CPNI
Centre for the Protection of National Infrastructure

15 July 2021

Guidance Note:
Full-Scale Vehicle Impact Testing and Computational Analysis

This guidance note discusses the differences between computational analysis and full scale vehicle impact testing and discusses their most appropriate uses. It is intended for security professionals responsible for the design, specification and selection of Vehicle Security Barriers (VSBs).

The guidance is grounded on comprehensive research, including vehicle structure and component analysis and characterisation, production of correlated finite element analysis (FEA) models and the comparative examination between actual vehicle impact testing and computational analysis.

CPNI recommends that a product deployed for the purposes of countering terrorism, to protect assets and people against vehicle-borne threats, should be a 'rated vehicle security barrier' that has undergone formal vehicle impact testing.

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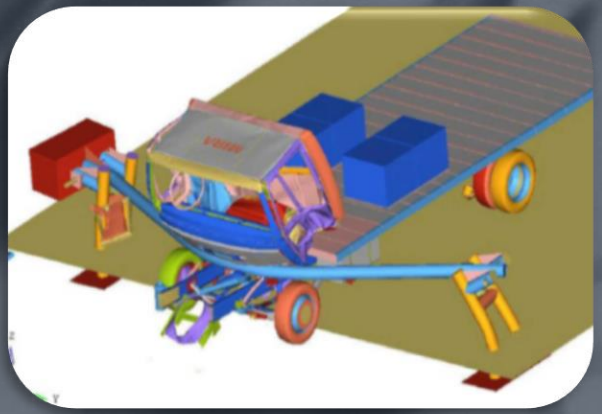
What is the difference?

A VSB is a product designed to prevent vehicle access. It has undergone testing at an independent and accredited test house, to a recognised **vehicle impact test** standard and achieved a performance rating in accordance with that standard. The test, which is often destructive, demonstrates the VSB performance in reality, against a specified vehicle, speed and impact angle.



Computational analysis, also known in this regard as nonlinear FEA, is a mathematical approach used by engineers in the design phase of product development to optimise components and systems in order to reduce the number of physical prototypes and testing required. It has the potential to reduce the overall development costs.

Vehicles and VSBs are composite systems with complex interacting geometric structures and materials, that, under highly dynamic impact conditions behave in a nonlinear manner.

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Full-Scale Vehicle Impact Testing

Full-scale vehicle impact testing provides results which:

- are observable;
- are demonstrable;
- can be closely scrutinised; and
- can be accurately compared to other ‘real’ tests.

The test parameters and outcomes, namely the vehicle type and mass, impact speed, impact angle and the outcome of the test including penetration distance, debris dispersal, component deformation or failure, can be clearly observed and analysed.

Repeatability is not easily achieved due to subtle changes in these parameters between tests. It is known that nuances around the vehicle construction are a factor on the performance of VSBs although tolerances in the standards reduce this to a pragmatic level.

Notwithstanding the evidential value of the results, it can be prohibitively expensive to repeatedly test a VSB in multiple configurations and conditions.

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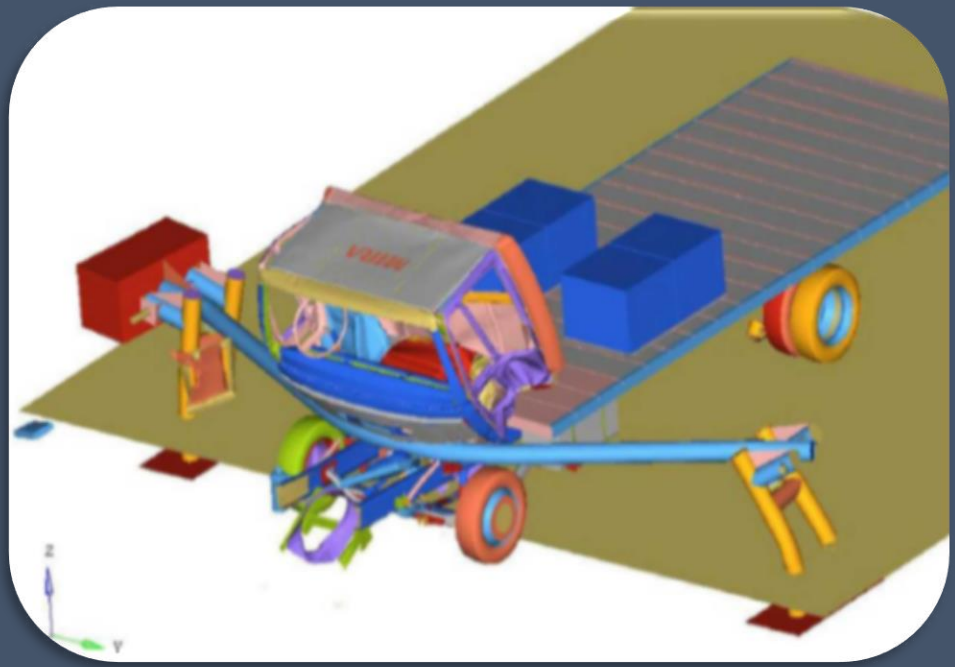
Finite Element Analysis

In the field of Hostile Vehicle Mitigation, FEA is used to **approximate** structural performance of a VSB design under **simulated** dynamic vehicle impact conditions.
The output of a simulation is **highly dependent** on the:

- True fidelity of the CAD model (vehicle, VSB, foundations, soil and material characterisation)
- CAD model conversion to FEA, including:
    - the materials and component characterisation;
    - connections between components;
    - interfaces and;
    - dimensions.
- Method of Finite Element Analysis;
- Mathematical / computational accuracy;
- Competency of the engineer.

The FEA methodology allows engineers to understand the impact, force transfer, energy dispassion and component interaction.

FEA carried out with information that has not be compared & validated through full scale vehicle impact test data can be highly inaccurate.



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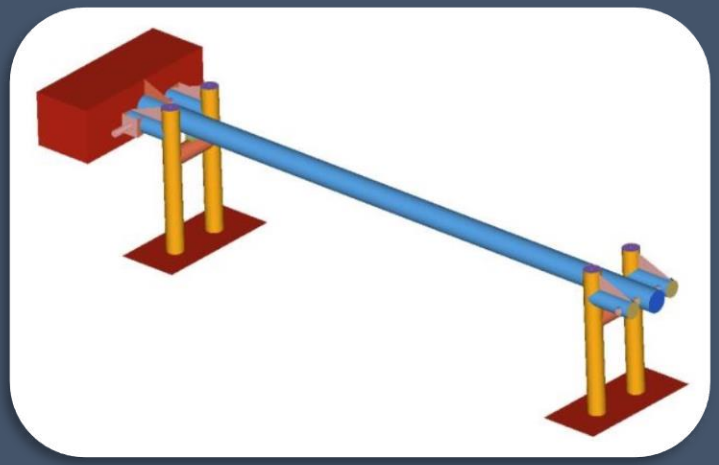
Optimisation in Design

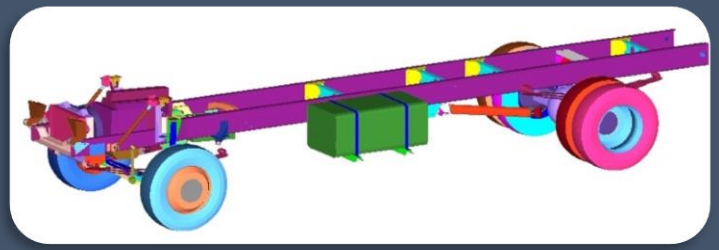
Most products, including vehicles and barriers, are designed using 3D Computer Aided Design (CAD) software. This technology allows products to be designed very accurately.

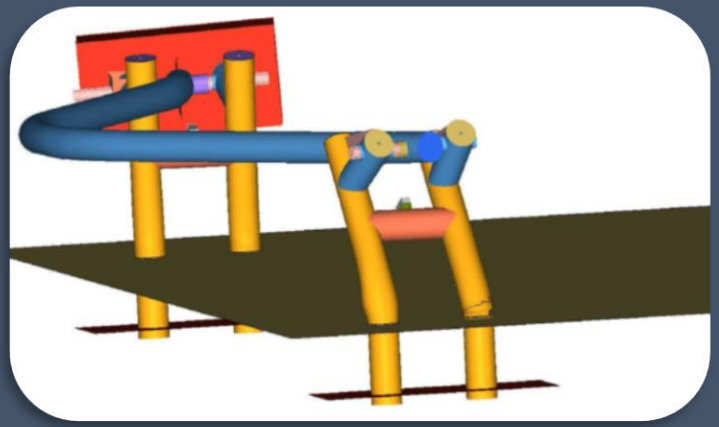
Some vehicle security barrier manufacturers use FEA simulations to estimate how the barrier will perform under vehicle impact conditions. It allows them optimise the design of a barrier, identify weak points, enhance performance, reduce development time and cost or 'value engineer' the product or manufacturing processes.

Whilst it can direct the manufacturer or end user towards a potential outcome from the design, it cannot replace full-scale vehicle impact testing *i.e. real testing*.

When a design is complete, the manufacturer will submit the manufactured product to an accredited test house to undergo a full-scale vehicle impact test to a recognised standard, with the intention of passing the test and achieving a performance rating.







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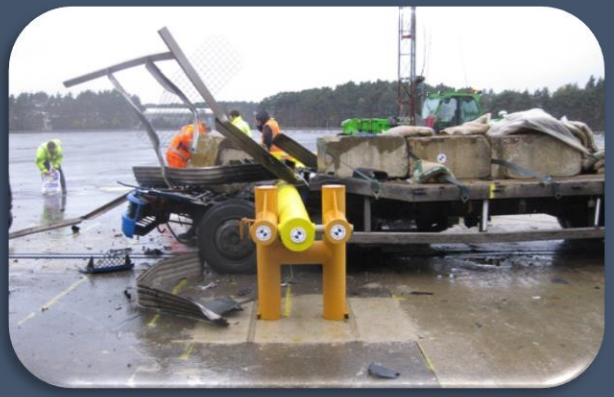
Adapting Designs to Suit Site Constraints



Conducting full-scale vehicle impact tests on a VSB for every site condition is impractical and so a universally agreed design/analysis methodology is appropriate when needing to adapt a rated vehicle security barrier for real world use.

Within the structural engineering community, an ongoing debate centres on the use of the design methodology versus full-scale vehicle impact testing.

This is particularly pertinent when recognising that site conditions (geometry and soil conditions) are not always directly comparable to the conditions in which the VSB was impact tested, and so a variation to the installation is required.

It is therefore acceptable, within reasonable bounds, to modify the foundations of an installation to suit specific site conditions, so that VSB can be installed.

Additionally, in accordance with ISO IWA 14.2, it is also acceptable to use the 'Design Method' to modify a 'rated' VSB and issue a 'design rating classification code' when interpolating results between upper and lower limits from previous tests on the VSB.

CPNI recommend that design modifications are carried out or validated by a Principal grade HVM specialist listed on the Register of Security Engineers and Specialists

RSES
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