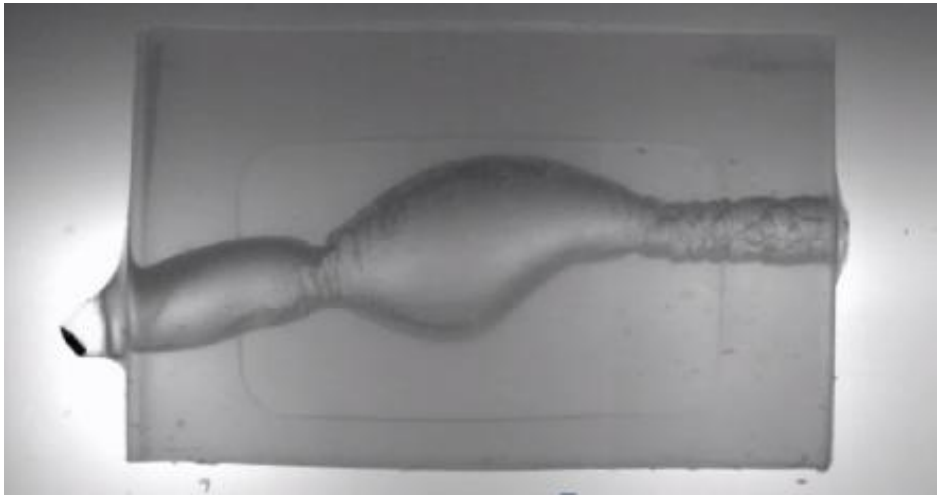
Assessing bullet terminal effects



14 May 2014

QINETIQ/14/01244

Contents

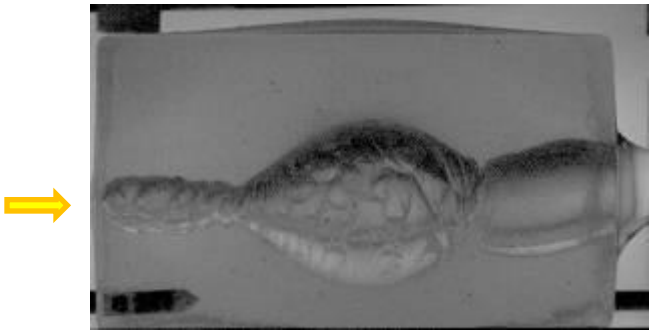
1
The method for testing bullet lethality

1 Bullet performance

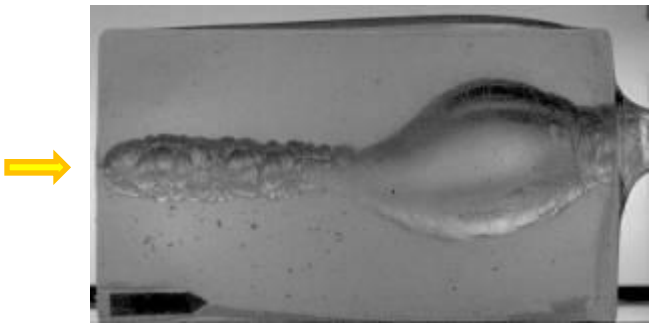
Bullet performance depends on two things

1. Amount of energy deposited

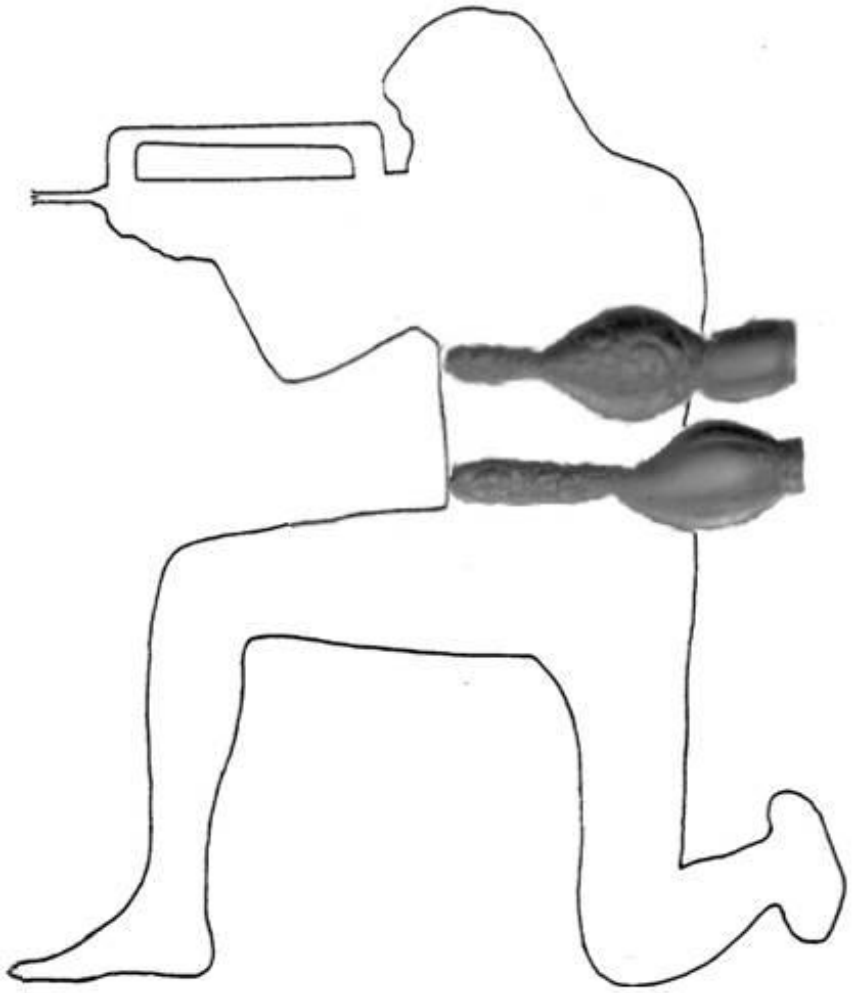
2. Depth of energy transfer



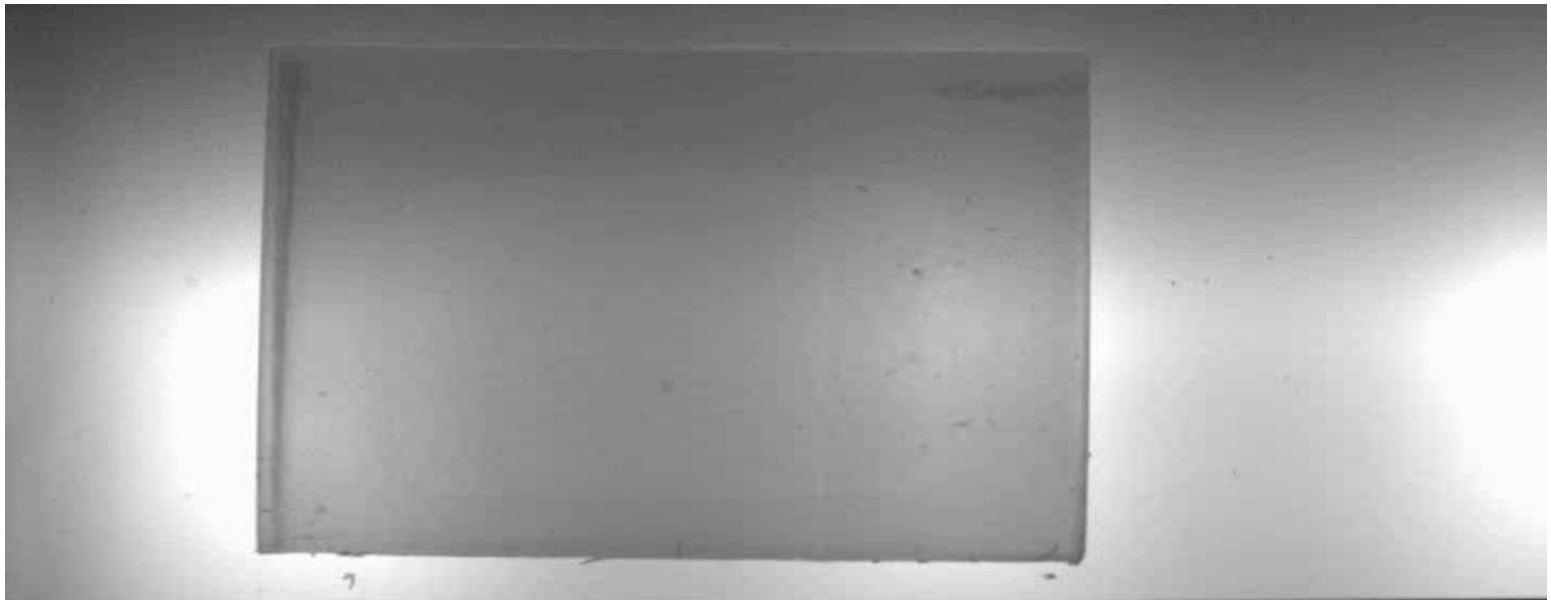
early turning



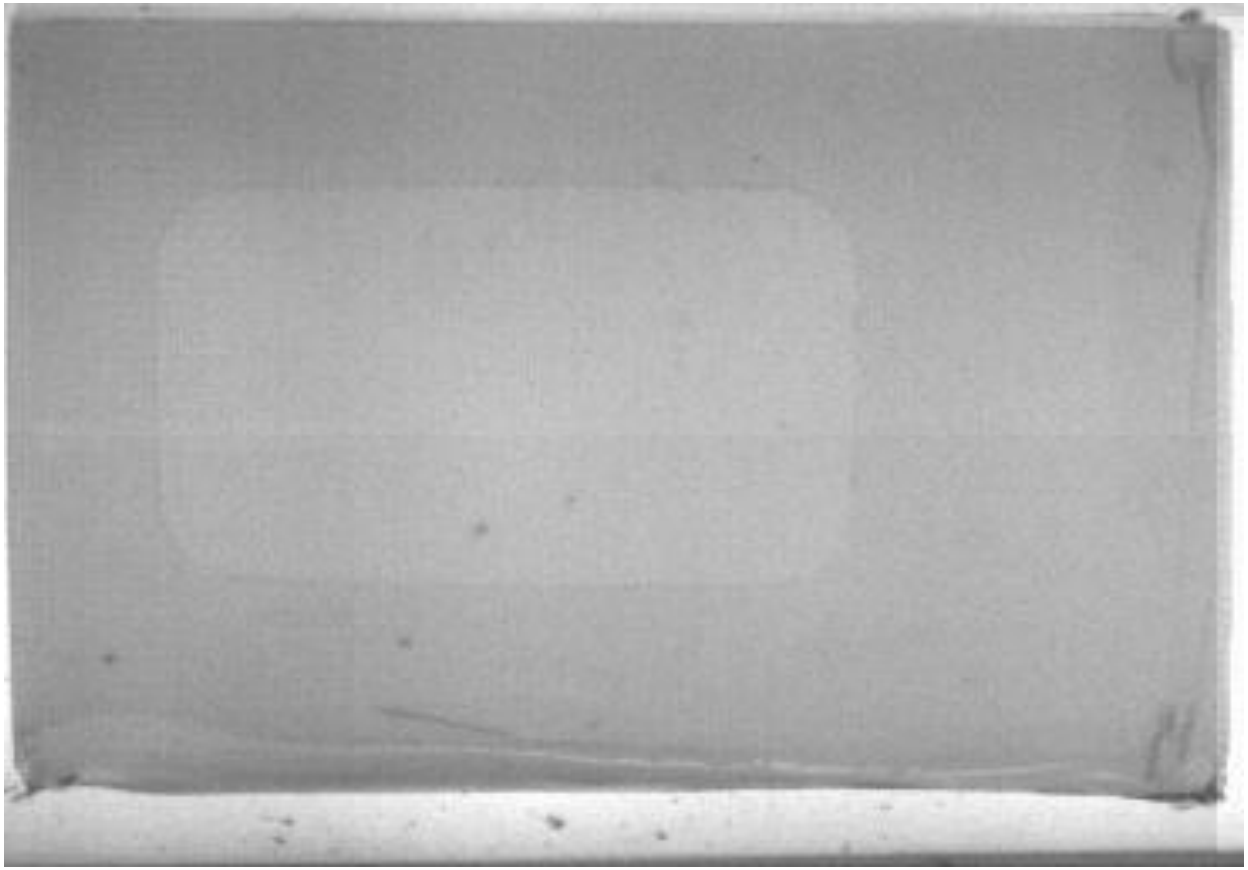
late turning



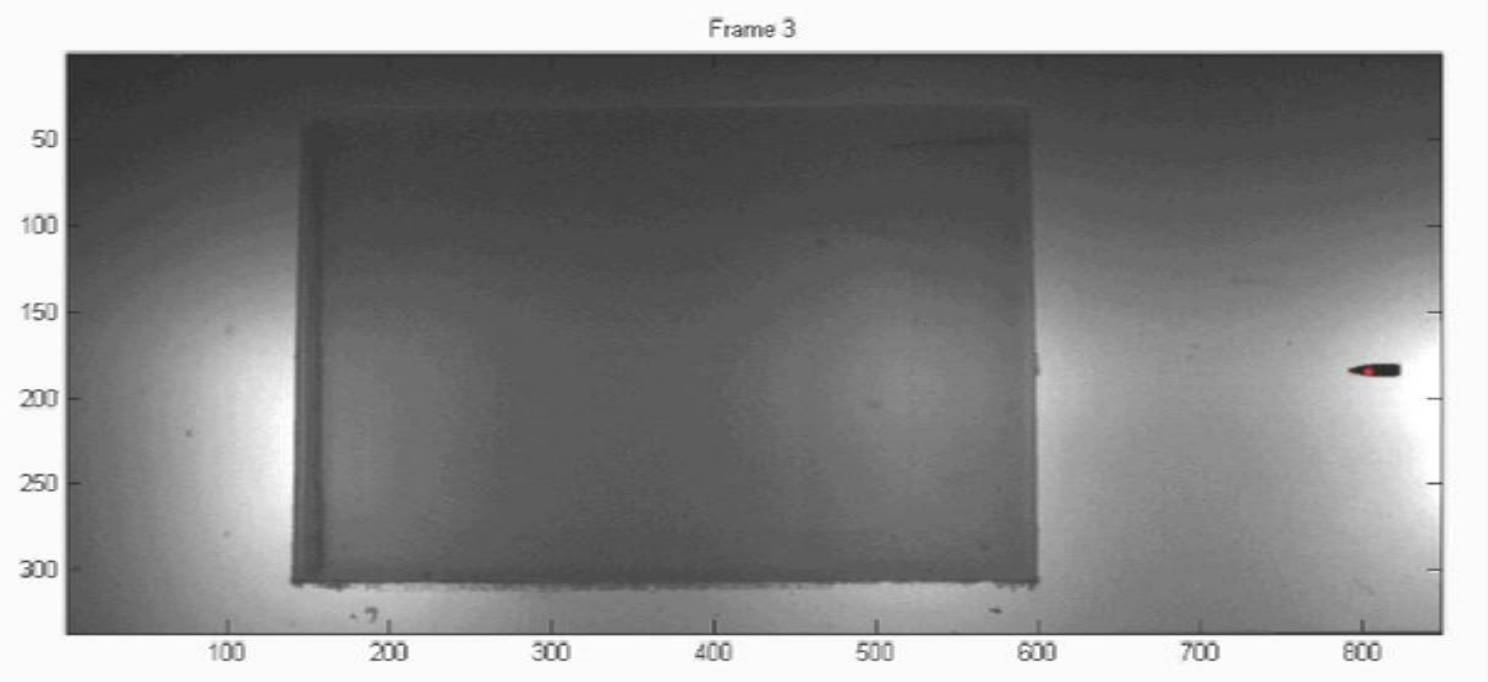
1 Example gel block high speed video



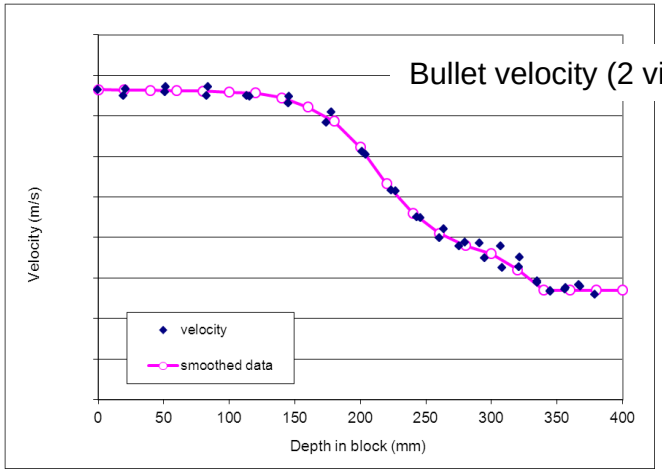
1 Example gel block high speed video



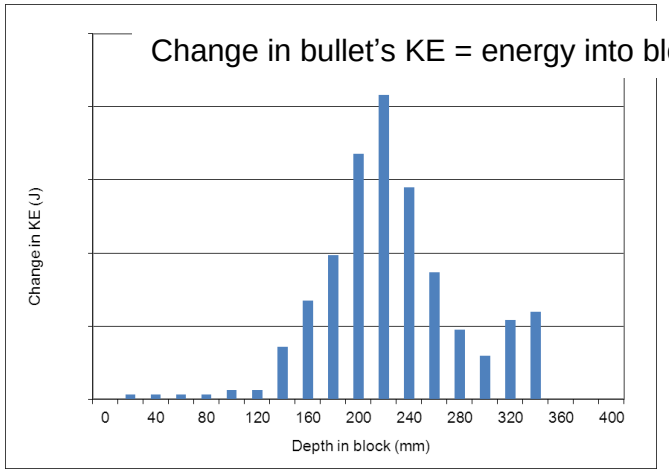
1 Example gel block high speed video



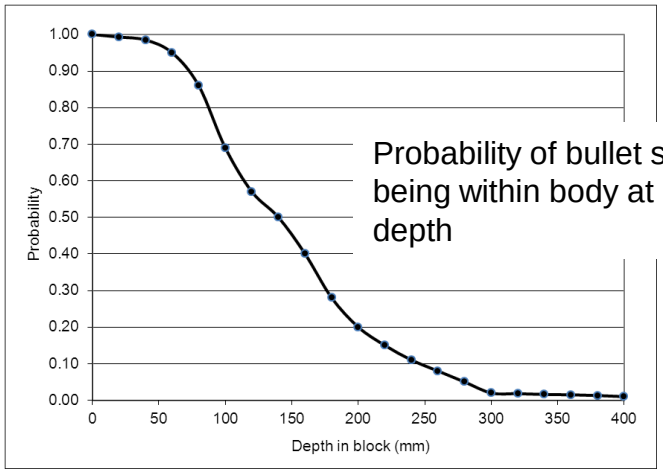
1 Calculate the energy transferred



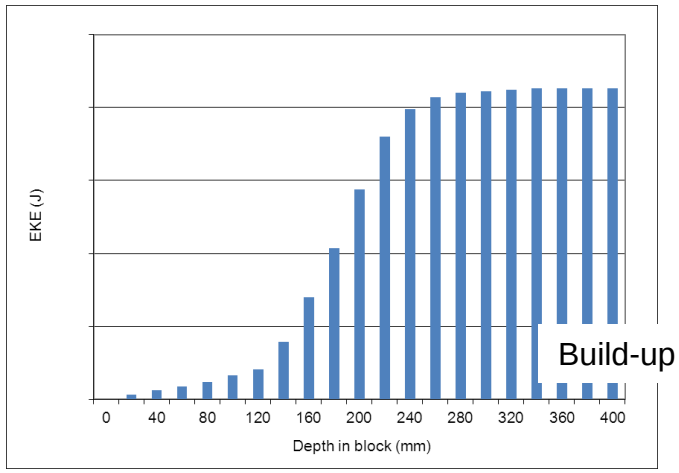
Bullet velocity (2 views)



Change in bullet's KE = energy into block



Probability of bullet still being within body at each depth



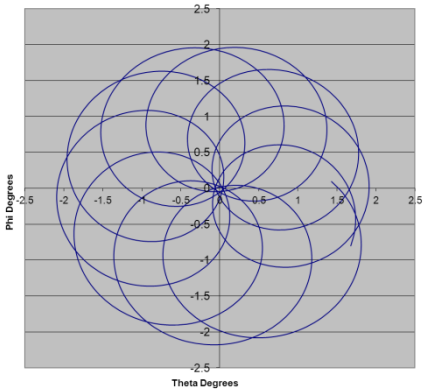
Build-up of EKE

Note: KE= Kinetic Energy

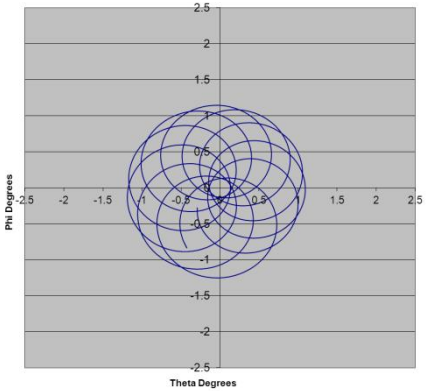
EKE=Expected KE

1 Strike yaw (and yaw rate) vary with range

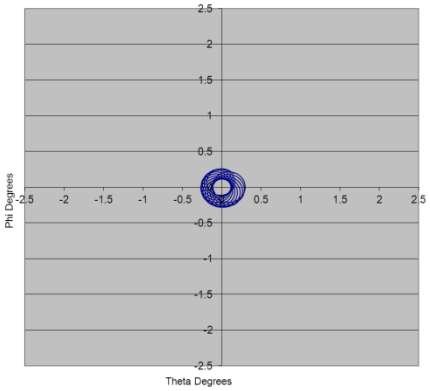
10m



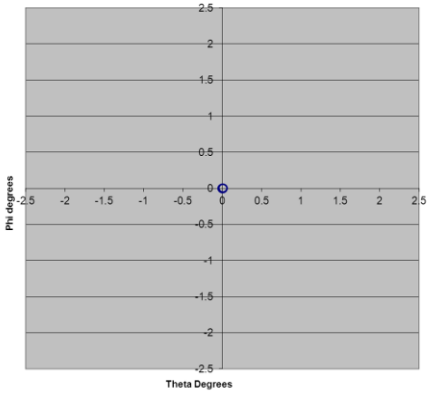
60m



200m

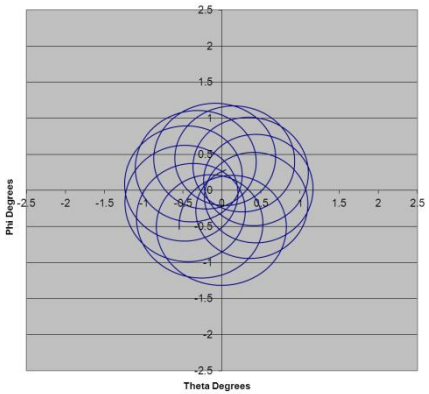


400m

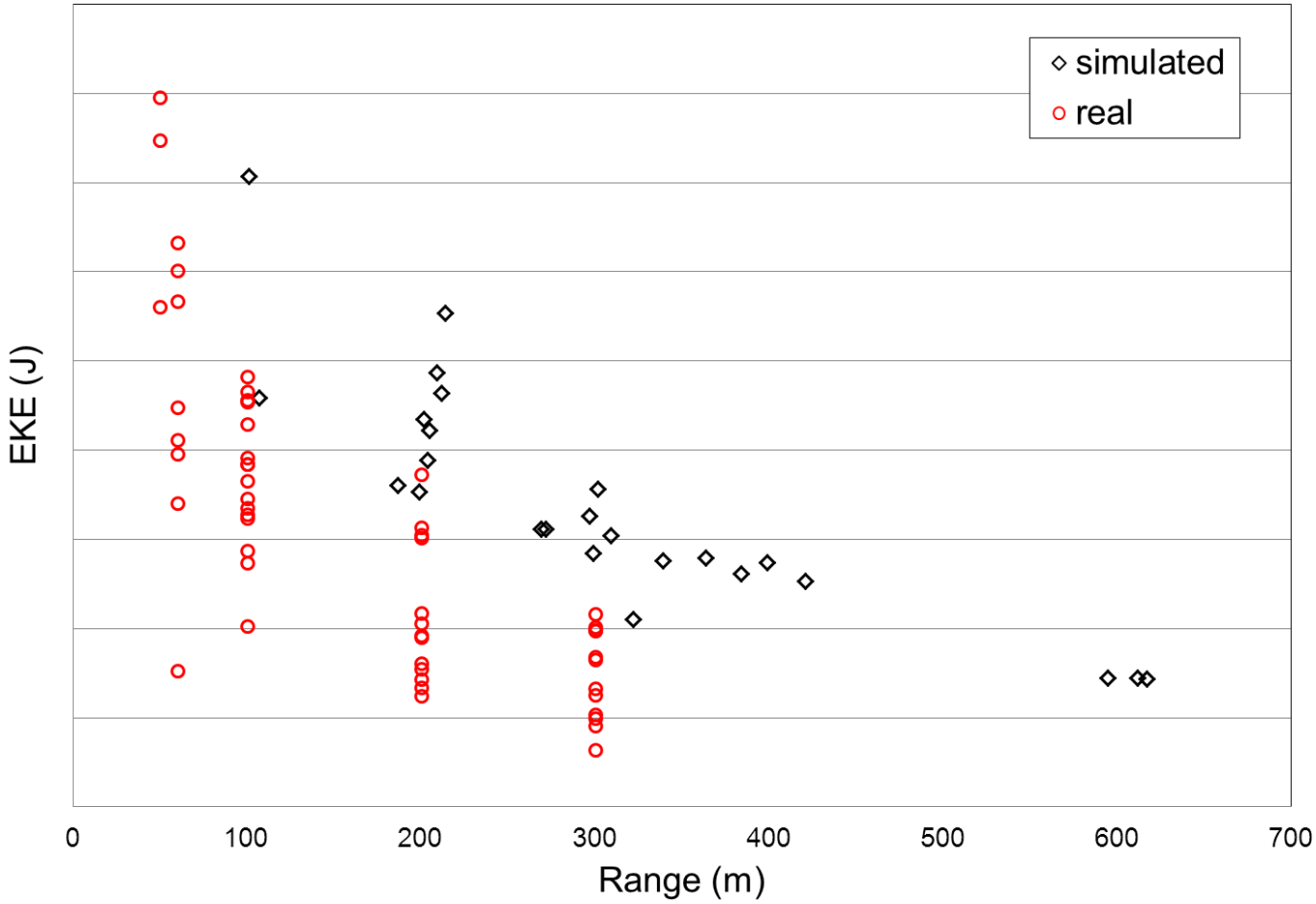


After 60m of trajectory →

(But a strike velocity equivalent to 200m of trajectory)



1 Results comparison



1 Outcomes

- The Expected Kinetic Energy (EKE) of a bullet is greatly influenced by the position of energy deposition within the target
- This position is greatly influenced by yaw at strike
- Testing using downloaded ammunition does not correctly replicate strike yaw and thus can give misleading results

- Improvements to the trials set-up mean that firing at real ranges is feasible:
  - New cameras that don't need such bright lighting
  - Use of high powered LED lights instead of pre-triggered flash bulbs
  - Use of a stripper plate to protect the gelatine target
  - Improved gelatine block manufacturing methodology

2
Using Flight Follower to characterise bullet flight behaviour

2 Ballistic coefficients define how a projectiles moves

Ballistic coefficients:

- Drag and yaw drag
- Lift
- Magnus
- Damping force
- Spin damping moment
- **Overturning moment**
- Magnus moment
- **Damping moment**

These are not single values: most vary according to projectile velocity and spin rate

They are determined from analysis of free-flight (not wind tunnel) observations

Ideally, you'd do this in a spark range

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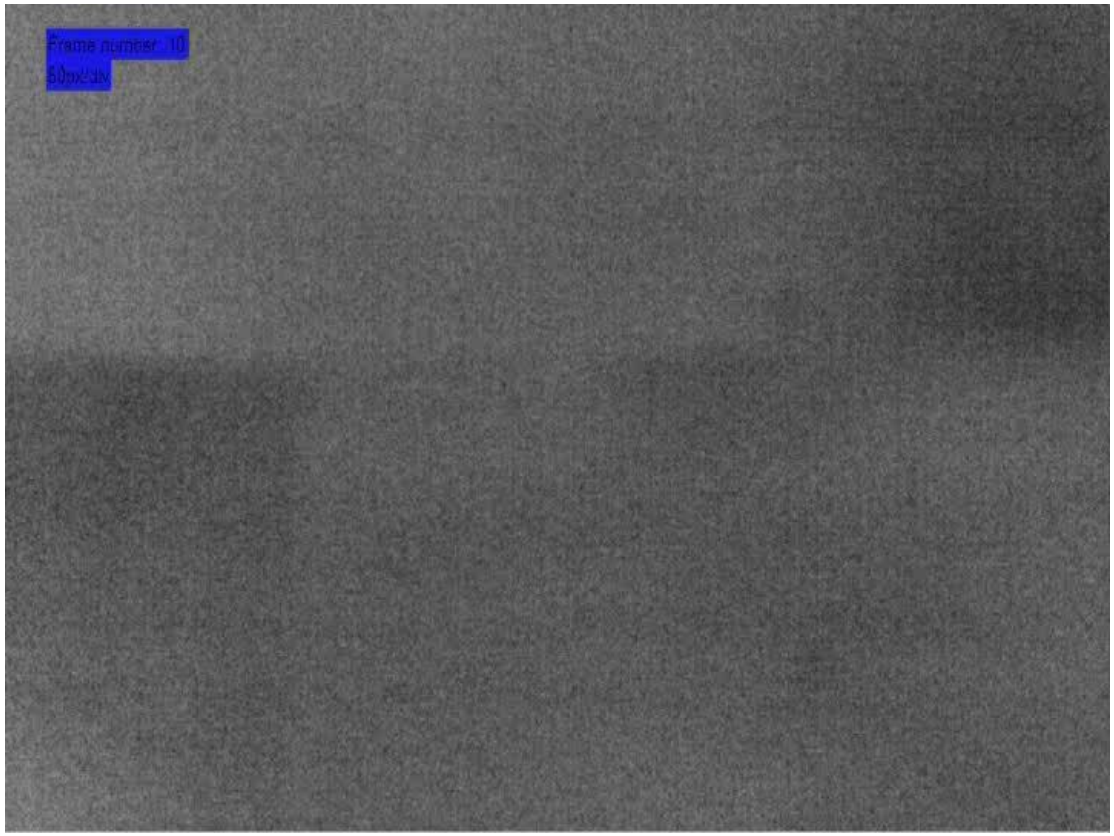
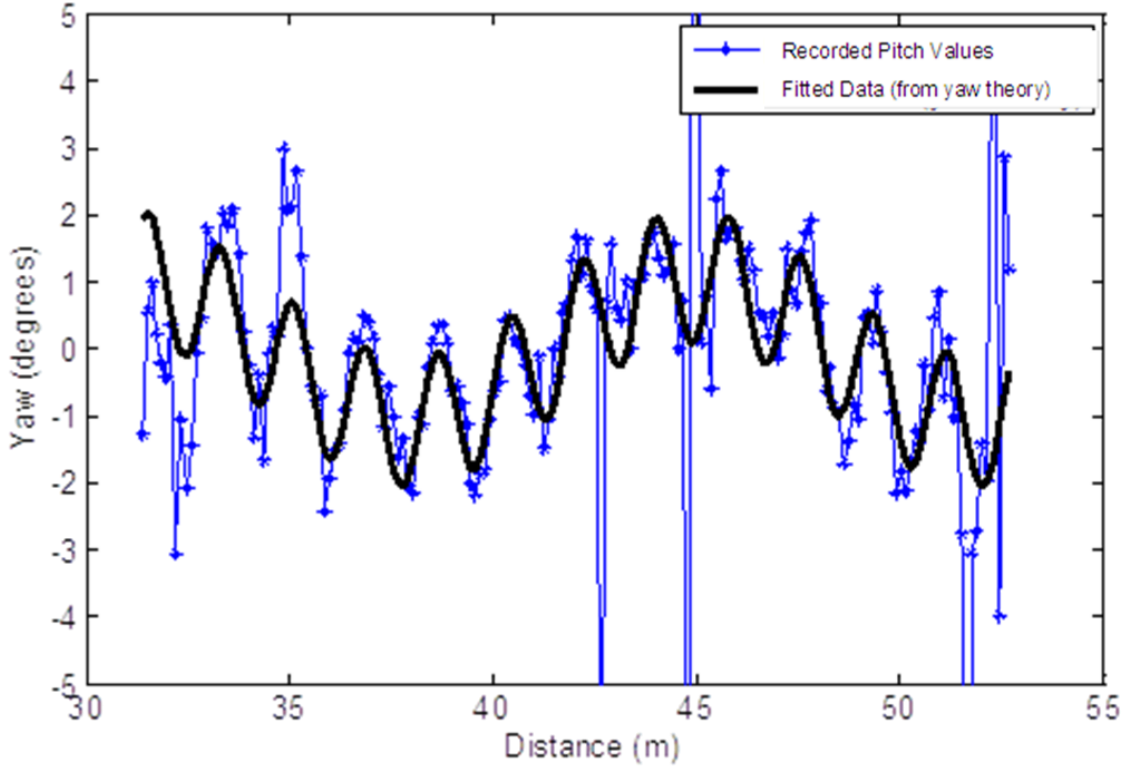
2 Example of recorded bullet flight



2 Recorded values compared to yaw theory



2 Outcomes

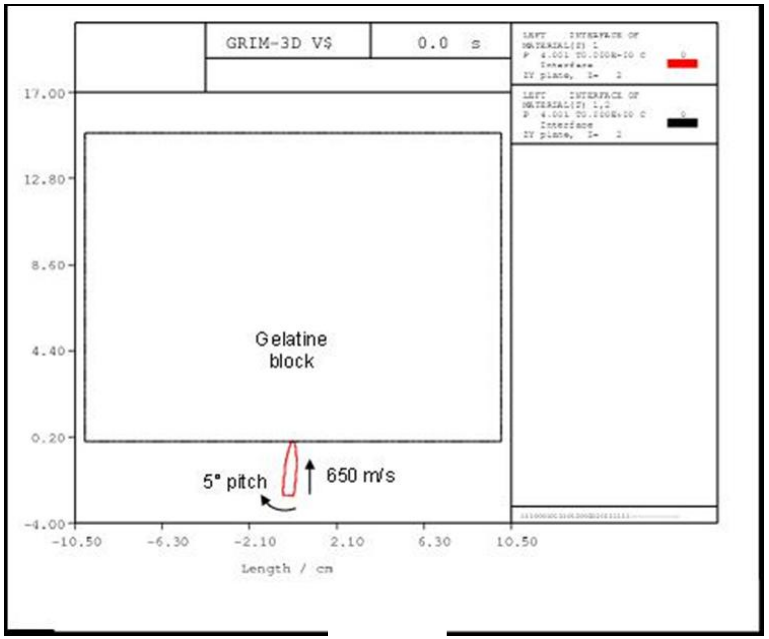
- The flight follower allows the pitch distribution along the flight line to be established
- The yaw amplitudes and rates are *distinguishable* and *measurable*
- A detailed analysis for a 5.56 mm bullet was achieved – and the ballistic coefficients were a good match with the ‘accepted’ values for this bullet

- The flight follower provides a non-intrusive technique that can be incorporated into other trials
- The infrastructure required is considerably less demanding than alternative systems

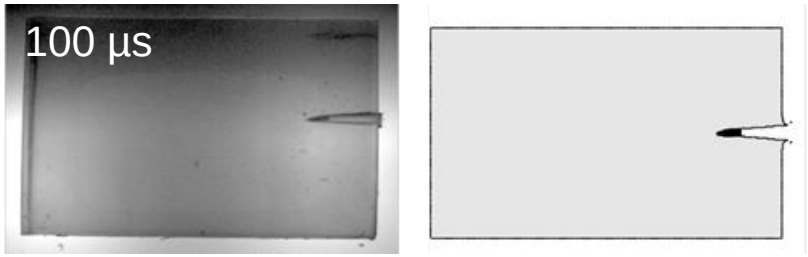
3
Hydrocode modelling

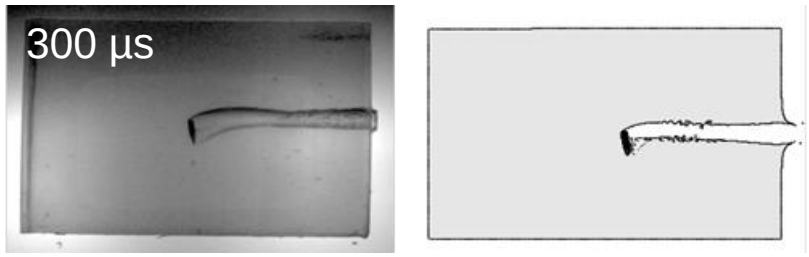
3 Hydrocode modelling

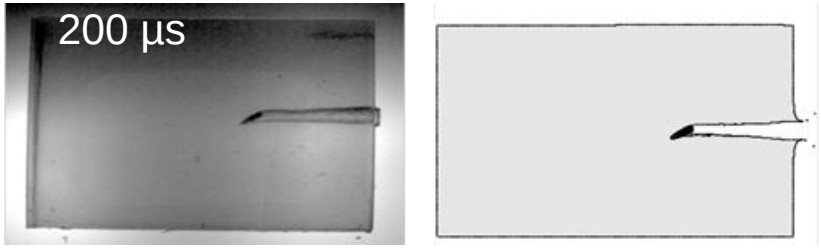
- This work used the QinetiQ ‘GRIM’ Eulerian hydrocode.
- The physical properties of the bullet and gelatine are defined using material models over a range of loading conditions.
- A gelatine constitutive model was determined from available data.

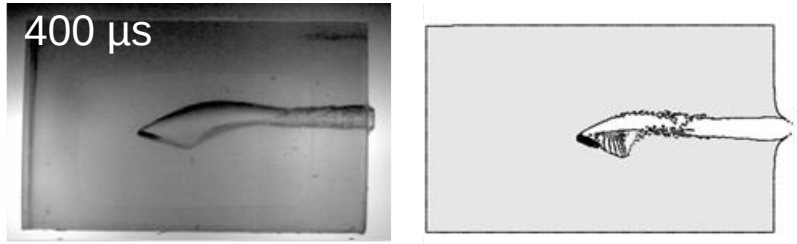


Hydrocode modelling: early results

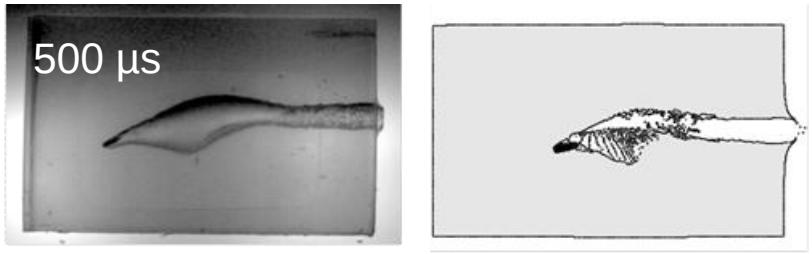








Bullet with 5° initial pitch



3
Conclusions

4 Conclusions

1. A technique for providing a quantification of bullet lethality has been devised
2. A cost effective method of determining bullet aeroballistic data is being developed
3. Hydrocode modelling offers a means of understanding performance

4. Tests strike a good balance between representativeness and repeatability
5. Procurement and use decisions can be made using (demonstrably) valid data

6. Linkage between test facilities and scientific / engineering resource to provide improvements to testing

Acknowledgements and Points of contact

This work was conducted on behalf of UK MOD Defence General Munitions Dismounted Munitions Project Team

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