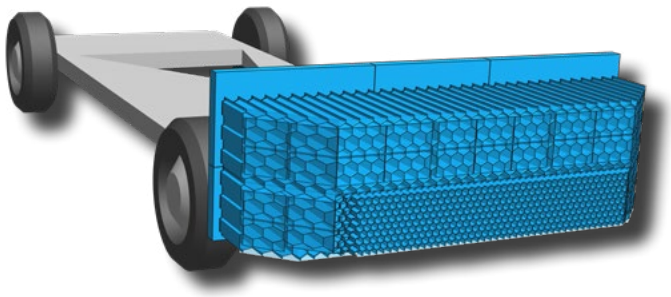
Arup Cellbond Barrier Models

Working in collaboration, Arup and Cellbond have developed a range of LS-DYNA finite element models based on the aluminium honeycomb barriers produced by Cellbond.



AE-MDB

Advanced European Mobile Deformable Barrier
LS-DYNA Shell model for side impact

The AE-MDB was adopted by EuroNCAP and replaced the Advanced-2000 barrier in 2015. It is intended to be used alongside the WorldSID dummy model.

- Used for side mobile impact testing.
- Adopted by ANCAP, EuroNCAP, JNCAP and KNCAP.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels.
- Arup has a track record with over 20 years of experience in barrier development using proven modelling techniques that demonstrate robustness and fidelity.

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AE-MDB

Advanced European Mobile Deformable Barrier LS-DYNA Shell model for side Impact

The specification used for the development of the AE-MDB deformable impact barrier has been taken from the Euro-NCAP document 'AE-MDB Specification,Version 1.0', dated 26th February 2013.

The AE-MDB was adopted by EuroNCAP and replaced the Advanced2000 barrier in 2015. It is intended to be used alongside the new WorldSID dummy.

This barrier uses the same manufacturing principles as the side impact barrier Advanced-2000.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Mass	Regulation Test	Regulation Speed
Shell	LS-DYNA 971, R7.1.2 SMP/MPP	382080	1300kg	UN R95 Lateral Collision Protection	50kph

Validation

The LS-DYNA model calibration has been done using the test results provided by Cellbond for a 35kph dynamic impact against a rigid wall. The test involves the barrier on a trolley impacting a rigid wall. This Shell version of the AE-MDB model is an upgrade of the AE-MDB Solid version.

The force-deflection curves (generated from model's analyses and tests) for the individual block of the barrier have been compared.

The results have also been checked against the force-deflection corridors from the specification document.

This validation work has been carried out in both SMP and MPP versions of LS-DYNA R9.2.0 and R7.1.2 to ensure the performance and accuracy.

The AE-MDB model is also available in the Solid element version.

Arup Cellbond Barrier Models

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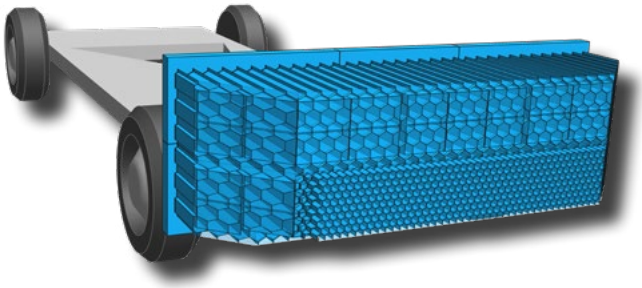

AE-MDB C-NCAP

Advanced European Mobile Deformable Barrier
LS-DYNA Shell model for side impact

This barrier has been adopted by C-NCAP from 2018. The design is based on the EuroNCAP AE-MDB with modifications to the total mass and height.

- Used for side mobile impact testing.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels.
- Arup has a track record with over 20 years of experience in barrier development using proven modelling techniques that demonstrate robustness and fidelity.

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AE-MDB C-NCAP

Advanced European Mobile Deformable Barrier LS-DYNA Shell model for side impact

The specification used for the develop the AE-MDB C-NCAP deformable impact barrier has been taken from the C-NCAP 2018 document 'C-NCAP Management Regulation 2018' dated April 2017 and the Euro-NCAP document 'AE-MDB Specification, Version 1.0', dated 26th February 2013.

The C-NCAP 2018 AE-MDB Side Impact Barrier is based on the Euro-NCAP AE-MDB Barrier with two main modifications: a total mass increase of 100kg and a 50mm increase in height.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Mass	Regulation Test	Regulation Speed
Shell	LS-DYNA 971, R7.1.2 SMP/MPP	382080	1400kg	UN R95 Lateral Collision Protection	50kph

Validation

The LS-DYNA model calibration has been done using the test results provided by Cellbond for a 35kph dynamic impact against a rigid wall. The test involves the barrier on a trolley impacting a rigid wall.

The force-deflection curves (generated from model's analyses and tests) for the individual block of the barrier have been compared. The results have also been checked against the force-deflection corridors from the specification document.

This validation work has been carried out in both SMP and MPP versions of LS-DYNA R9.2.0 and R7.1.2 to ensure the performance and accuracy.

Arup Cellbond Barrier Models

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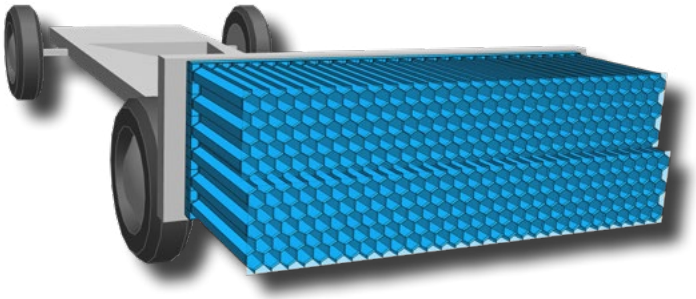

EEVC Advanced 2000

European Enhanced Vehicle-safety Committee
LS-DYNA Shell model for side impact

This model is a requirement for the side barrier impact safety regulations. It was used by EuroNCAP for side testing until 2015 when it was superseded by the AE-MDB barrier.

- Used for side mobile impact testing.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels.
- Arup has a track record with over 20 years of experience in barrier development using proven modelling techniques that demonstrate robustness and fidelity.

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EEVC Advanced 2000

European Enhanced Vehicle-safety Committee Advanced 2000 LS-DYNA Shell model for side impact

This barrier is used in the EU front impact regulation and by several consumer test organisations in their front offset impact test. The specification used for the deformable impact barrier has been taken from the ECE R95 Amendment 3 dated September 2003.

Validation

The LS-DYNA model calibration has been done using the test results provided by Cellbond:

- Offset Pole Impact at 5.6 m/s
- Rigid wall impact at 9.7 m/s

The force-deflection curves (generated from model analysis and test) for the individual block of the barrier have been compared. The results have also been checked against the force-deflection corridors from the specification document.

This validation work has been carried out in both SMP and MPP versions of LS-DYNA R9.2 and R7.12 to ensure the performance and accuracy.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Timestep	Regulation Test	Regulation Speed
Shell	LS-DYNA 971 R7.1.2 SMP/MPP	322876	-	-	-

Arup Cellbond Barrier Models

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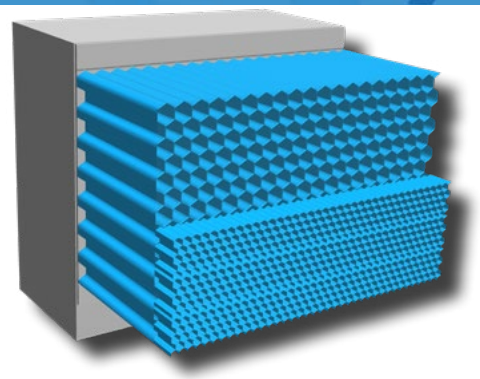

EEVC ODB

EEVC Offset Deformable Barrier
LS-DYNA Shell model for frontal impact

This European Enhanced Vehicle-safety Committee model is a requirement for the offset front impact safety regulations.

- Used for frontal impact testing.
- Replaced in EuroNCAP consumer tests by the MPDB.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels.
- Arup has a track record with over 20 years of experience in barrier development using proven modelling techniques that demonstrate robustness and fidelity.

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EEVC ODB

EEVC Offset Deformable Barrier LS-DYNA Shell model for frontal impact

The specification used for the development of the EEVC Offset Deformable Frontal Impact Barrier has been taken from the 'ECE R94 Revision 1 -Frontal Impact Protection' document, dated May 2007.

The EEVC Offset Deformable Barrier (ODB) is used in the EU front impact regulation and by some consumer test organizations in their front offset impact test. It has been replaced in EuroNCAP consumer tests by the MPDB.

The ODB model consists of two different sized aluminium honeycomb blocks partially covered in aluminium sheets. It is also available in a Solid element version.

Validation

The LS-DYNA model calibration has been done using the test results provided by Cellbond for a 5 different impact tests: Rigid Wall, Half Rigid Wall, Low Horizontal Bar, High Horizontal Bar and Vertical Bar. The tests involve the impactors on a trolley impacting the barrier.

The force-deflection curves (generated from model analysis and test) have been compared.

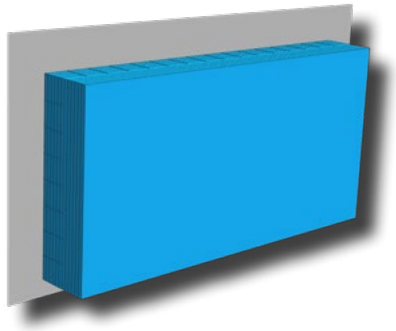
This validation work has been carried out in both SMP and MPP versions of LS-DYNA R7.1.2 to ensure the correct performance and accuracy of the LS-DYNA model.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Timestep	Regulation Test	Regulation Speed
Shell	LS-DYNA 971, R7.1.2 SMP/ MPP	298103	1320kg	EU Directive 96/79/EC Frontal Impact Protection	56kph
Shell	LS-DYNA 971, R7.1.2 SMP/ MPP	298103	1320kg	UN-ECE Reg.94 Rev.1 Frontal Impact Protection (ECE R94)	56kph
Shell	LS-DYNA 971, R7.1.2 SMP/ MPP	298103	1320kg	FMVSS 208 Occupant Crash Protection	40kph

Arup Cellbond Barrier Models

Working in collaboration, Arup and Cellbond have developed a range of LS-DYNA finite element models based on the aluminium honeycomb barriers produced by Cellbond.



FWDB

Full Width Deformable Barrier
LS-DYNA Solid model for frontal impact

This barrier, also known as Full Width Compatibility Barrier, was developed by Cellbond on behalf of the Transport Research Laboratory, UK as part of the VC-Compat project.

- Used for frontal full width impact testing.
- Developed to work alongside the EEVC Frontal Offset Barrier to fulfil needs for research on the compatibility of vehicle fronts.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels.
- Arup has a track record with over 20 years of experience in barrier development using proven modelling techniques that demonstrate robustness and fidelity.

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FWDB

Full Width Deformable Barrier LS-DYNA Solid model for frontal impact

The Full Width Deformable Barrier (also known as Full Width Compatibility Barrier) was proposed by the Vehicle Crash Compatibility Project (VC-Compat) and is developed by Cellbond on behalf of the Transport Research Laboratory (TRL), UK.

This barrier was been developed to work alongside the EEVC Frontal Offset Barrier to fulfil needs for research on the compatibility of vehicle fronts, their aggressivity and partner protection.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Timestep	Regulation Test	Regulation Speed
Solid	R7.1.2 SMP/MPP	117233	1.2E-6sec	-	-

Validation

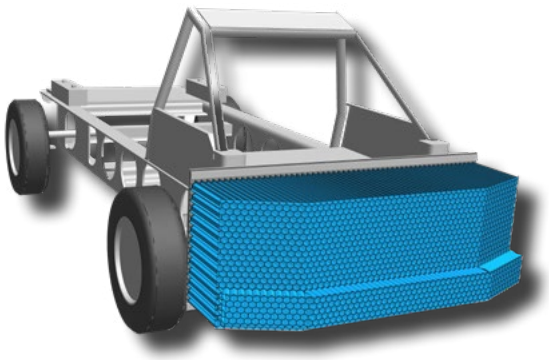
Two tests have been selected for correlating the LS-DYNA FWDB model: a flat wall impact at 17kph and the TRL Sled Test at 40kph. The tests involve the impactors on a trolley impacting the fixed FWDB barrier. For the Flat Wall case, the correlation has been carried out using test results provided by Cellbond. The test results used in the Sled Test correlation have been taken from a number of reports published by TRL Limited.

The force - deflection curves generated from model's analyses and tests have been compared.

This validation work has been carried out in both SMP and MPP versions of LS-DYNA R7.1.2 to ensure the correct performance and accuracy.

Arup Cellbond Barrier Models

Working in collaboration, Arup and Cellbond have developed a range of LS-DYNA finite element models based on the aluminium honeycomb barriers produced by Cellbond.



IIHS Spec 2.0

Insurance Institute for Highway Safety
LS-DYNA Shell model for side impact

Introduced for the 2023 IIHS test program update, replacing the previous IIHS Side Impact Barrier to better represent the front-end shape of current real-life vehicles.

- Used for side impact testing.
- Model developed to take advantage of the latest tools in the LS-DYNA code and designed to provide robust and efficient analysis.
- Calibration and validation processes for the LS-DYNA model go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels, including full speed real vehicle tests.

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IIHS Spec 2.0

Insurance Institute for Highway Safety LS-DYNA Shell model for side impact

Upgraded Test Protocol

The specifications used for the development of the IIHS Side Impact Moving Deformable (MDB) Barrier 2.0 Specification described here have been taken from 'Side Impact Crashworthiness Evaluation Moving Deformable Barrier 2.0 Specification', Version 1, October 2020.

This moving barrier replaces the previous IIHS Side Impact Barrier developed back in 2000-2001. IIHS is now upgrading their side impact test protocol to include an updated deformable barrier (Specification 2.0) and a test setup that continues to reflect changes in vehicle types and accidents.

This new Specification 2.0 barrier has been redesigned to better represent the front-end shape of certain types of vehicles, SUVs and Pick-ups and is being introduced to make the barrier to vehicle tests more representative of real-life vehicle impacts. Planned introduction for the new test protocol is 2022.

Validation

The LS-DYNA model calibration has been done using the test data provided by Cellbond for three different impact conditions. The tests involve the barrier on a trolley impacting a vertical impactor, offset vertical impactor and a flat wall. The force-deflection curves for the barrier (generated from analyses and tests) have been compared.

Additionally, material testing has also been performed to define the material models for the different parts of the barrier. The barrier model has also been tested against a full vehicle model to calibrate its behaviour under regulation conditions. This validation work has been carried out in both SMP and MPP versions of LS-DYNA R12.0.0 to ensure performance and accuracy.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Timestep	Regulation Test	Regulation Speed
Shell	LS-DYNA 971 R12.0.0 SMP/MPP	1239920	1.0E-6	IIHS Side Impact Tests	60kph

Arup Cellbond Barrier Models

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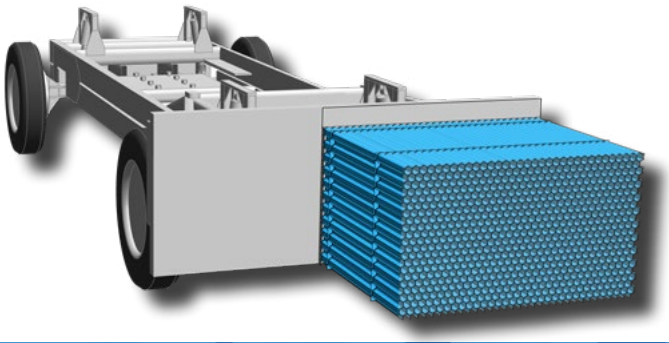

MPDB

Mobile Offset Progressive Deformable Barrier
LS-DYNA Shell model for frontal impact

This model has been developed to take advantage of the latest developments in the LS-DYNA code and is designed to provide robust and efficient analysis.

- Used for frontal impact testing.
- Introduced in 2020 by ANCAP, C-NCAP, EuroNCAP and JNCAP.
- Unique REPORTER template that fully automates the post-processing of the LS-DYNA analysis results according to Euro and China NCAP assessments is available in the Oasys REPORTER Automotive library.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels, including full speed real vehicle tests.

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MPDB

Mobile Offset Progressive Deformable Barrier LS-DYNA Shell model for frontal impact

The specifications used for the development of the Mobile Offset Progressive Deformable frontal impact barrier (MPDB) described in this document have been taken from 'Euro NCAP Mobile Progressive Deformable Barrier Face Specification' Draft Version 1.0, 23 October 2017, TB 022.

The MPDB barrier is used in the 2020 European New Car Assessment Programme (EuroNCAP) in their Frontal Impact Testing Protocol.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Timestep	Regulation Test	Regulation Speed
Shell	LS-DYNA 971 R9.3.0 SMP/MPP	1221651	0.9E-6	EuroNCAP 2020 Frontal Impact Test	Target: 50kph for vehicle and trolley

Validation

The LS-DYNA model calibration has been done using the test results provided by Cellbond for four different impact conditions. The tests involve the barrier on a trolley impacting a vertical impactor, a quarter wall, a rounded impactor and an tubular impactor (specified by Euro NCAP).The force-deflection curves for the barrier (generated from analyses and tests) have been compared. Additionally, material testing has also been performed to define the material models for the different parts of the barrier.

This validation work has been carried out in both SMP and MPP versions of LS-DYNA R9.3.0 to ensure the performance and accuracy.

Oasys D3PLOT and REPORTER Tools

The MPDB LS-DYNA model comes with an Oasys D3PLOT post-processing tool and Oasys REPORTER template which fully automate the post-processing of results and the calculation of the Euro NCAP compatibility modifier. These tools can be readily integrated with the official EuroNCAP compatibility assessment spreadsheet for this regulation.

The REPORTER template is easy to use and provides test-specific relevant information: compatibility penalty, barrier intrusion plot, scoring rationale, OLC calculation details and deformed screenshots among its many features.

Arup Cellbond Barrier Models

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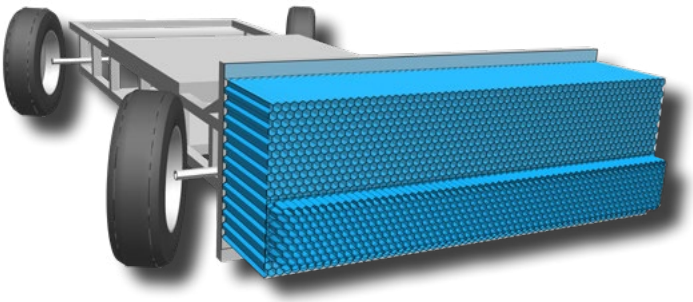

NHTSA Barrier

National Highway Traffic Safety Administration
LS-DYNA Shell model for side and rear impact

This model is used for side and rear testing. The model is provided with different heights, initial speeds, and tyre orientations for the two load cases.

- Used for side and rear impact testing.
- Required for NHTSA FMVSS 214 and FMVSS 301 evaluations; and for U.S. NCAP.
- Model calibration and validation processes go beyond the barrier specification tests: the model is correlated to additional dynamic tests at component and full barrier levels.
- Arup has a track record with over 20 years of experience in barrier development using proven modelling techniques that demonstrate robustness and fidelity.

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NHTSA Barrier

National Highway Traffic Safety Administration LS-DYNA Shell model for side and rear impact

The specifications used for the development of the NHTSA Side and Rear Moving Deformable Barrier have been taken from the NHTSA documents 'Federal Motor Safety Standard, MVSS 214 – Side Impact Protection', 'Federal Motor Safety Standard, FMVSS 301 – Fuel System Integrity – Rear Impact Test' and 'National Highway Traffic Safety Administration, PART 587 – Side Impact Moving Deformable Barrier'.

The NHSTA MDB barrier is used by NHTSA in their SINCAP side and rear impact tests and was also adopted by US-NCAP in 2012 for their side impact tests. When used in the FMVSS 301 rear impact the barrier is set 50mm lower.

Validation

The LS-DYNA model calibration has been done using the test results provided by Cellbond for four different impact conditions. The tests involve the barrier on a trolley impacting a rigid pole, a rigid wall, a rigid rear armature and a half rigid wall. The force-deflection curves (generated from model's analyses and tests) for the barrier have been compared.

This validation work for this Shell model has been carried out in LS-DYNA R9.3.0 SMP and MPP versions.

NHTSA Side and Rear Impact Barrier is also available in the Solid element version.

Specifications

Element Type	LS-DYNA Release Version	Total Number of Elements	Timestep	Regulation Test	Regulation Speed
Shell	LS-DYNA 971 R.9.3.0 SMP/MPP	1134707	1.2E-6	FMVSS 301 Fuel System Integrity (Rear Impact Test)	80kph
Shell	LS-DYNA 971 R.9.3.0 SMP/MPP	1134707	1.2E-6	FMVSS 214 Side Impact Protection	53kph
Shell	LS-DYNA 971 R.9.3.0 SMP/MPP	1134707	1.2E-6	US-NCAP Side Impact Test	61.9kph