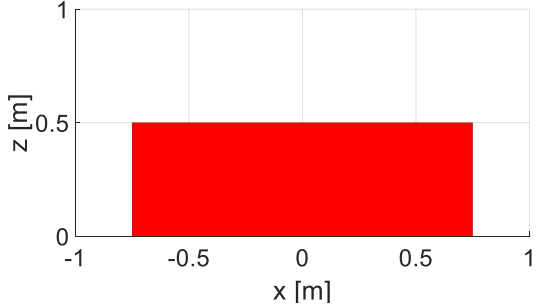
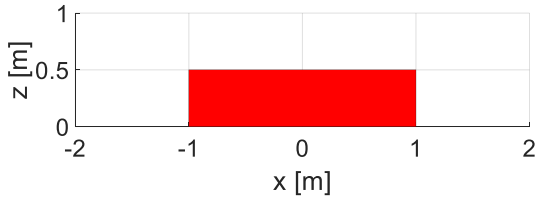
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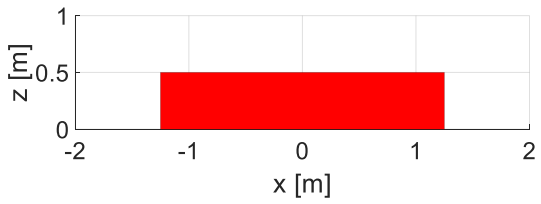
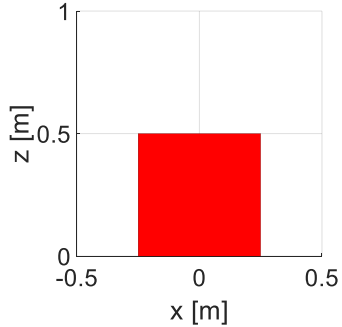
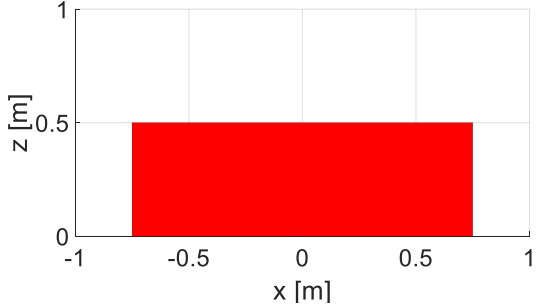
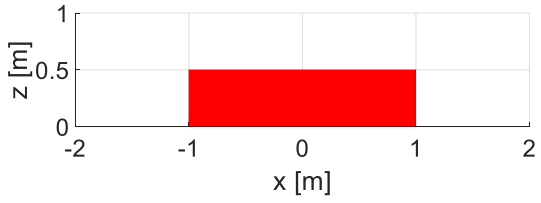
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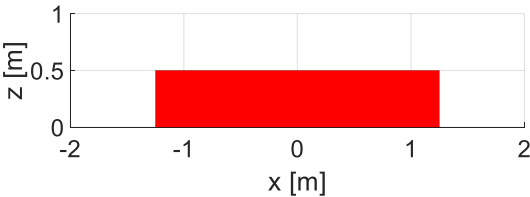
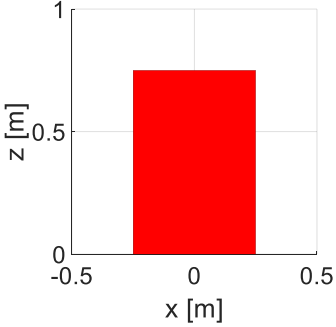
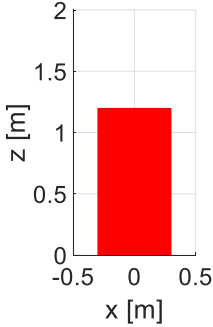
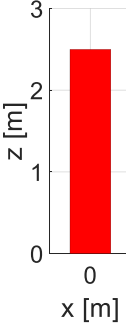
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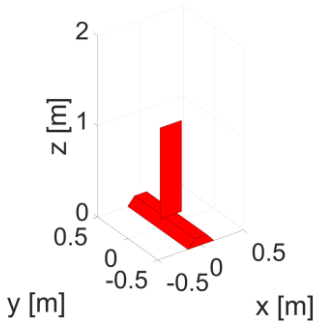
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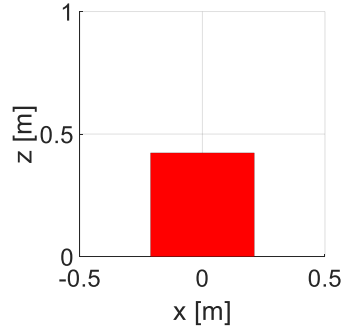
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