SPEED

***S**hock **P**hysics **E**xplicit **E**ulerian/Lagrangian **D**ynamics*

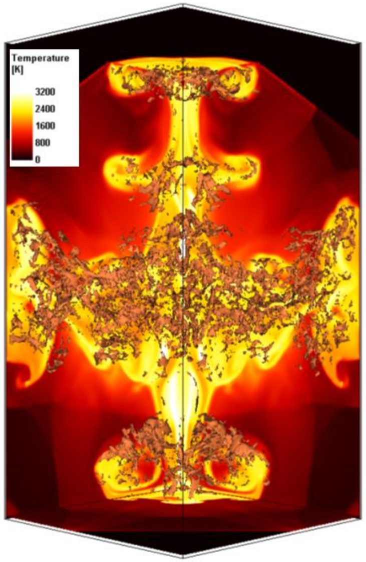
SPEED

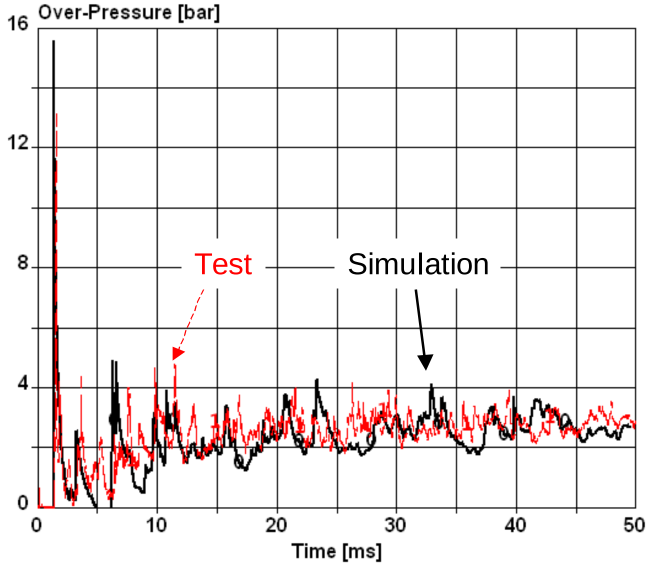
Product Information

Introduction

SPEED is a multi-material Eulerian / Lagrangian hydrocode with explicit solver technique for the analysis of nonlinear transient problems of shock and impact physics.

The software offers a maximum of computational speed as well as superior stability and accuracy.

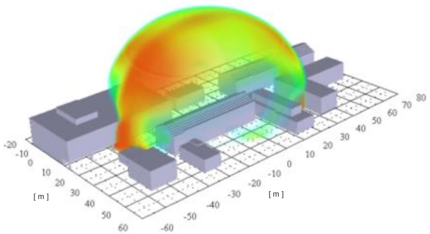


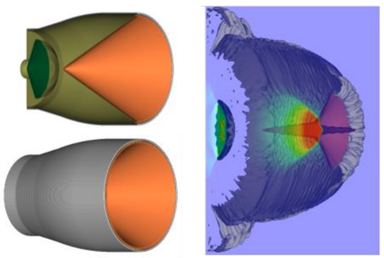


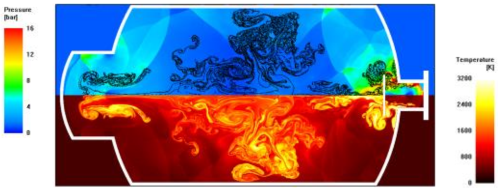
Applications

SPEED is an analysis tool for modeling various problems in the field of nonlinear dynamics of gases, fluids and solids. SPEED is used for test planning, pretest prediction analysis, post test analysis, test reports, and more. Typical applications are:

- Detonation and blast propagation
- Optimization of blast-fragment warheads
- Shaped charge design
- Internal detonation and combustion
- Underwater detonation
- Tactical ballistic missile defense



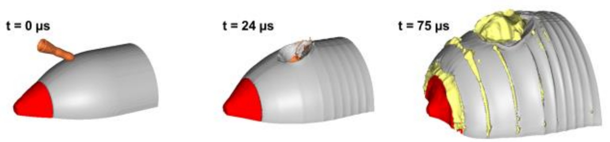


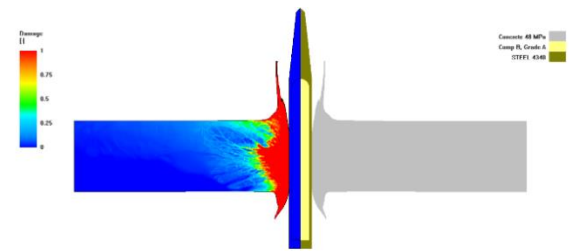


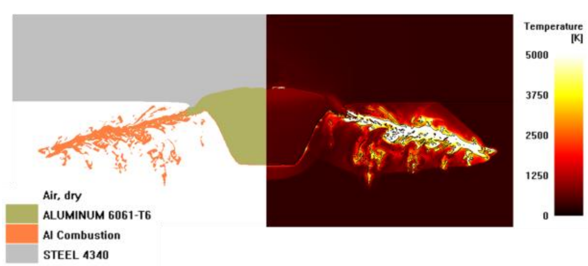
Applications (cont.)

SPEED is an analysis tool for modeling various problems in the field of nonlinear dynamics of gases, fluids and solids. SPEED is used for test planning, pretest prediction analysis, post test analysis, test reports, and more. Typical applications are:

- Explosive ordnance disposal
- Armor design
- Hazard analysis for ammunition storage
- Building protection measures in urban areas
- Reactive materials, particle burn *





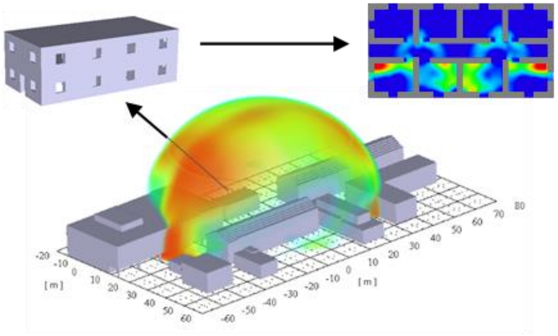


* the “Particle Burn“ model is under development and not yet available in the current version of SPEED

General Features

SPEED offers the full spectrum of analysis capabilities like

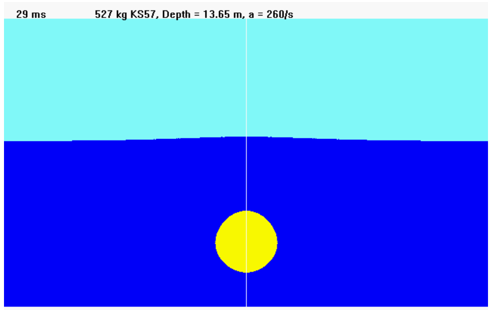
- Multi-Material Euler (2D Cartesian and rotational symmetry, 3D Cartesian)
- Ideal gas Godunov solver (3D Cartesian)
- Lagrange (2D Cartesian and rotational symmetry and 3D)
- Lagrangian contacts (Hancock, Petrov / Galerkin)
- Embedded rigid bodies
- Adaptive mesh expansion / translation
- Mesh activity control
- Mapping: 2D to 2D, 2D to 3D and 3D to 3D

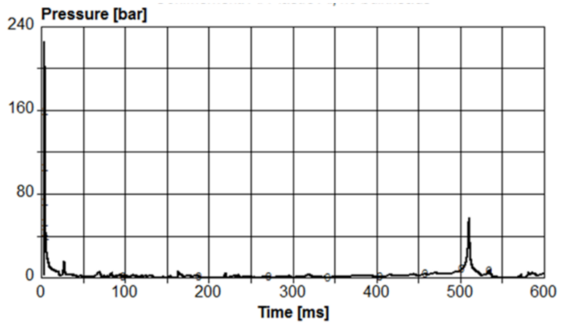


Performance

The solver technologies in SPEED are developed to provide significant advantages in performance, e.g.:

- Outstanding computational speed and minimized memory requirements
- Multithreading (multiple CPU shared memory)
- Sharp shock resolution and higher order advection schemes to limit diffusion
- Robust algorithms for multi-material cells
- Intuitive user interface for an interactive model setup
- Outstanding post-processing capabilities

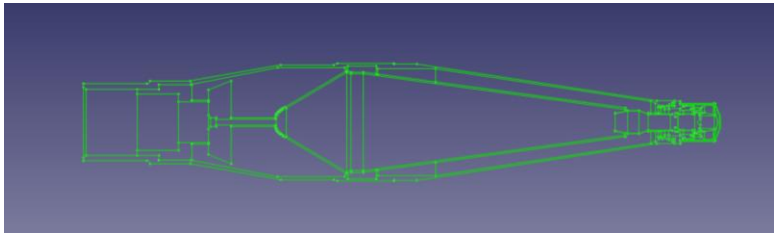


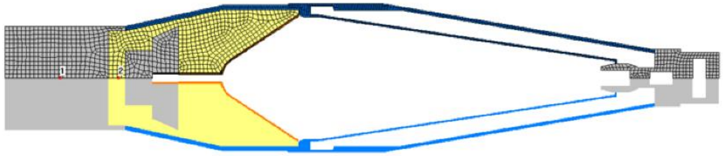


Pre-Processing

SPEED offers an intuitive and interactive model setup. It provides an easy-to-use constructive solid geometry modeler as well as an integrated CAD module to setup or import arbitrarily complex geometries. Further highlights are:

- Geometry import from LS-DYNA
- Visualization during model setup
- Arbitrary setting of units (SI or imperial)
- Tools to convert elastic constants and hardness-to-strength



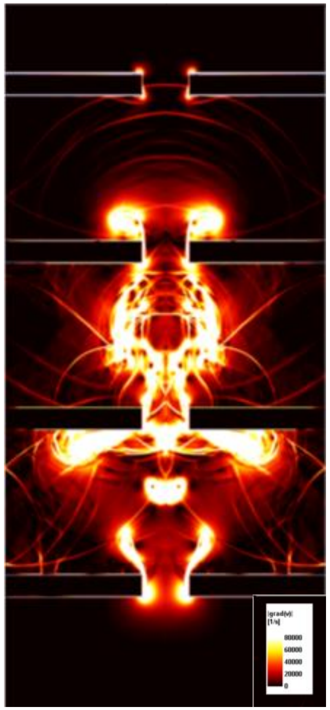


Material Model Library

SPEED includes a comprehensive library with more than 250 material data sets for gases, fluids, metals, plastics, concrete, soils and many others.

Equations of State (EoS) for

- Ideal gas (Constant-Gamma, $c_v(T)$)
- Liquids (Universal Liquid EOS)
- Explosives (JWL, TD-JWL)
- Explosive burn and combustion model
- Explosive initiation (HVRB, Lee-Tarver)
- Solids (Shock, Mie-Gruneisen, Tillotson)
- Porous solids (p-alpha)



Material Model Library (cont.)

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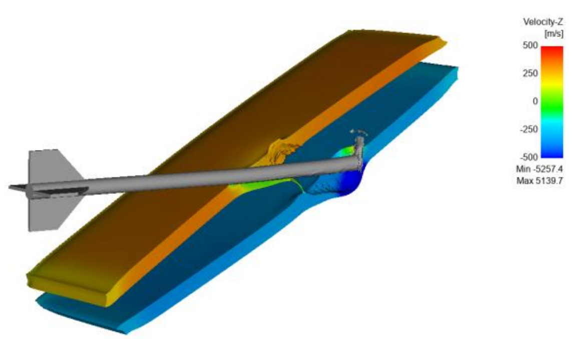
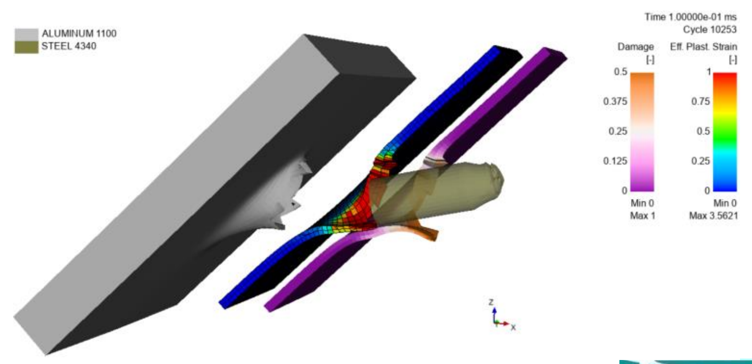
Strength Models for

- General solids (Elastic-plastic with work hardening)
- Metals (Johnson-Cook, Zerilli-Armstrong, Steinberg-Guinan)
- Concrete (Holmquist-Johnson-Cook, RHT)
- Ceramics (JH-2)
- Soils, granular materials (Drucker-Prager)





Material Model Library (cont.)

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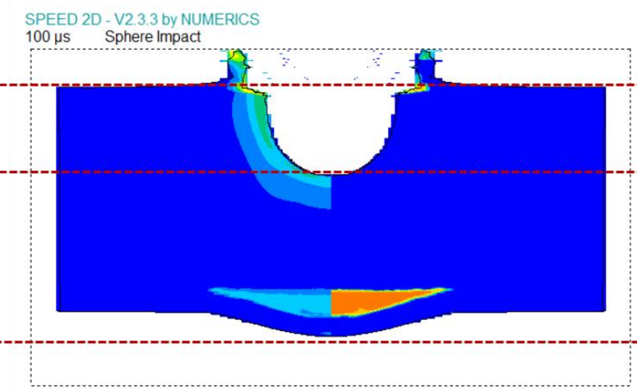
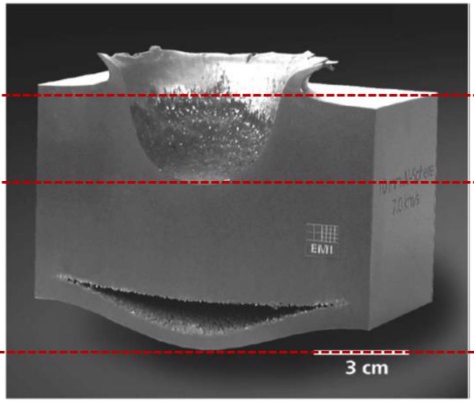
Failure Models

- Plastic failure strain
- Johnson-Cook damage model
- Accumulated spall damage
- Xue-Wierzbicki

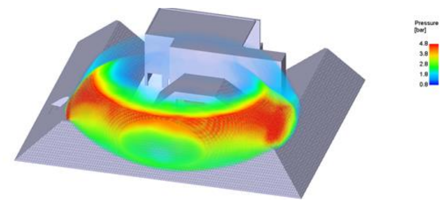


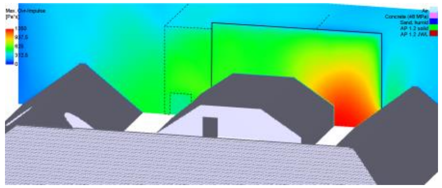


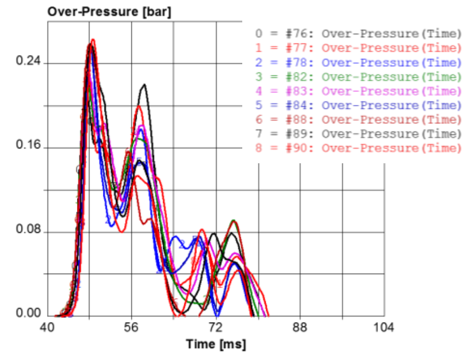
Post-Processing

The code offers a variety of functionalities for the evaluation and illustration of the results.

- Visualization of scalar, vector, tensor data
- Arbitrary mix of rendering techniques (sliced plots, surfaces, volume rendering)
- Profile plots
- Material and gauge time histories
- Signal processing options (filters, frequency analyses, integration, derivative, merging, averaging, feature point analysis…)



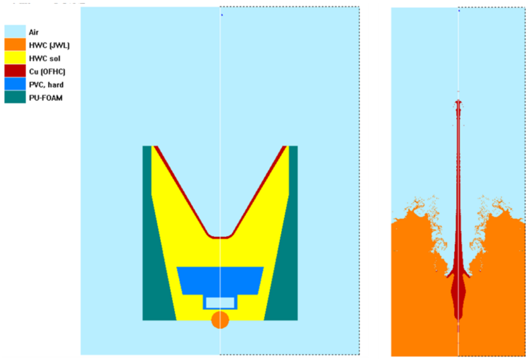


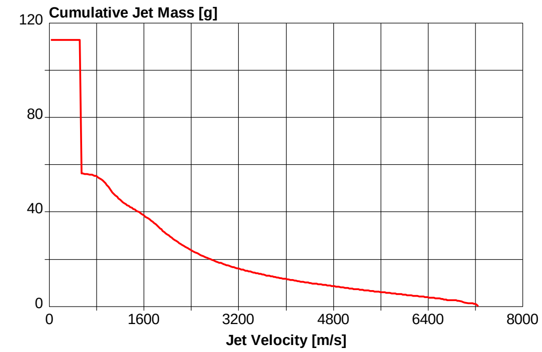


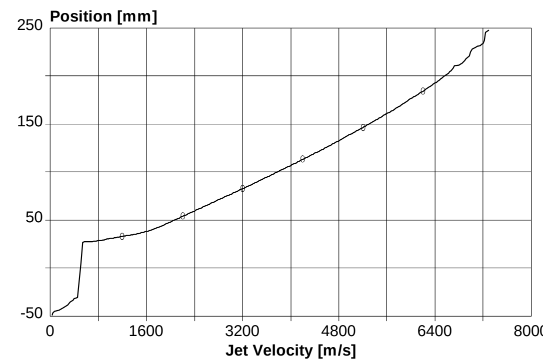
Post-Processing (cont.)

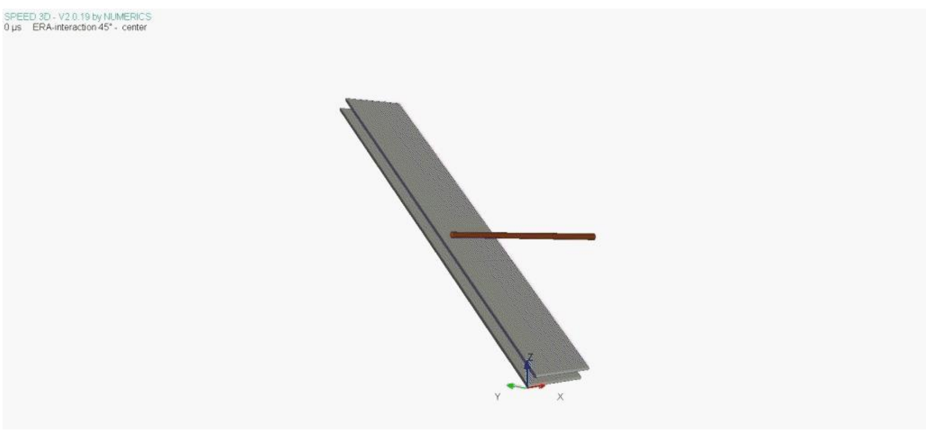
The code offers a variety of functionalities for the evaluation and illustration of the results.

- Mass / velocity distributions for shaped charge jets and behind armor debris
- Export of text & graphics to MS applications
- Movies (avi-files)





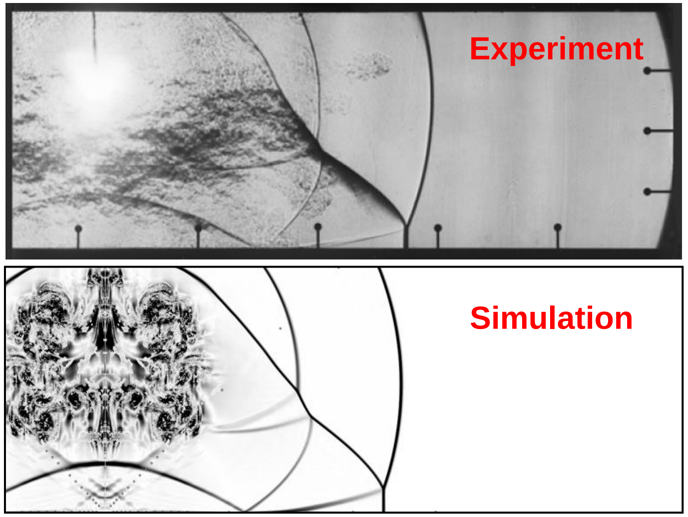


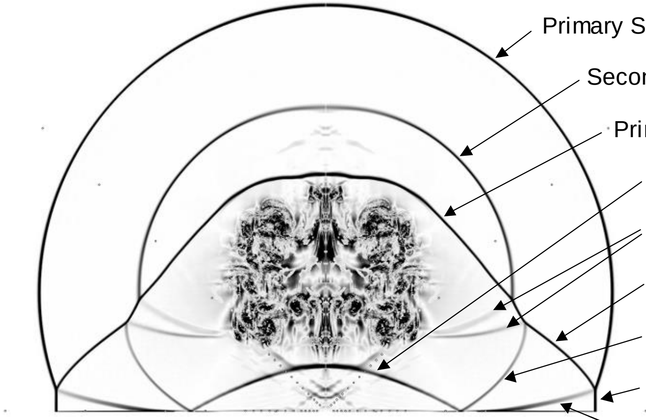


Shock Resolution

SPEED captures all features of complex shock structures:

- Mach stem formation
- Reflections
- Slip lines

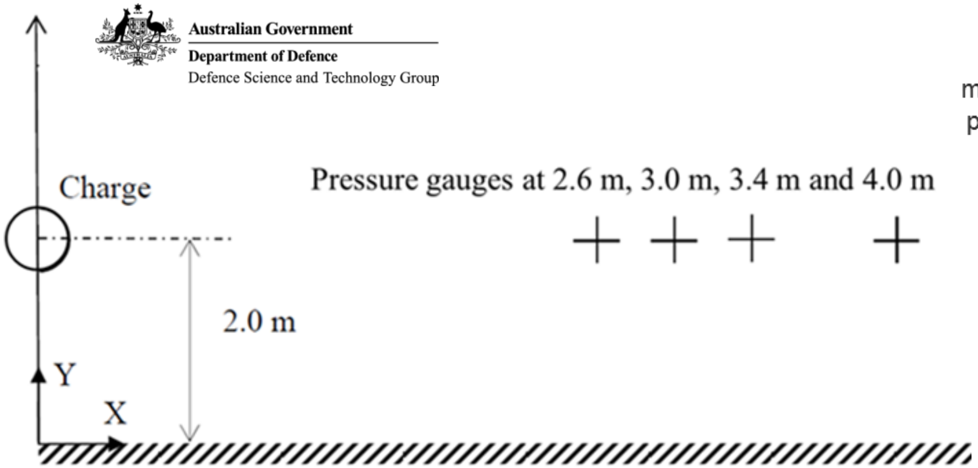




Application Example - Blast Propagation

A 2kg spherical bare CompB charge suspended 2m above ground was fired.

Pressure was measured at 2.6m, 3.0m, 3.4m, and 4.0m distance.



Rottenkolber E., Anderson J., Hartmann T., “Effect of Aerobic Afterburn on Free Field Blast“, Proc. of the 25th International Symposium on Military Aspects of Blast and Shock, The Hague, Netherlands, 2018

Application Example - Blast Propagation

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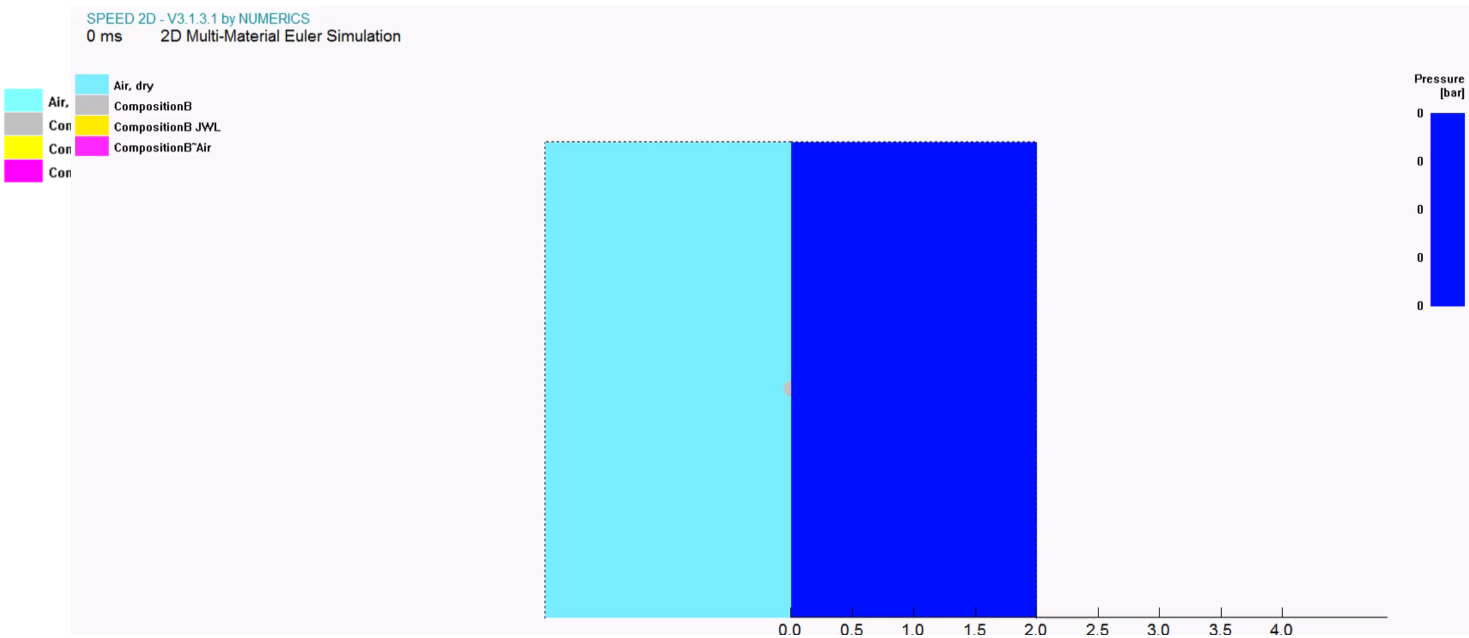
Simulation with expanding mesh:



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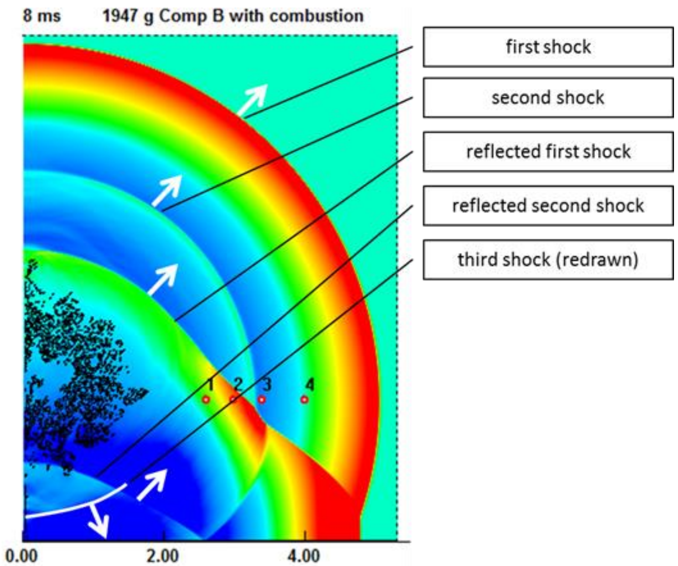
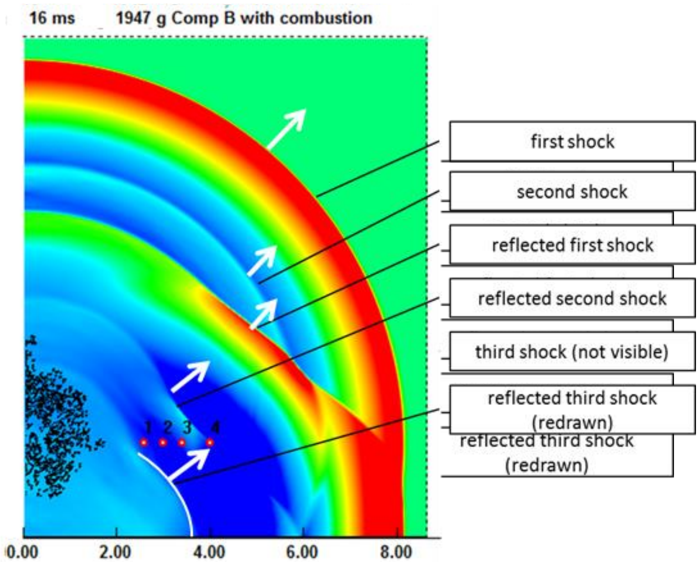
Simulation details:





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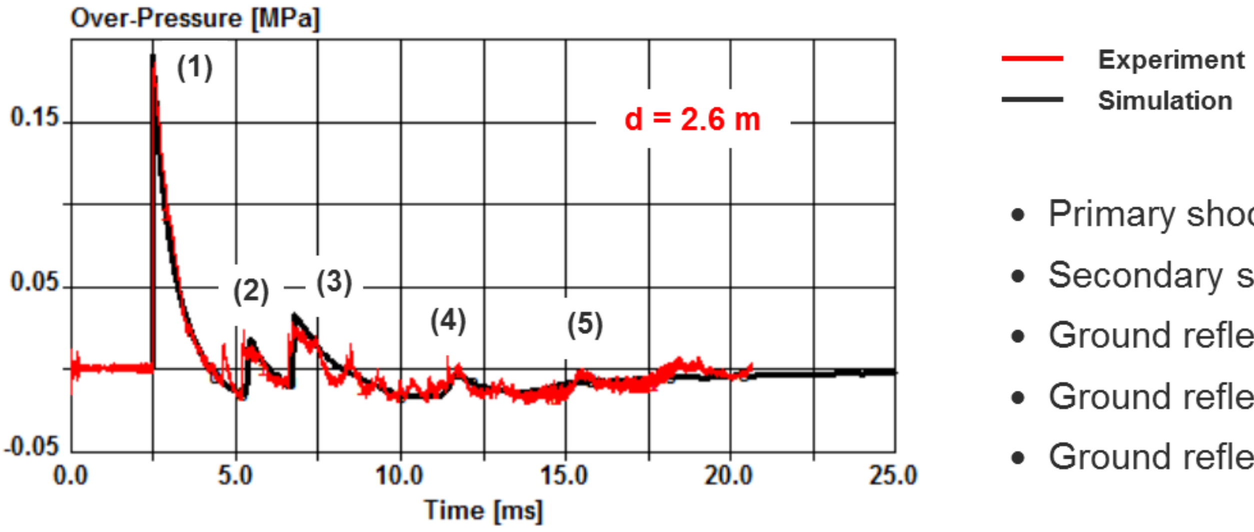
Simulation results:



- Primary shock (1)
- Secondary shock (2)
- Ground reflected primary shock (3)
- Ground reflected secondary shock (4)
- Ground reflected tertiary shock (5)

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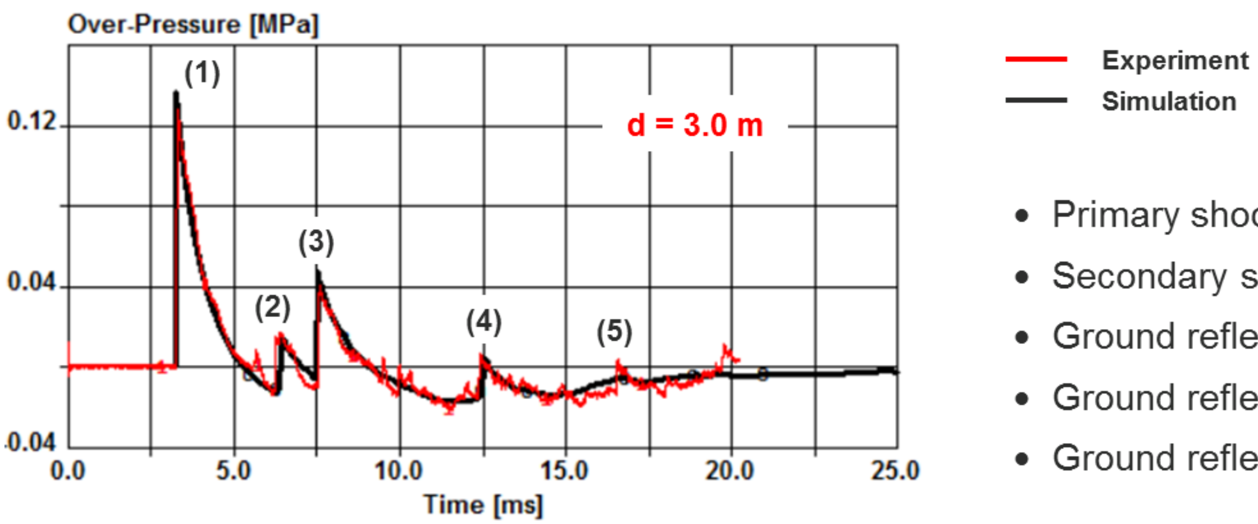

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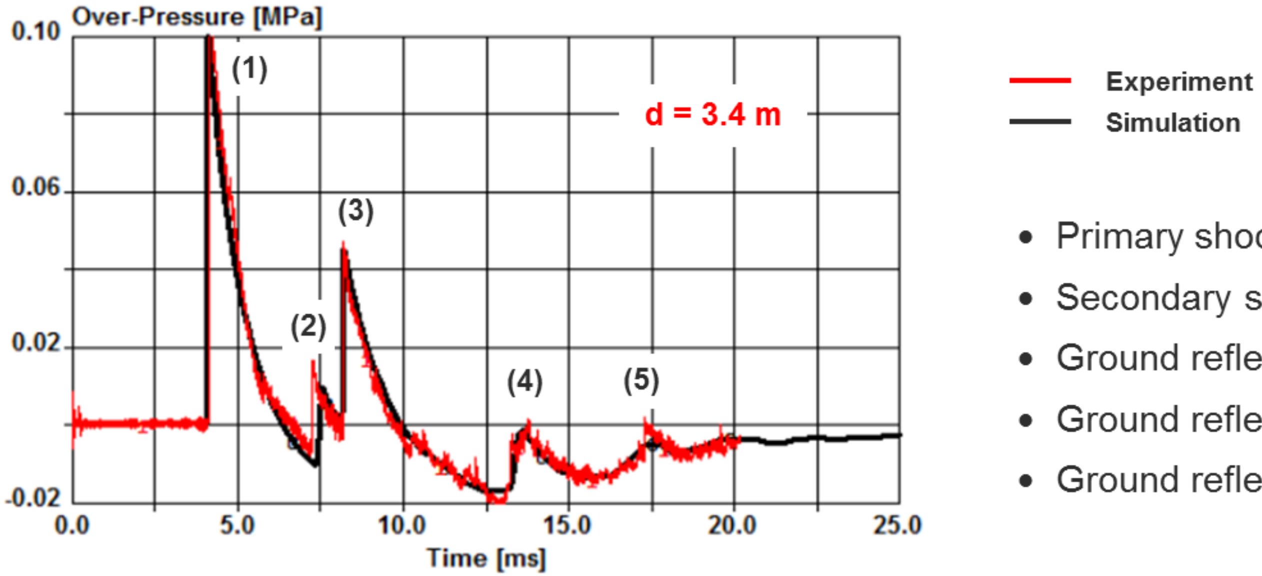

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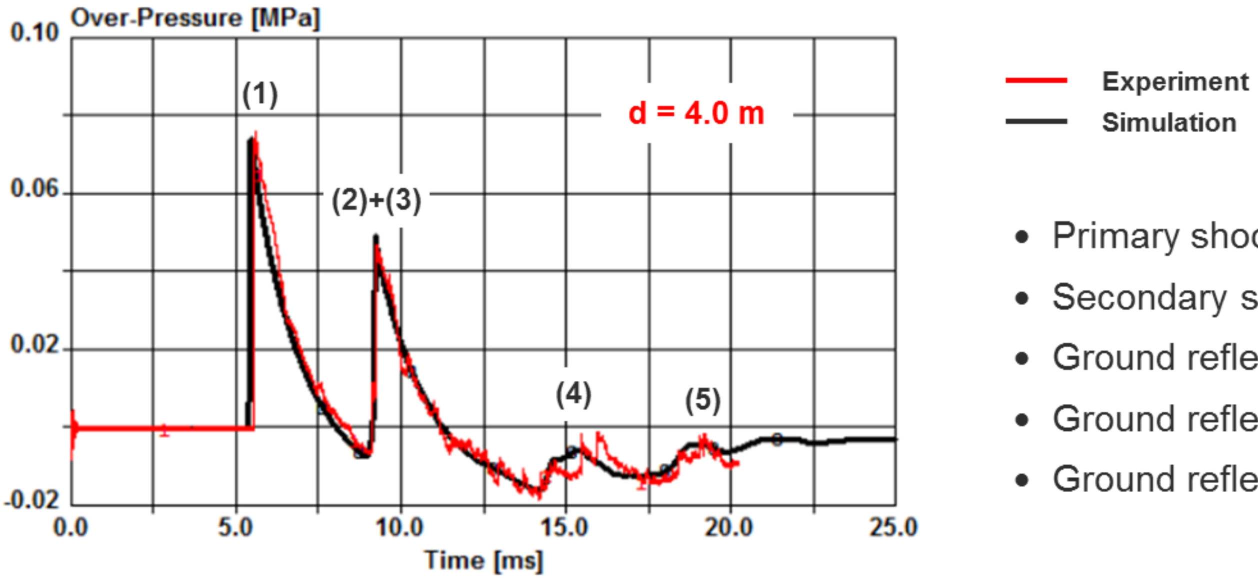

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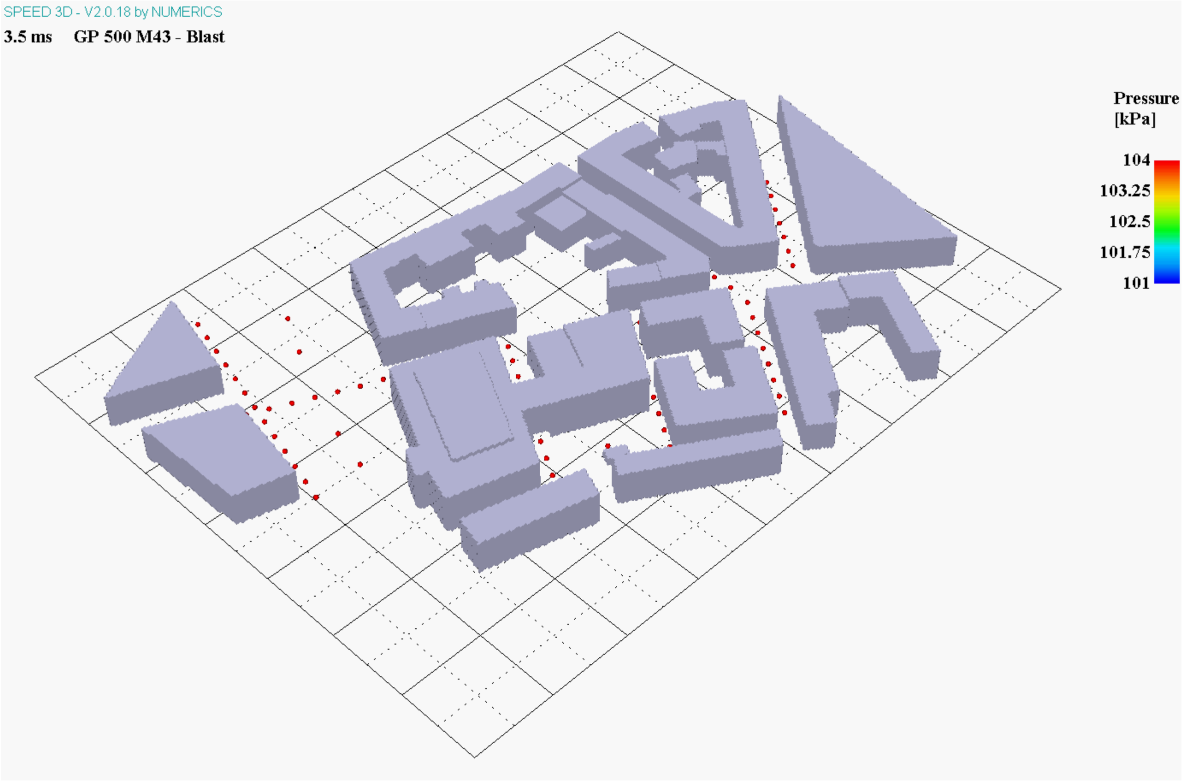
Application Example - Urban Blast Propagation

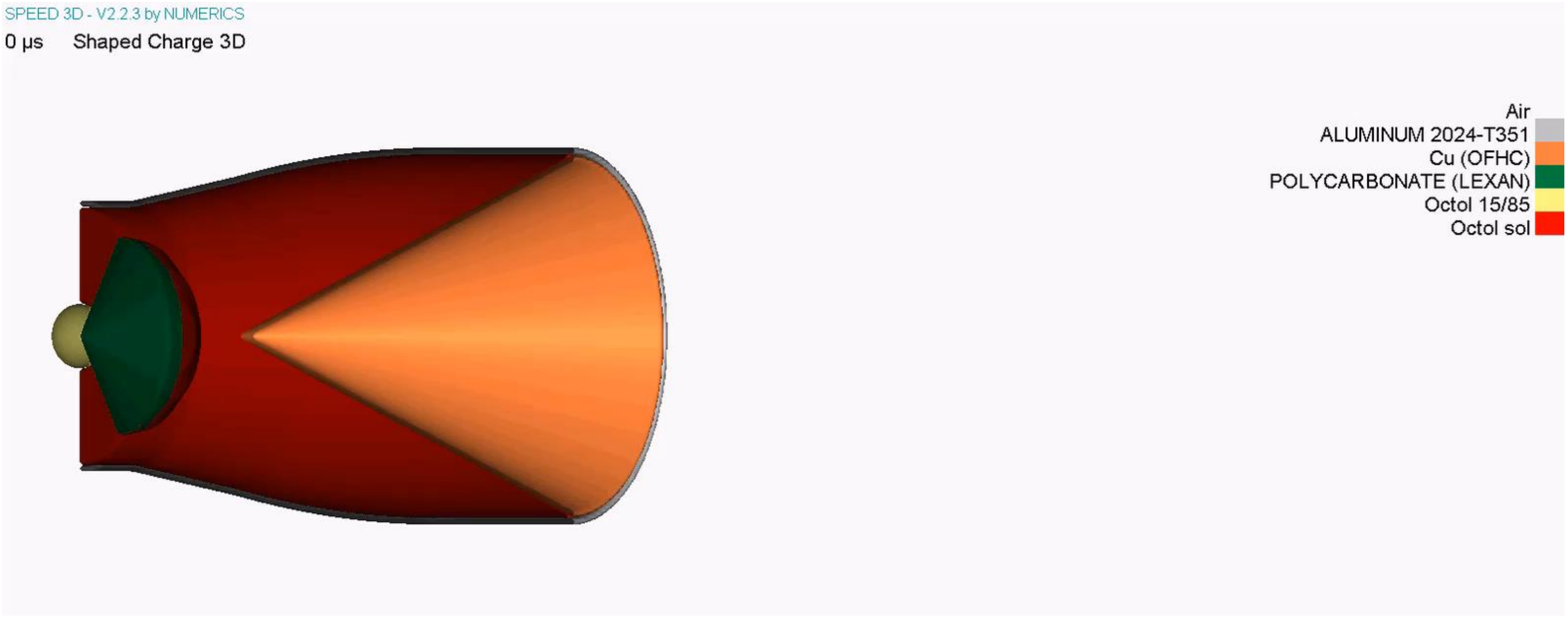
On-site demolition of a 250 kg bomb in the city of Munich on the 28th of August 2012.



Hartmann T., Greulich S., Richter R., “Fast Analysis of Safety Areas for EOD in Urban Environment" Proc. of the 15th International Symposium on Interaction of the Effects of Munitions with Structures (ISIEMS), Potsdam, Germany, 2013

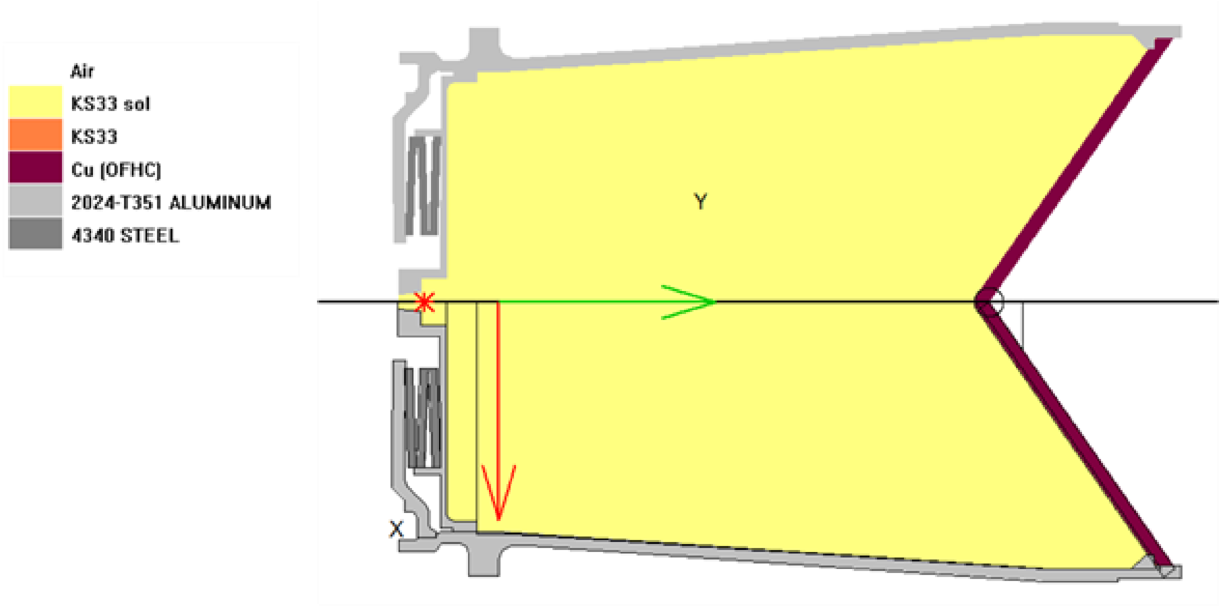
Application Example – SC-Jet Formation 3D

Detonation of a shaped charge in 3D.



Application Example – SC-Jet Formation 2D

Detonation of a Cal. 145 mm “simplified” shaped charge in 2D.



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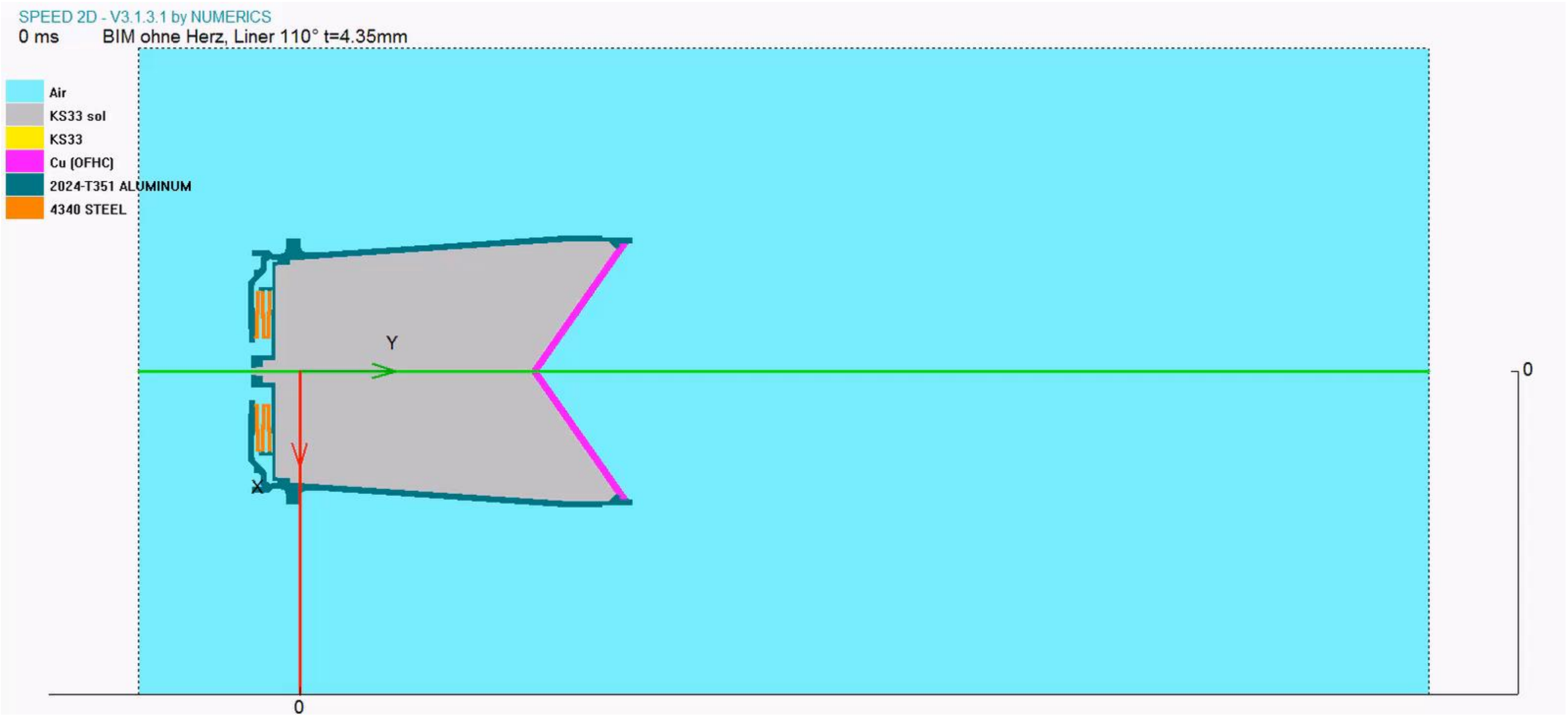

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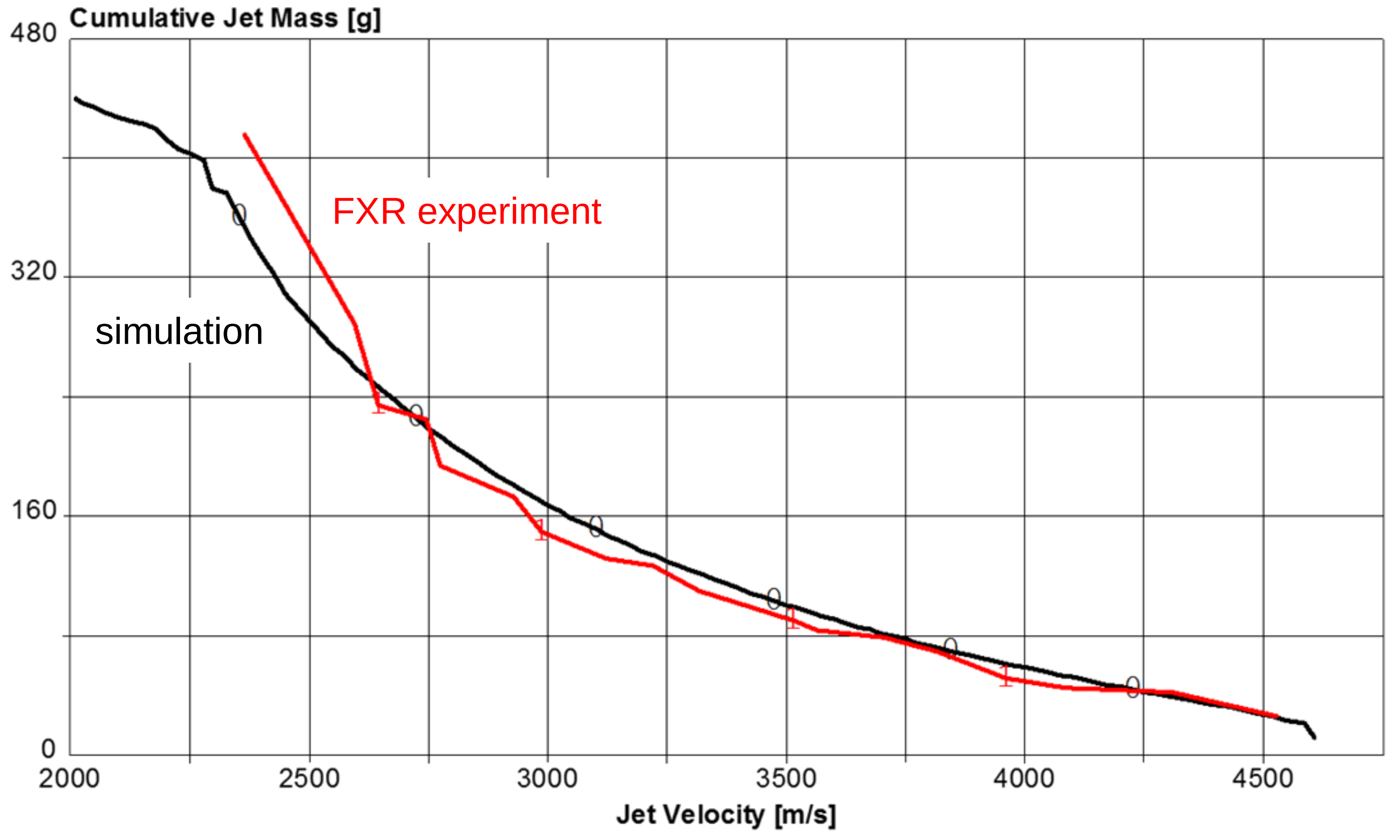

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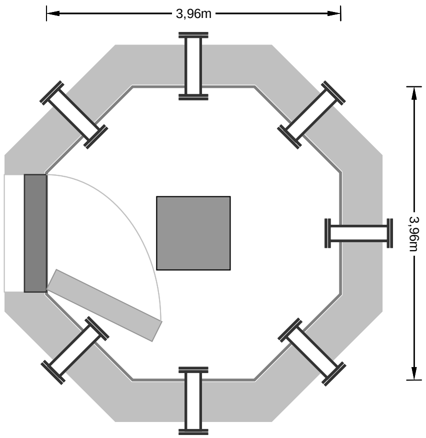
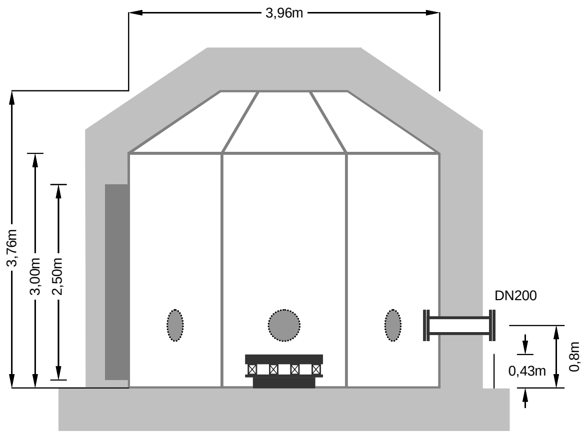
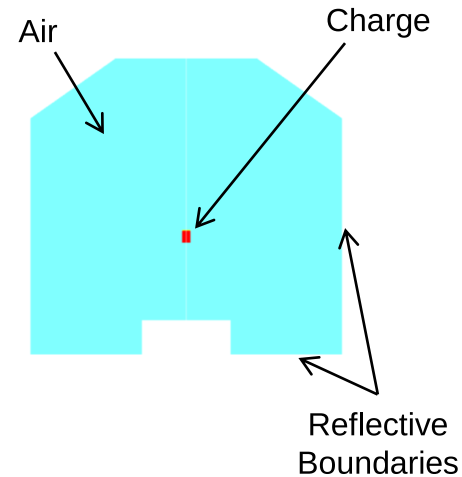
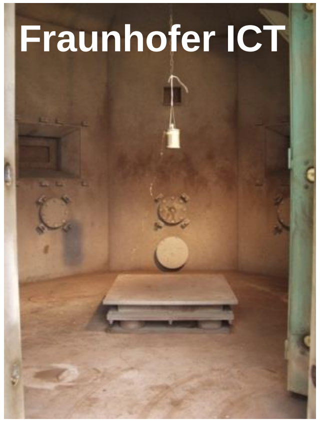
Application Example – Confined Detonation

Detonation chamber (45m³) test with 2kg KS22a (67/18/15 RDX/Al/PB)





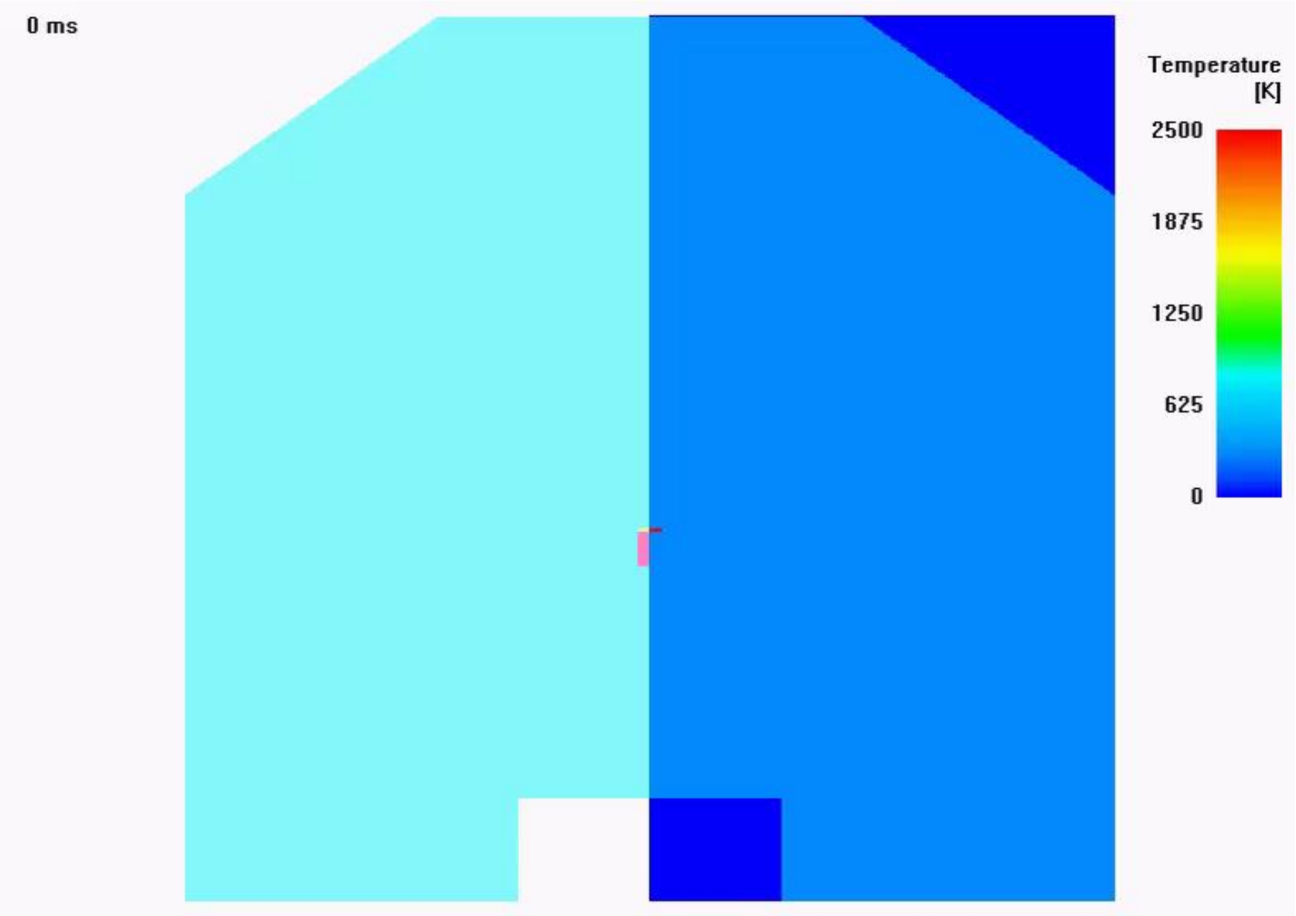




- 2D axisymmetric model (SPEED)
- KS22a JWL-parameters from thermochemical calculation (DRAGON), validated by test data
- Combustion model parameters from thermochemical calculation (DRAGON)

Hartmann T., Rottenkolber E., Boimel A., “Modeling of Aerobic Combustion“, in: 30th International Symposium on Shock Waves 1, G. Ben-Dor (ed.), ISBN 978-3-319-46213-4, pp. 467-472, 2017

Application Example – Confined Detonation



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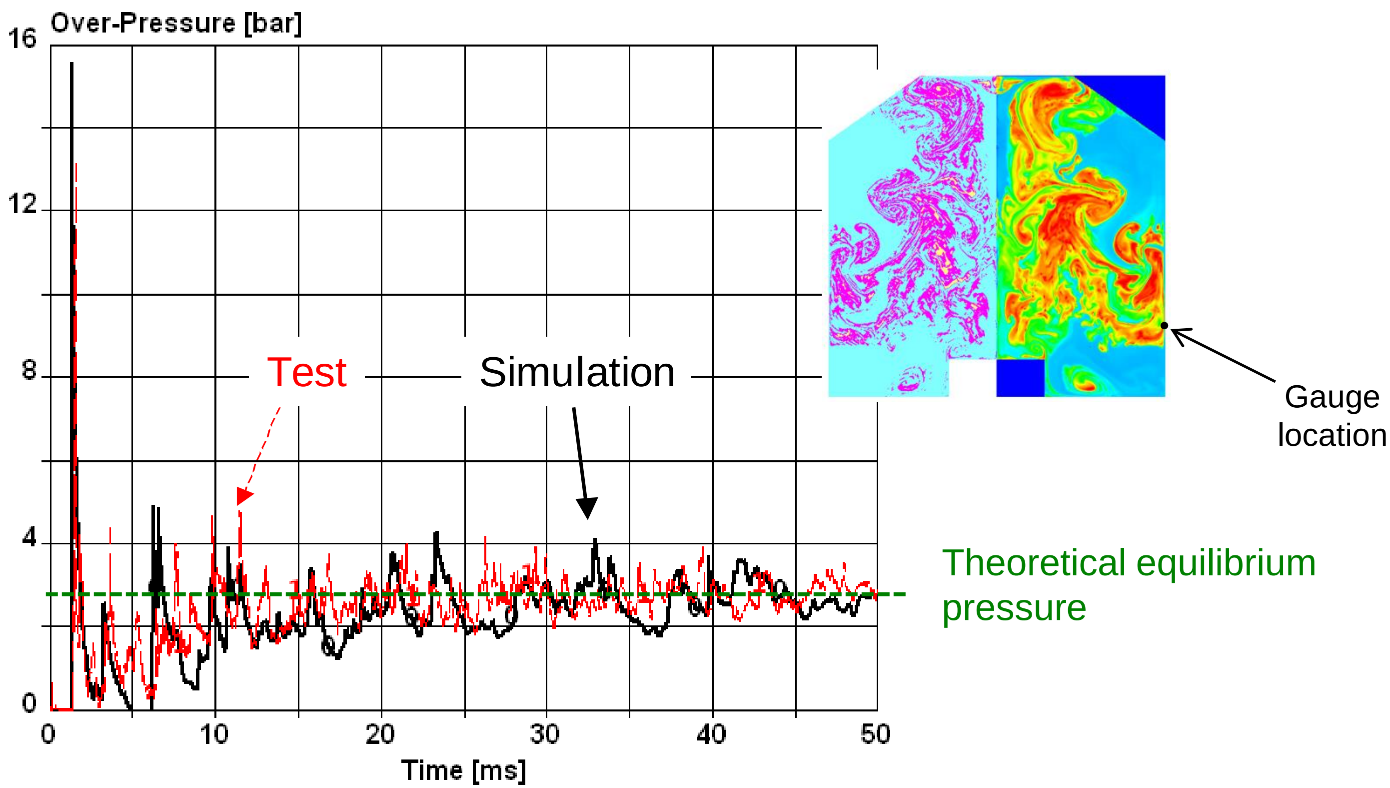
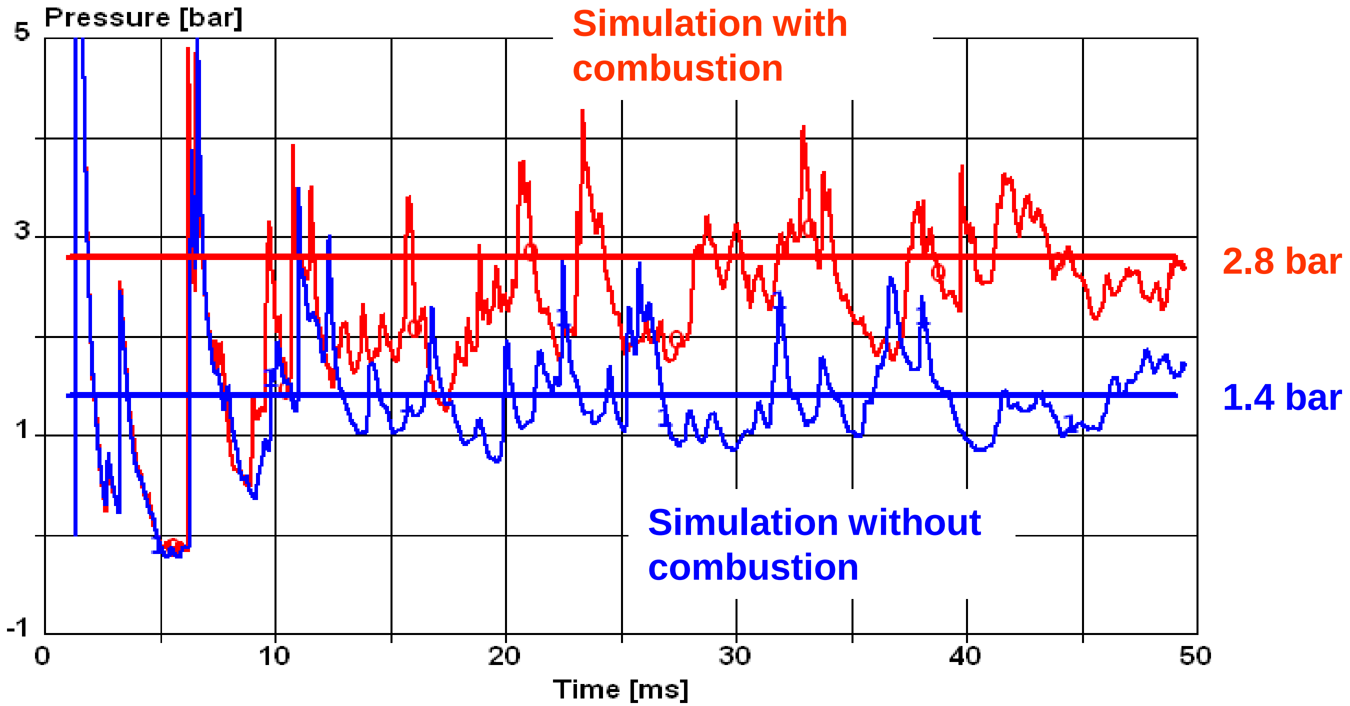


- Agreement of initial shock (arrival time & peak pressure)
- Same asymptotic value → equilibrium pressure
- Good correlation of pressure history up to 20 ms → combustion rate

Hartmann T., Rottenkolber E., Boimel A., "Modeling of Aerobic Combustion", in: 30th International Symposium on Shock Waves 1, G. Ben-Dor (ed.), ISBN 978-3-319-46213-4, pp. 467-472, 2017

Application Example – Confined Detonation

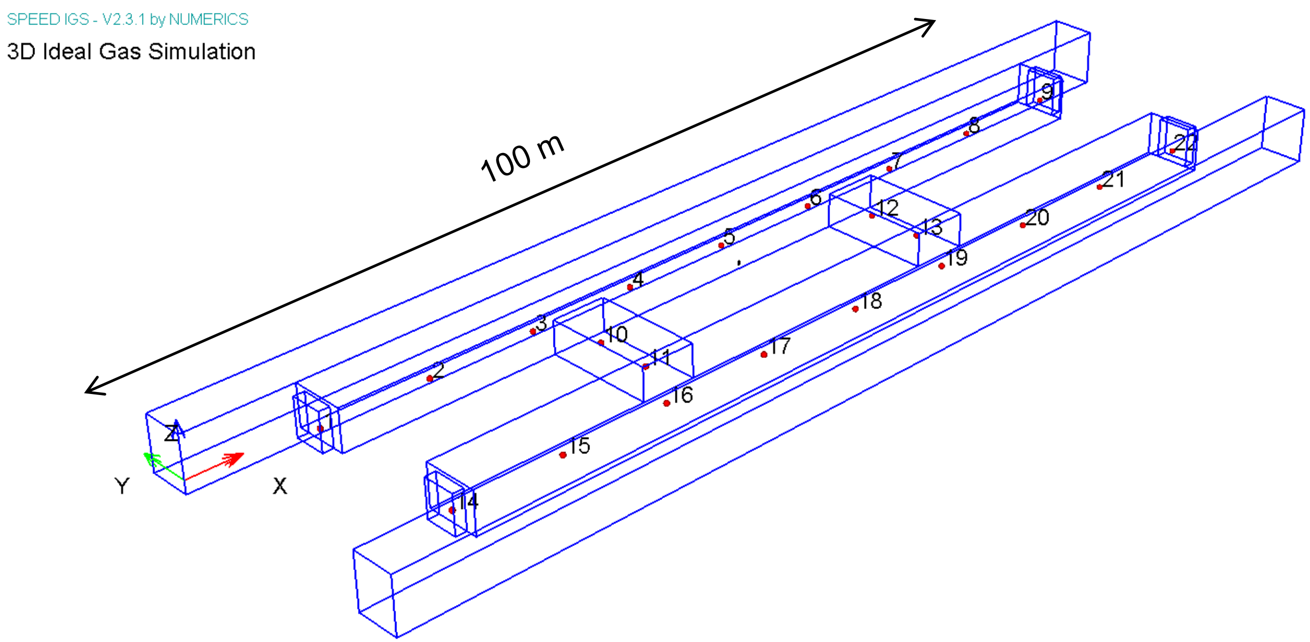


- The initial shock is independent from combustion
- Combustion provides the lion’s share to quasi-static pressure

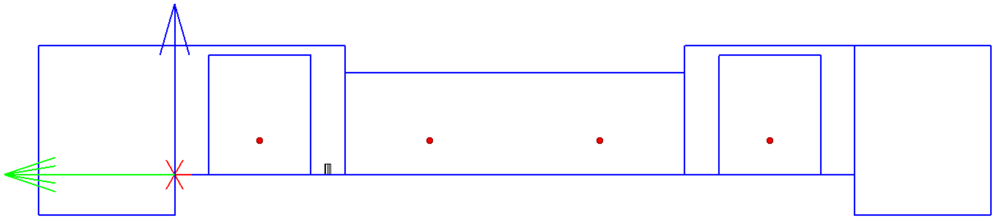
Hartmann T., Rottenkolber E., Boimel A., “Modeling of Aerobic Combustion“, in: 30th International Symposium on Shock Waves 1, G. Ben-Dor (ed.), ISBN 978-3-319-46213-4, pp. 467-472, 2017

Application Example – Ideal Gas Solver

Detonation of backpack bomb in a subway station.



Coss section view:



Application Example – Ideal Gas Solver

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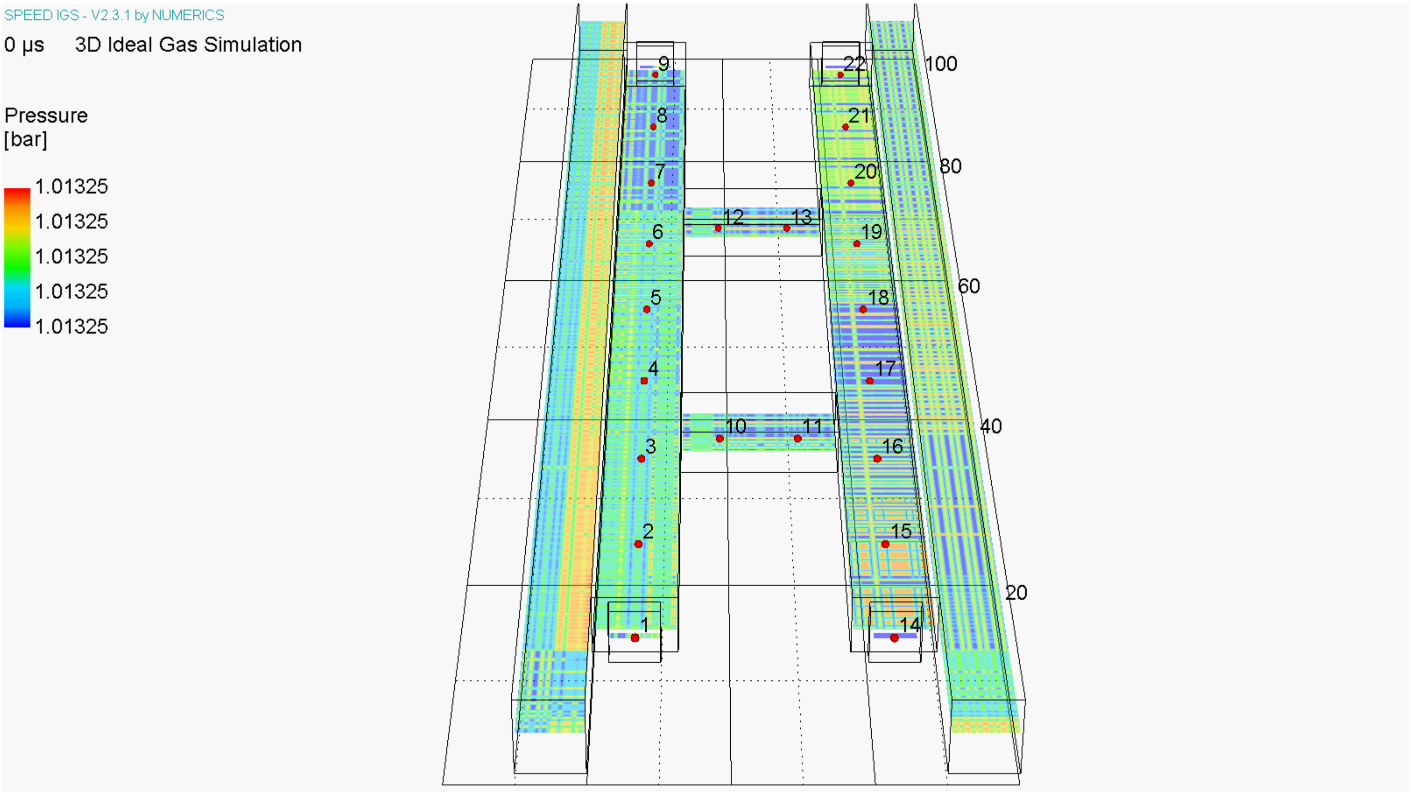


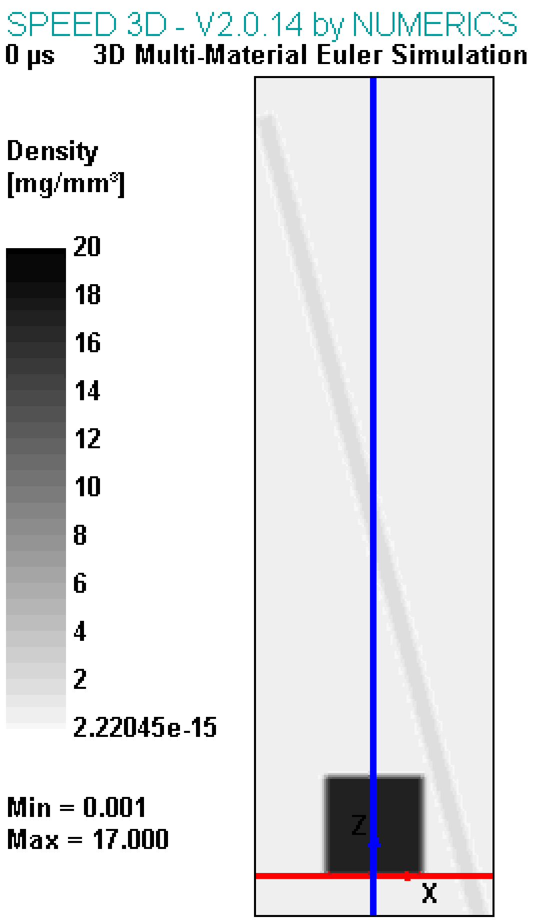
> 900,000 elements
Calculation time: 1h 20 min (not parallelized)

Application Example – High-Velocity Impact

Highly oblique tungsten fragment impact on an aluminum plate at 7000 m/s.

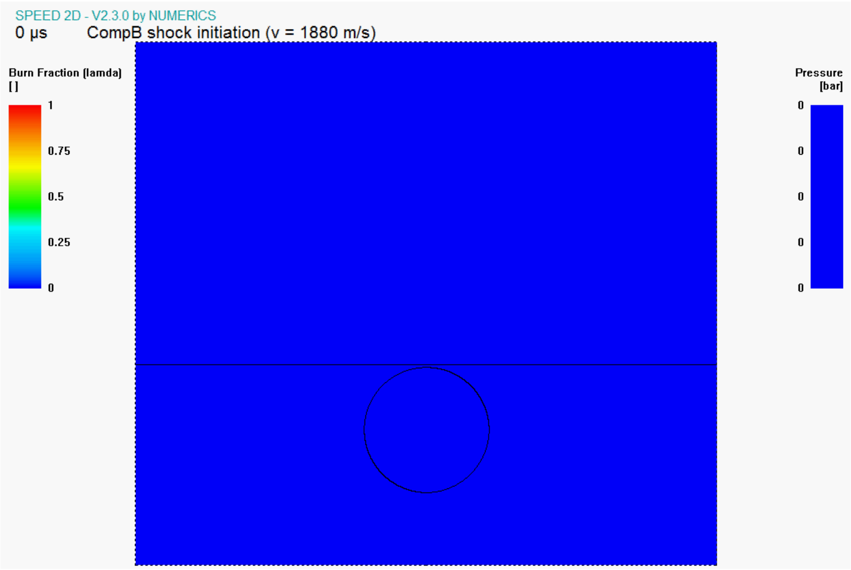
(grey-scale density plot)

(Part of a project for preformed fragment design to penetrate highly oblique target structures in TBM defence)

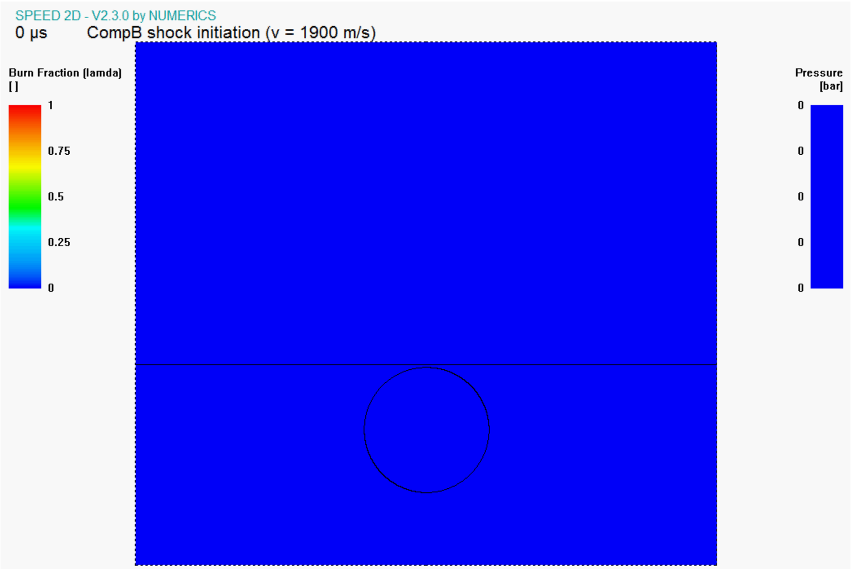


Application Example – Impact Initiation of HE

Projectile impact on bare CompB.



v_{imp} = 1880 m/s

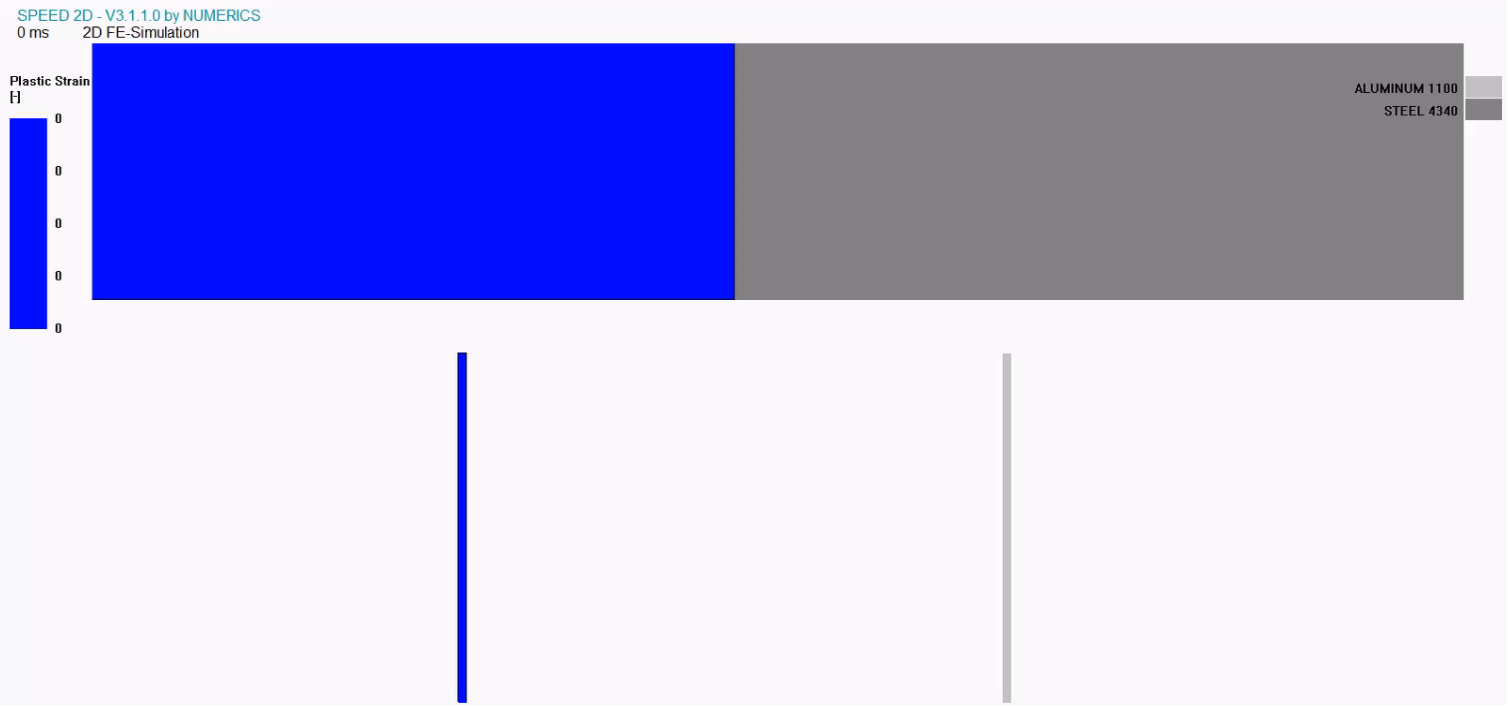


v_{imp} = 1900 m/s

James H.R., Hewitt D.B., “Critical Energy Criterion for the Initiation of Explosives by Spherical Projectiles" Propellants, Explosives, Pyrotechnics 14, 223-233 (1989)

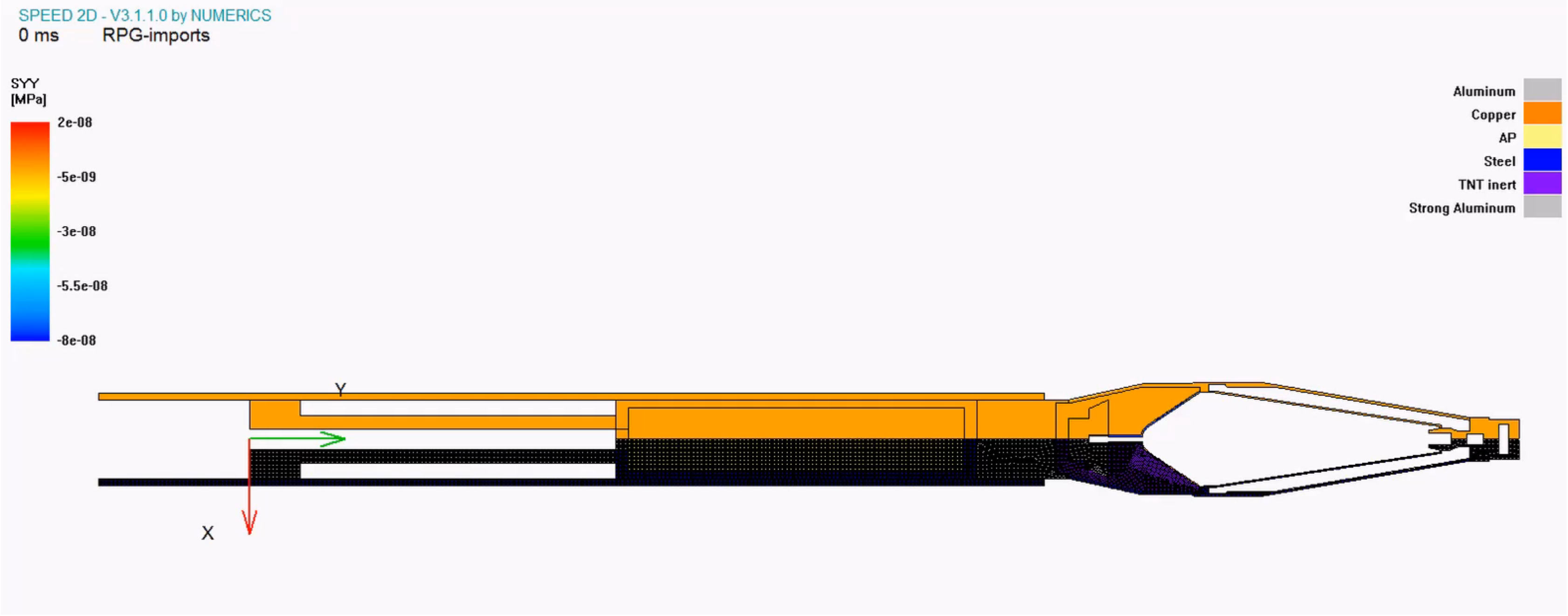
Application Example – Buckling

Aluminum tube impacting armor steel plate.



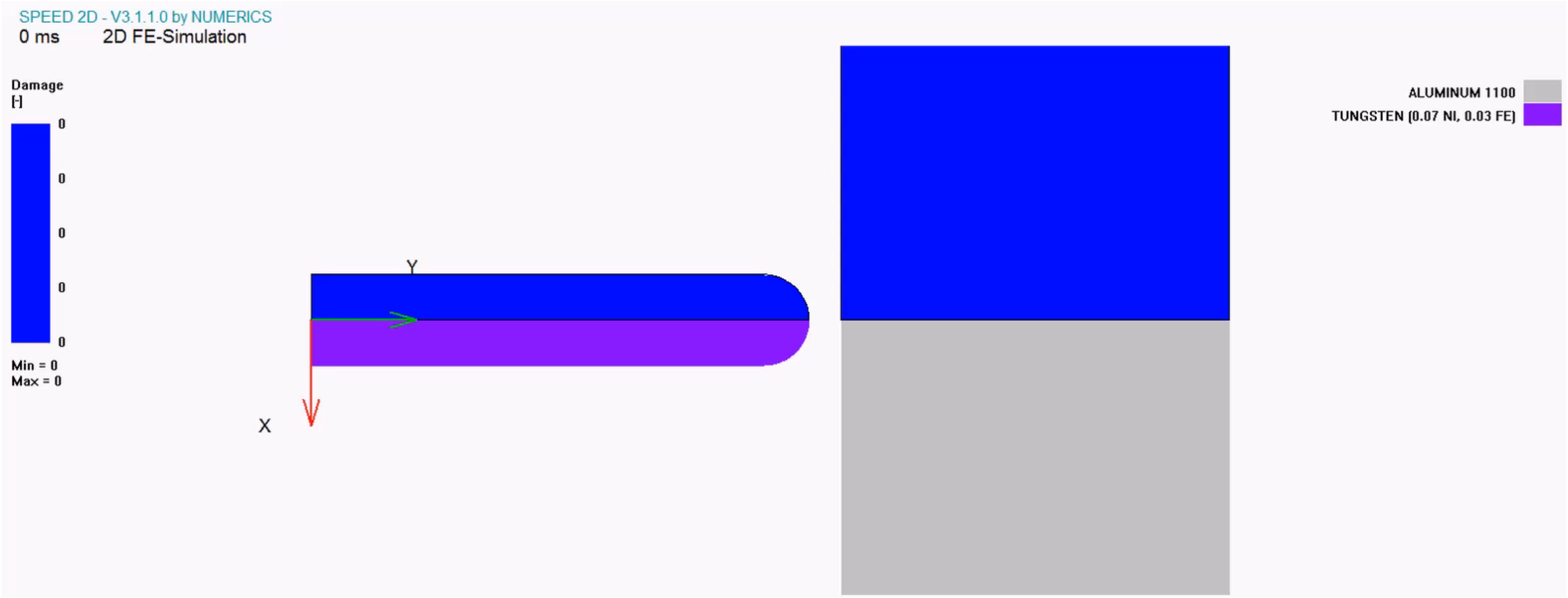
Application Example – RPG-Launch

Stress evaluation during RPG launch process.



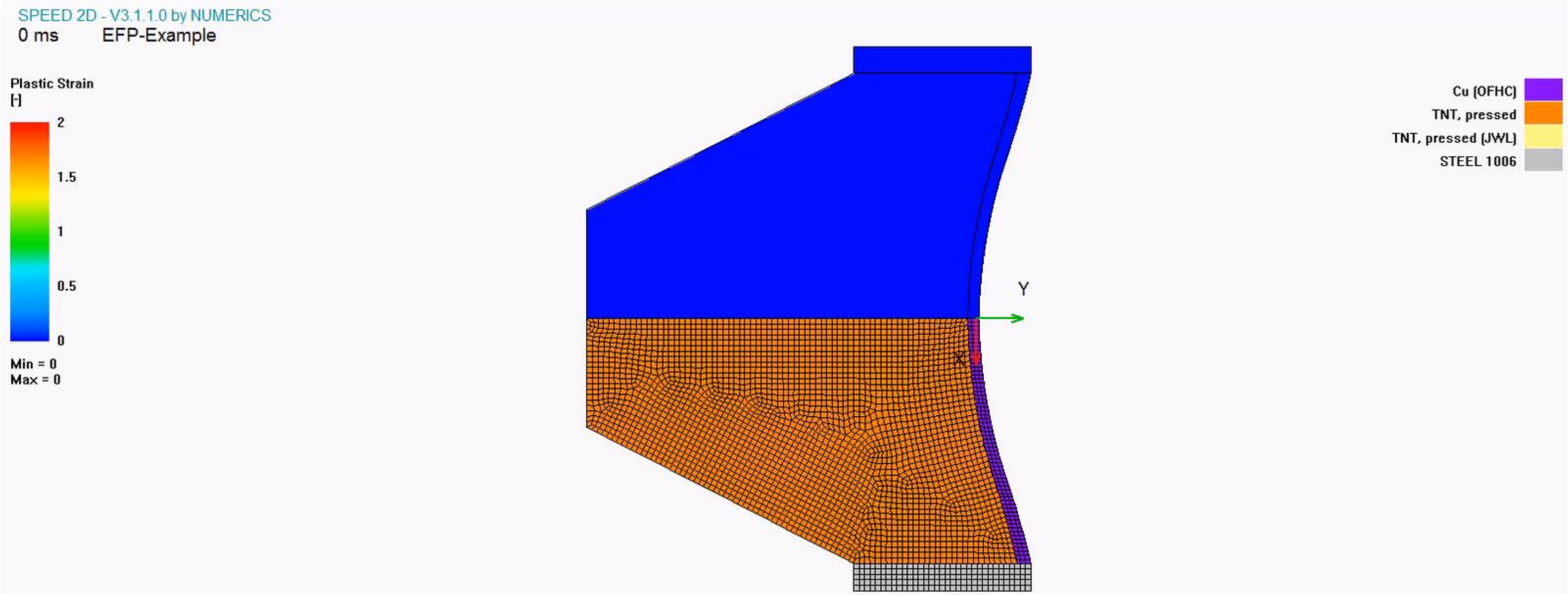
Application Example – WHA Penetrator

Tungsten heavy alloy penetrator perforating an Al target.



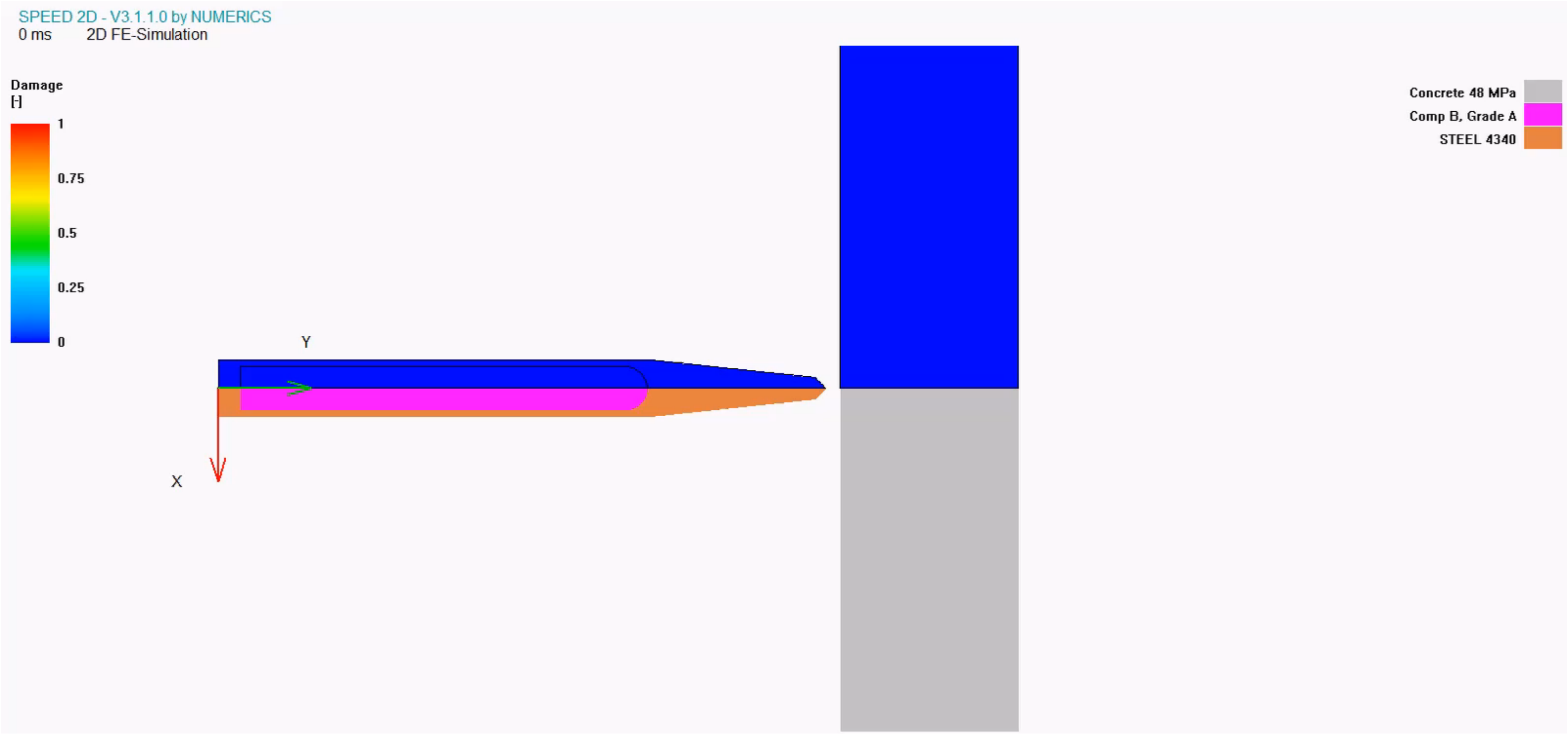
Application Example – EFP Formation 2D

EFP formation in 2D.



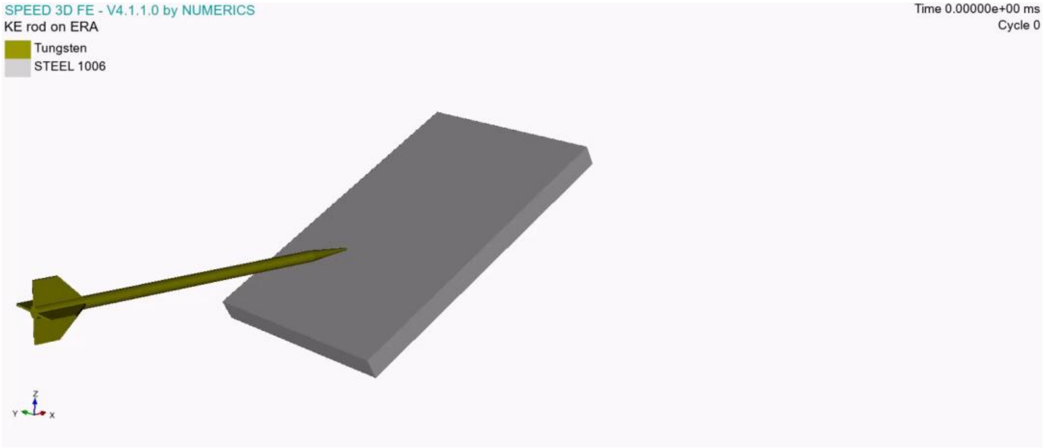
Application Example – Concrete Penetration

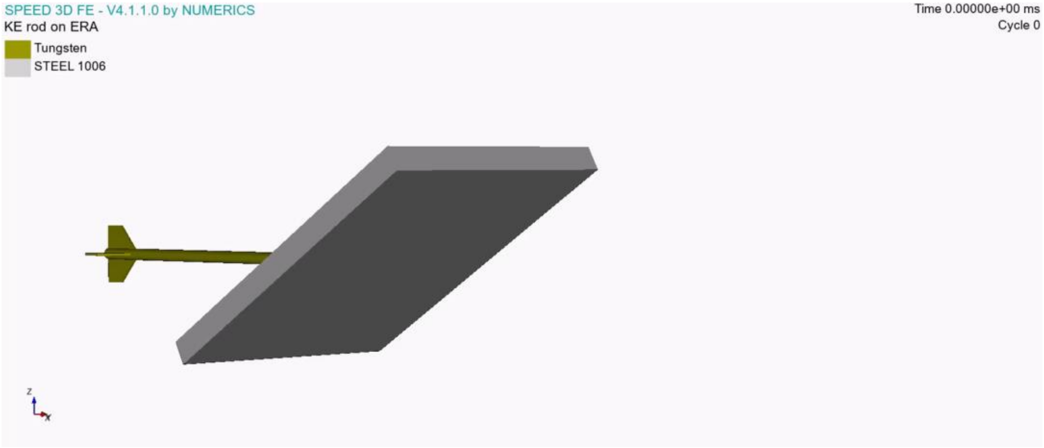
"Bunker buster" penetrating a concrete slab.



Application Example – Oblique Impact

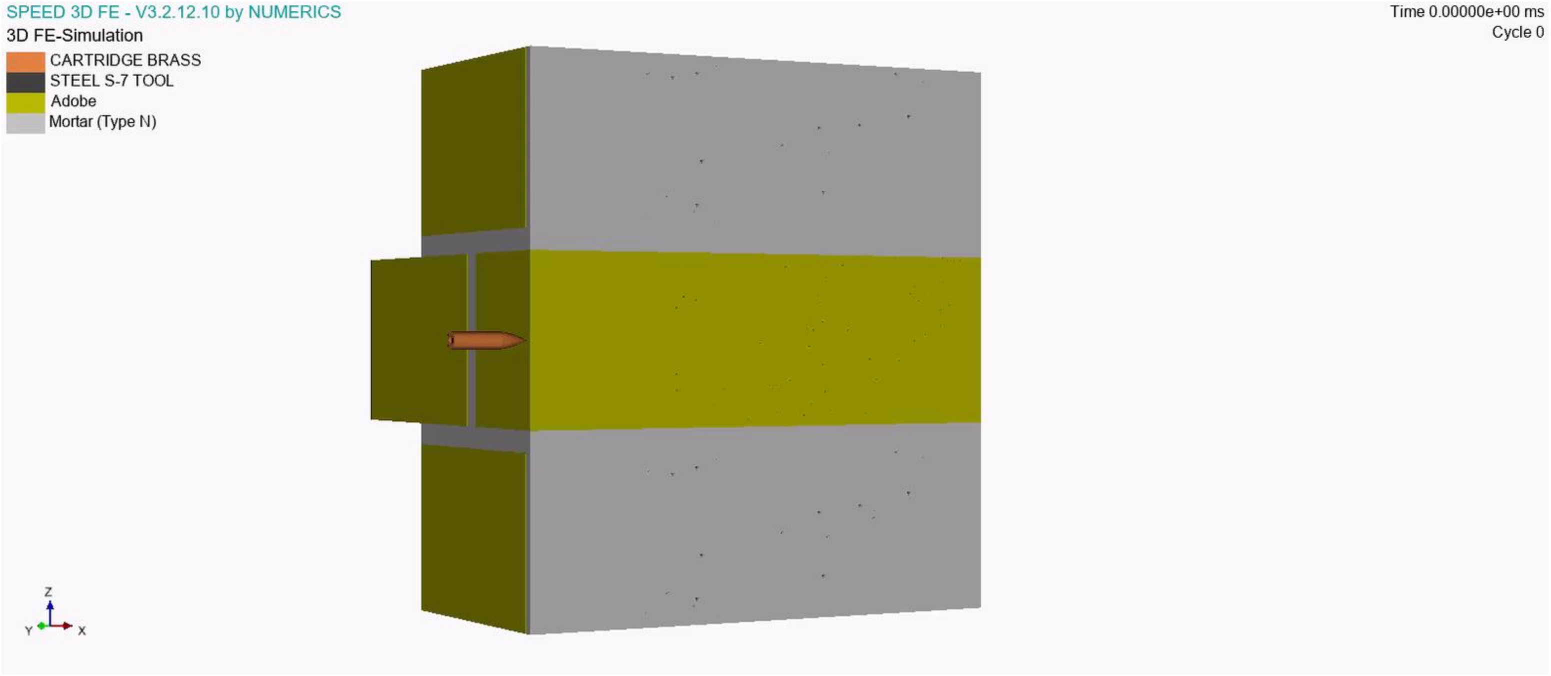
APFSDS with spin perforating a steel plate





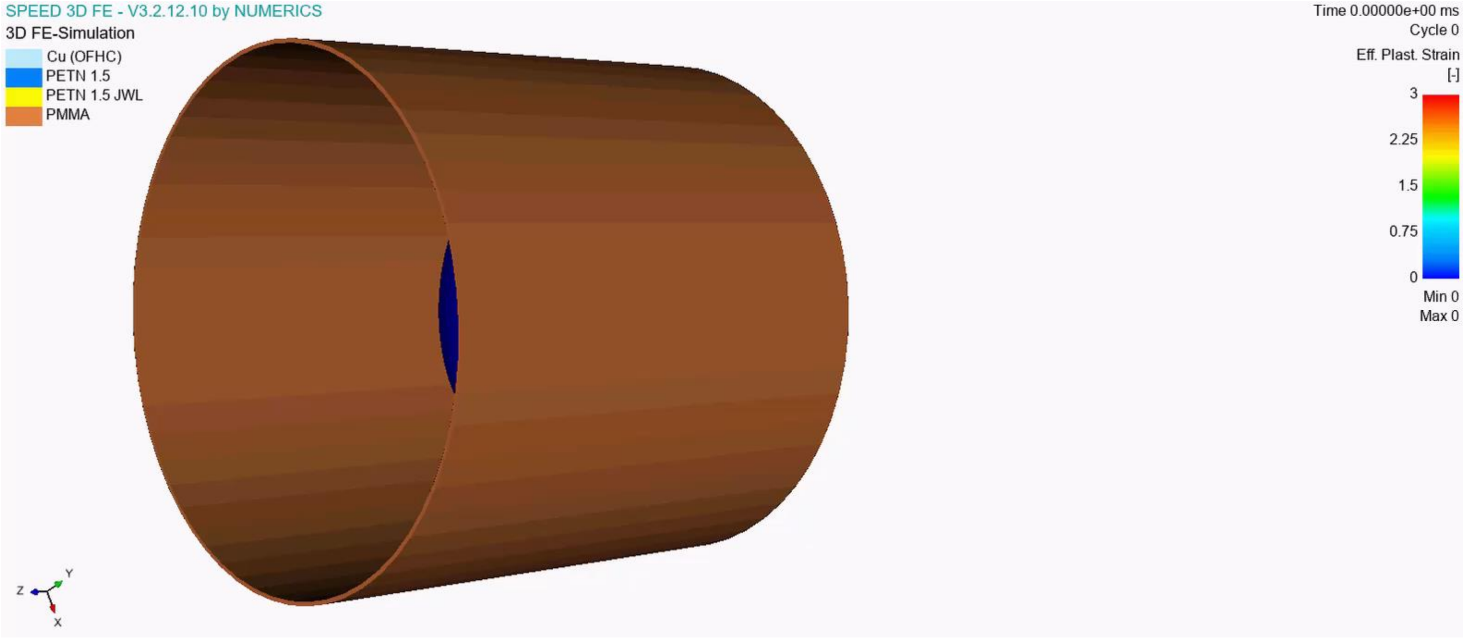
Application Example – Mud Brick Penetration

Yawed impact of jacketed projectile on mud brick wall



Application Example – EFP Formation 3D

EFP formation in 3D (HE not shown)



Further Benefits

The highly efficient computation technology with its high speed and low memory requirements saves computational costs. High productivity is ensured by

- the superior stability that saves manpower,
- the generally included multithreading capability that saves computation time,
- a batch mode that permits to process simulations without requiring user activities, and
- the intuitive user interface that significantly reduces the teach-in phase.

The additional free of charge SPEED^{PrePost} app offers efficient and flexible model setup and result evaluation, presentation or report preparation.

Contact: info@numerics.de

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