LETHALITY ANALYSIS BASED ON A FRAGMENTATION MODEL FOR NATURALLY FRAGMENTING SHELLS

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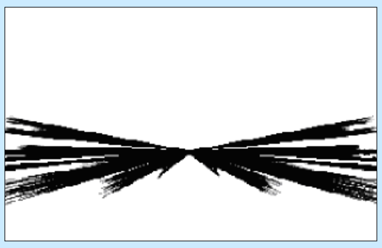
Abstract

In this paper, we analyze the lethality effects of exploding naturally fragmenting warhead by computing a three dimensional fragment distribution around the warhead. For the fragment generation we modified an earlier proposed method that uses a transformation of a general geometrical shape to a hollow sphere, subsequently applying the Gurney's principles. The method allows for prediction of fragment velocity vectors' distribution. Another method was used to model the fragmentation process and that method allows for capturing fragments' masses, sizes and classes of shapes. Consequently, the air drag equations are applied to calculate the trajectory of each fragment. For lethality analysis we used the kinetic energy supplemented by other fragment parameters to compute lethality effects. We proposed a general approach to calculate lethality as a function defined over a volume. We explored several basic lethality functions and discuss differences between them. We claim that the approach presented can be used to analyze lethality on complex shapes. A set of experiments based on an actual artillery shell is included to provide validation of the approach is presented.

Results

The software simulations were able to recreate empirical fragmentation patterns. The effects of terminal and rotational velocity can be visualised and quantified in terms of lethal effects.



Kinetic Energy Distribution for a Static Shell

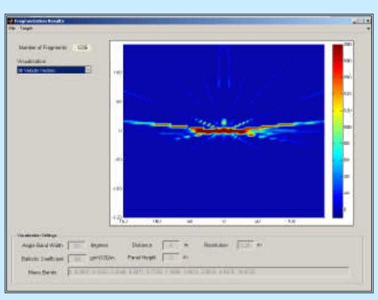
Kinetic Energy Distribution for a Shell Travelling at 300 m/s

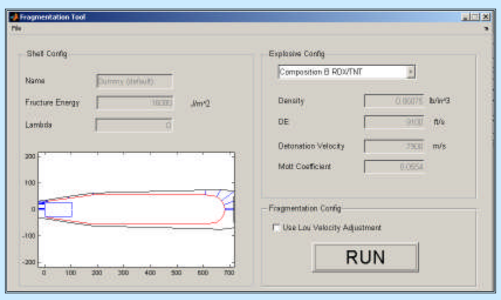
Applications

Once properly validated, the software tool can provide cost-effective and method for estimating lethality effects of various designs of shapes, compositions, terminal velocities, etc.

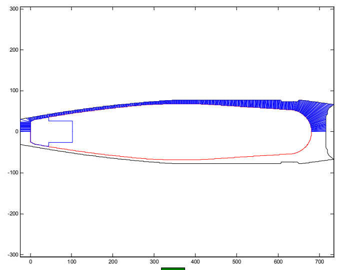
FATool Software

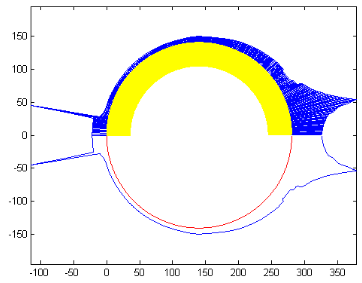
The lethality analysis model presented on the right-hand-side was implemented as an analytic tool within the FATool software framework. FATool is implemented in the MATLAB modelling environment and is deployed as a stand-alone application. FATool is designed with a modular approach in mind allowing for using different models for aeroballistics, lethality, etc. and batch-running and parallelization.

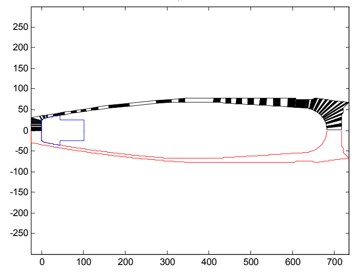




Method Overview



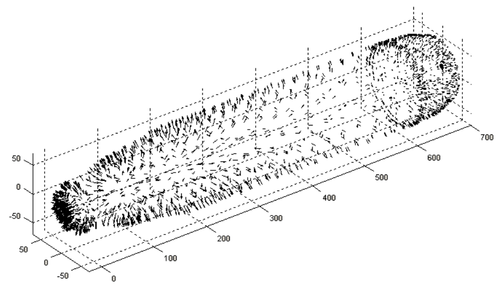




FRAGMENTATION MODEL

The original 2D shape is converted into a sphere to determine initial velocities using the method developed by Jayaratnam in 2001.
Fragmentation model is based on Szmelter 2003, but was significantly improved.
The model results with the following for each fragment:

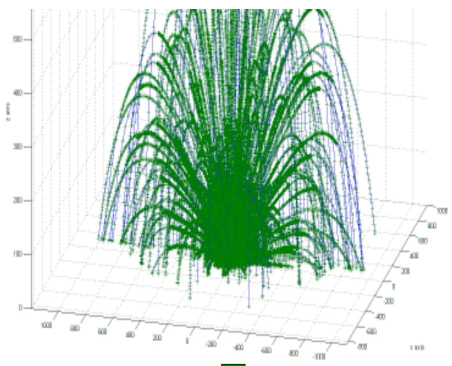
- Initial velocity vector
- Initial position
- Shape class
- Width, length, and height



AEROBALISTIC MODEL

A trajectory for each individual fragment is calculated:

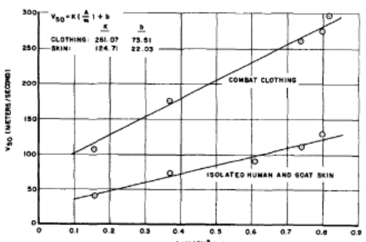
- Drag coefficient is determined based on shape and velocity
- Drag coefficient model based on McCleskey (1988)



LETHALITY MODELS

Different lethality functions can be used, currently available:

- Thresholded Kinetic Energy
- Cost-augmented function based on Kinetic Energy
- Lethality function based on Sperrazza and Kokinakis (1968) that accounts for velocity and shape of the fragment



REPORTING RESULTS

The approach assumes that the area is uniformly covered with targets and the distribution of probability of kill is calculated for each point on the grid (50cm x 50cm grid by default). Since results are non-deterministic multiple simulations are necessary to determine averaged effect. Around 200 simulations is needed to provide robust estimates.