PS3D

Penetration **S**imulation with **3**-**D**imensional Trajectories

Introduction

PS3D, developed by NUMERICS GmbH, is a PC-based program running under Windows operating systems. It is designed to simulate the penetration of non-eroding projectiles into a variety of targets. PS3D calculates projectile trajectories, deformations and sensor signals. Projectile design as well as design and assessment of protective structures are the fields of application.
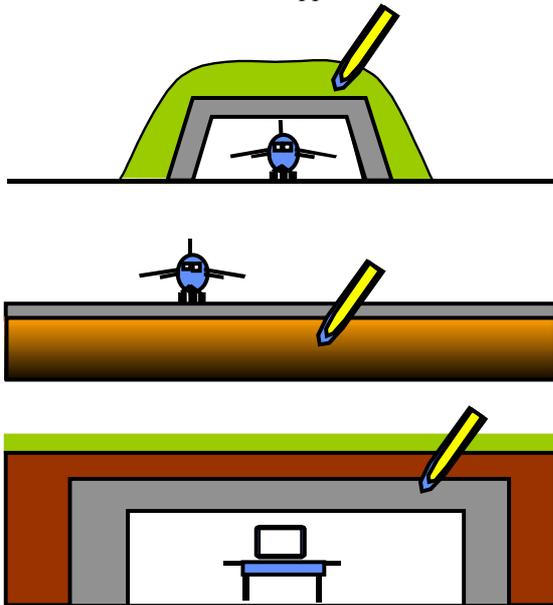
PS3D is an interactive program with a graphical user interface for setting up a simulation, monitoring it and displaying the results. Computational times are in the order of several seconds, so that the user is able to do a large amount of parametric analyses. Optionally, PS3D can run parametric analyses in batch mode, simulating thousands of impacts within a few hours.

Projectiles

A projectile has a casing that bears the structural loads. It may be filled with materials like explosives and it may be equipped with sensors, which are stations where the local acceleration and rotation rates are recorded. There is no limitation regarding the complexity of projectile geometry or nose shape.

A unique feature of PS3D is that it can model a projectile not only as **rigid body**, but also by means of **elastic-plastic beam elements**. In either case there is no need to do the discretization manually since the program according to user supplied control parameters automatically does that. Mass, center of gravity, and the inertia tensor are calculated by the code, too.
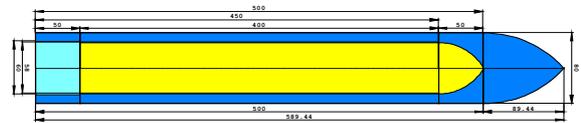
Verified projectile parameter ranges.

Material	Steel, Tungsten Alloy		
Caliber	5 mm	…	500 mm
Mass	1 gram	…	1000 kg
L/D ratio	1:1	...	12:1
Impact Speed	30 m/s	...	1500 m/s

Targets

Targets are composed of an arbitrary number of rectangular blocks. The blocks can be positioned and oriented arbitrarily, too.
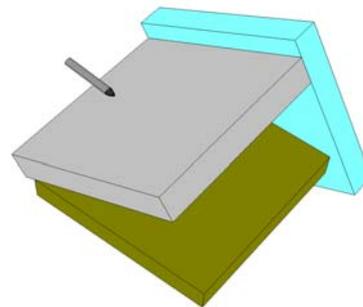
A target block may be reinforced by meshes of steel bars as indicated by the blue lines in the figure below. A target may also have a predrilled hole or it may have a cavity of piecewise linear shape as visualized with the red lines.
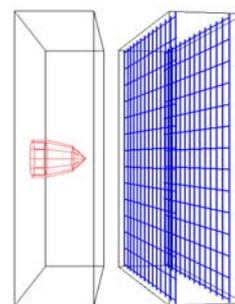
Analytical Background

Targets are simulated in a semi-empirical way. Projectile/target interaction is implemented as a differential area force law (DAFL). Force laws may be derived from cavity expansion theories (CET) or they may be composed by the user from a variety of supplied strength, drag and friction terms. Typical target materials are

- concrete, reinforced concrete,
- gravel, sand,
- soil, rock,
- aluminum, steel.

Application Examples

Projectile impact on a concrete slab may result in ricochet or perforation. PS3D can estimate the critical angle for ricochet as a function of the striking velocity and the target strength as well as the ballistic limit velocity and residual velocity after perforation. The figure below shows time sequences for two different impact situations.
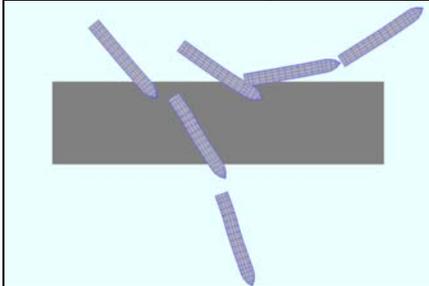
In the example above the projectile was modelled as elastic-plastic-strain hardening beam model. One of the most important results of the structural analysis is the plastic strain in the projectile casing. PS3D offers the total plastic strain and the tensile plastic strain as a function of the position along the projectile as possible failure criteria.
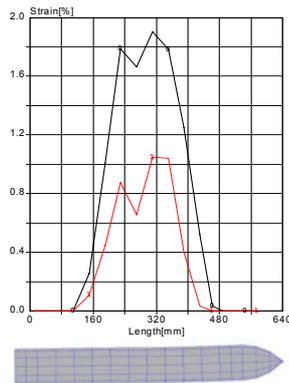
Another important problem is the prediction of acceleration signals that might be recorded within the projectile. PS3D uses sensor elements that record accelerations and angular rates in a body-fixed coordinate system just as accelerometers or gyroscopes would do. The figure below shows axial and lateral accelerations calculated for a sensor near the tail of the projectile.
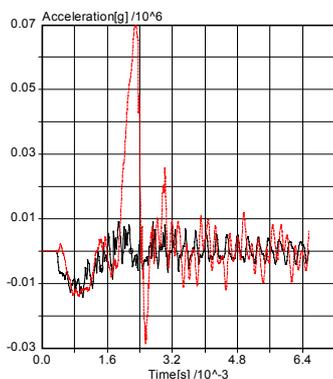
The stability of the projectile trajectory is of interest in low strength targets like natural soil. If the impact speed exceeds a certain limit, a very small initial yaw is sufficient to cause the well known J-shaped trajectory of earth penetrators as shown in the example below.
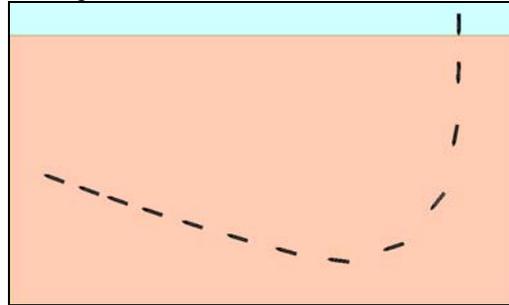
Benefits

The following are the benefits of using the PS3D software:

- **Cost Savings:** The program can be used to rapidly assess penetrator and protective designs. The design can then be easily modified to optimise performance for a specific requirement.
- **High Productivity:** The user interface makes PS3D easy to use and supports rapid generation of reports and presentations.
- **Continuous Development:** PS3D will continue to be developed to maintain and enhance its capabilities and to incorporate the suggestions of its users.

Licences

PS3D may be purchased as a paid-up license for perpetual use, or as an annual license.

In addition, a demonstration version is available during an exploration period of a few months.

Services

NUMERICS has a wealth of experience in the development and application of this and other analytical and numerical methods. We offer a broad range of supporting consultancy services designed to meet the clients needs, including technical training and support, specialist software development, turnkey analyses and research and development.