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# My Journey & Ballistic Impact Modelling

-Samuel Yeap

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# BAE Systems Land Placement (RBSL)

# Loughborough University

# Independent Ballistic Modelling

# Frazer-Nash Consultancy

# The Need for Ballistic Impact & Blast Modelling

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# Placement Year at BAE Systems Land (RBSL)

- Design Engineer within the mobility team
- Extensive use of NX Computer Aided Design (CAD) and PLM software
- Research & report writing for running gear design
- Component design and hybridisation work
- ADAMS tracked vehicle dynamics modelling

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# Mechanical Engineering at Loughborough University

- MEng degree, with Finite Element Analysis and CAD modules
- Individual project on the Numerical Modelling of Explosive Reactive Armour
- EPSRC Vacation Internship on the same topic
- Led to a Journal Paper being published

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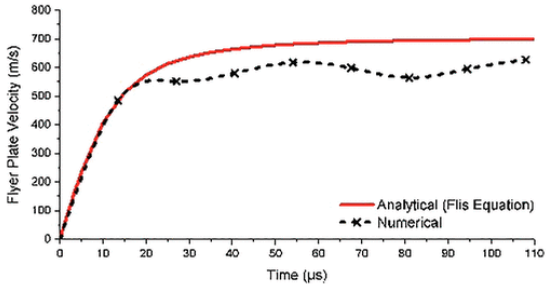
# Final Year Project

## Novel Reactive Armour Model

Predictive equations of flyer plate velocity-time profiles were used to create a variable pressure load. This replicates the explosion without modelling the explosive explicitly, reducing computational time significantly

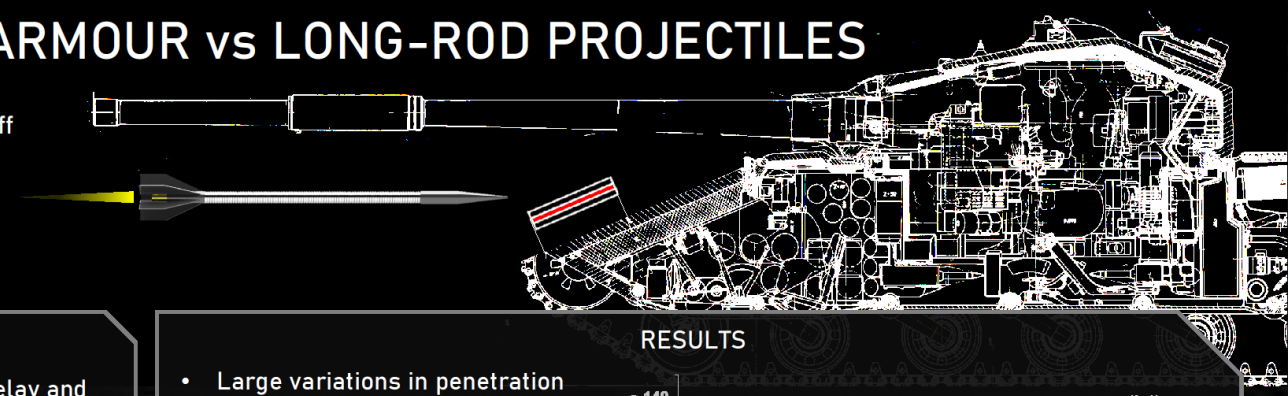
$$V_{max} = \sqrt{2E}\left(\frac{M}{C} + \frac{1}{3}\right)^{-0.5}$$

$$V_t = V_{max}\left(\frac{t\,V_{max}}{h_X}\right)\left[\left(\frac{t\,V_{max}}{h_X}\right)^2 + 1\right]^{-0.5}$$




# EXPLOSIVE REACTIVE ARMOUR vs LONG-ROD PROJECTILES

A numerical study into the Effects of Explosive Reactive Armour Detonation Delay and Stand-Off Distance against Long-Rod Projectiles

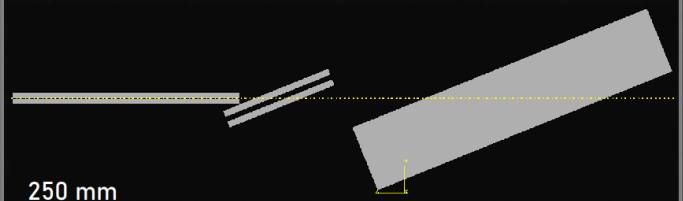


### AIM

- To investigate how varying the detonation delay and stand-off distance of ERA affects the penetration of a long-rod projectile

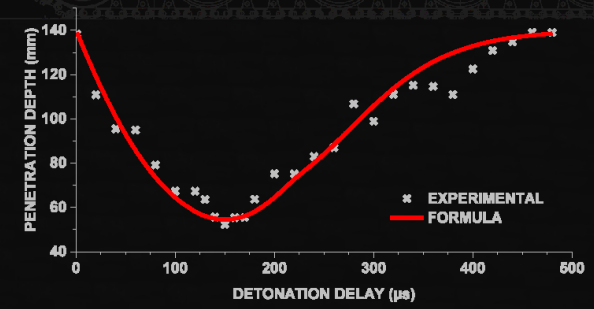
### METHODOLOGY

- Model calibrated to experimentally derived perforation and flyer plate velocity equations
- Material parameters sourced from published work
- Simplified APFSDS and oblique armour array



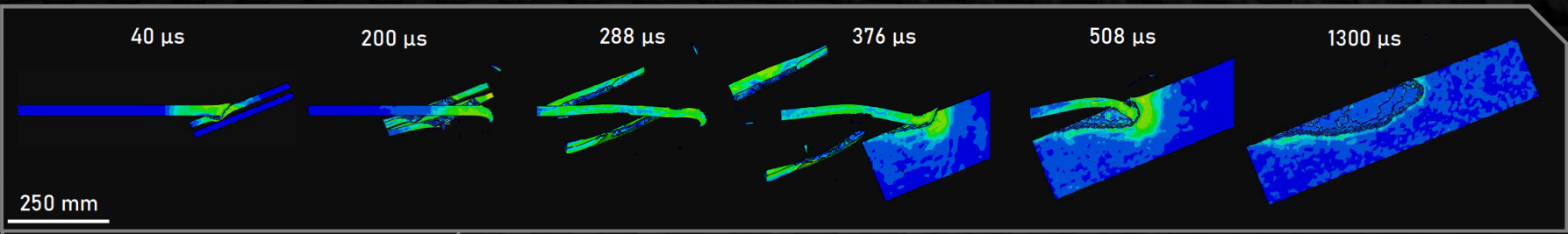

### RESULTS

- Large variations in penetration depth
- 4 key interaction types identified
  - Early Detonation
  - Plate Feeding
  - Plate Shearing
  - Late Detonation
- Predictive penetration depth formula developed based on all tested parameters




### CONCLUSIONS

- Detonation Delay plays a major role in ERA effectiveness
  - The ERA can reduce penetration by up to 71.5%
- Linear relationship between Stand-Off distance and penetration reduction
  - But significantly less effective than Detonation Delay




200 μs Detonation Delay

Samuel Yeap

# Independent Ballistic Impact Modelling

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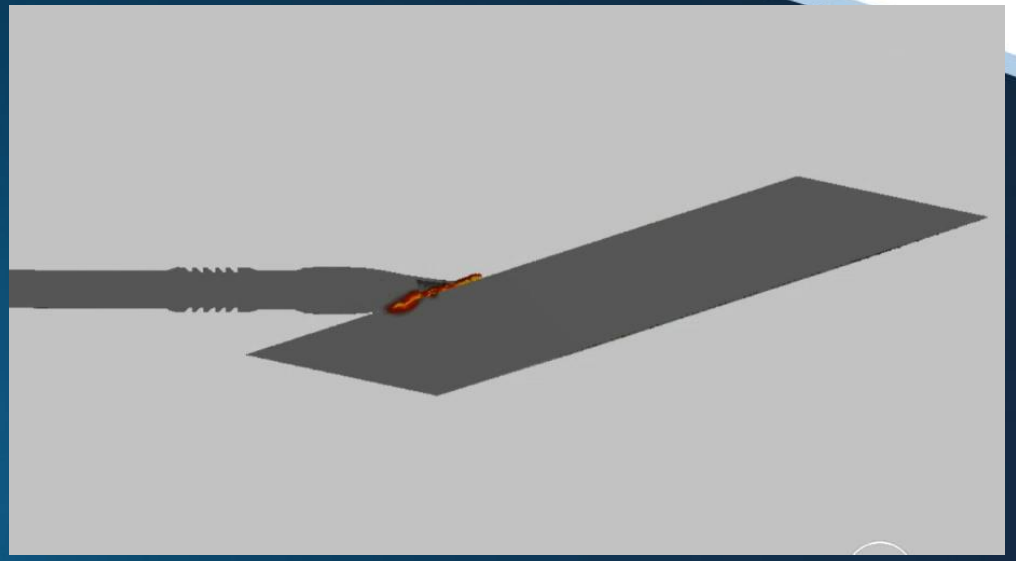
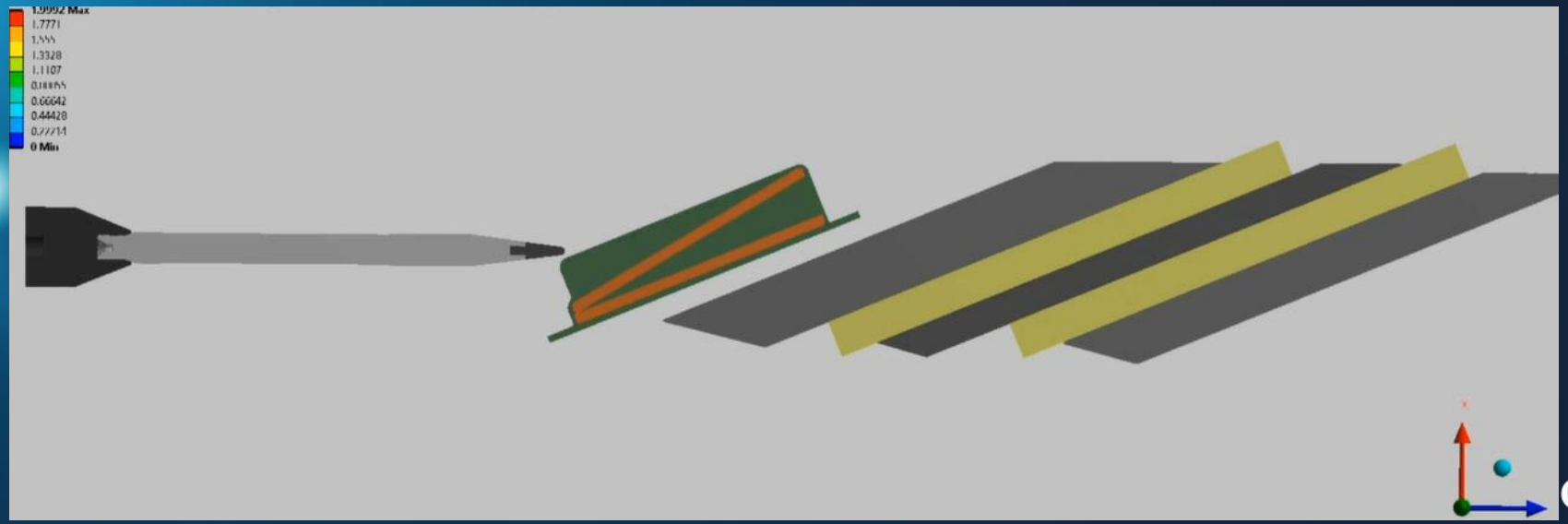
Learned how to model ballistic impacts in Abaqus and Ansys

Adjusted material models to capture real-world phenomena



Worked on lagrangian, Hybrid SPH, eulerian, and coupled eulerian-lagrangian models




CHNOLOGY

# Independent Ballistic Impact Modelling

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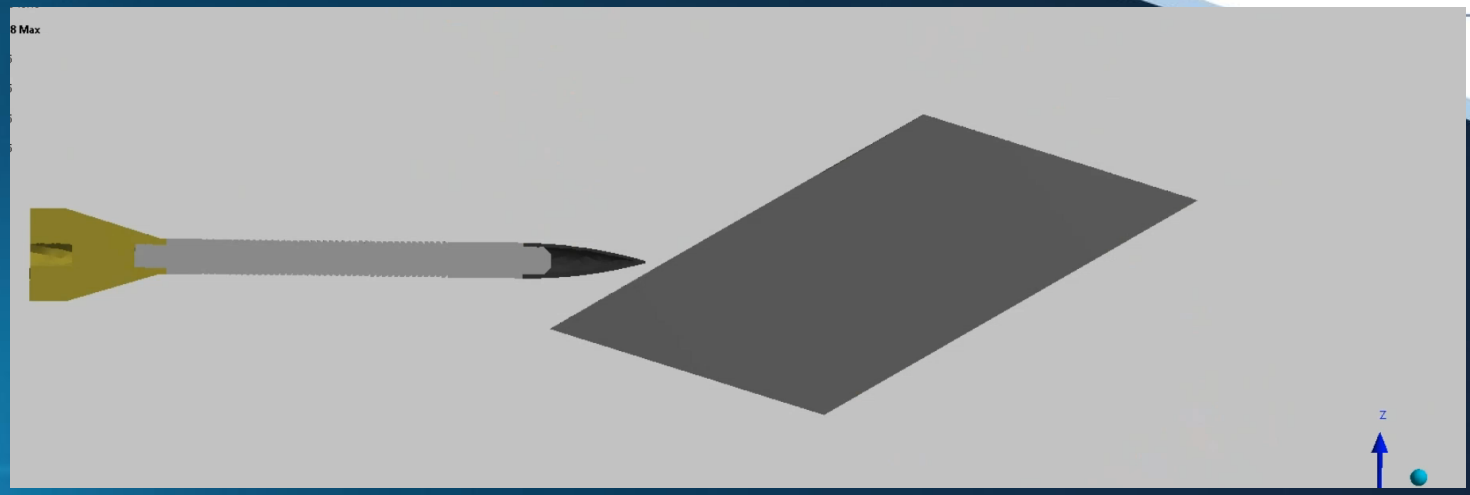


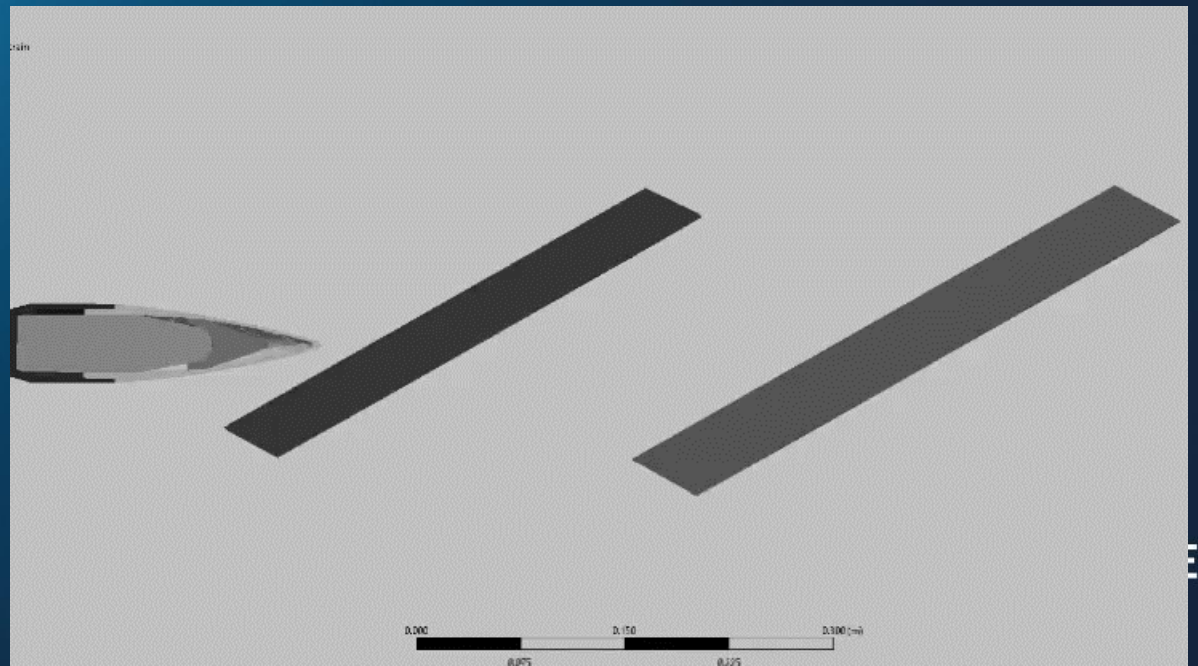

Developed and calibrated simulations to match real-world experimental data

Modelled a range of materials; from Tungsten Heavy Alloy, to Fibreglass-like Textolite

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# Frazer-Nash Consultancy

- Started in September 2022
- Engineer within the Energetics & Vulnerability Team
- Worked on various projects, including ones within the commercial defence sector, with clients such as DSTL (FE modelling/CAD/concept design)
- Campaigning with Weapons & Land vehicle teams
- Ballistic impact & blast modelling

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# The Need for Ballistic Impact & Blast Modelling

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## SAVING LIVES

Ensuring our people are protected

Ensuring that a threat can be dealt with

## COST

Minimising the need for real-world testing

## TIME

Allowing for a fast, iterative design process

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# Live Fire Testing


https://www.youtube.com/watch?v=X56z3i1CXII

# Live Fire Testing

## Expensive, Time Consuming, Location Limited, Safety Risks

Live fire testing is essential, but comes with drawbacks

Expensive materials, manufacturing, measuring equipment, range rental, qualified staff

Slow design-to-testing cycle

Limited locations available

Safety concerns with live munitions

Hard to capture and assess such fast-occurring events

https://external-preview.redd.it/u1Vg-7V7xVdtpI8I12icy1ckOeI_x9Ub_2-oi7owZGk.jpg?auto=webp&s=ffbffc81f44d799e32bb709675974399ba487dd8

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# Blast & Ballistic Impact Modelling

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## Fast, Iterative, Versatile, Cheap

No safety or location concerns

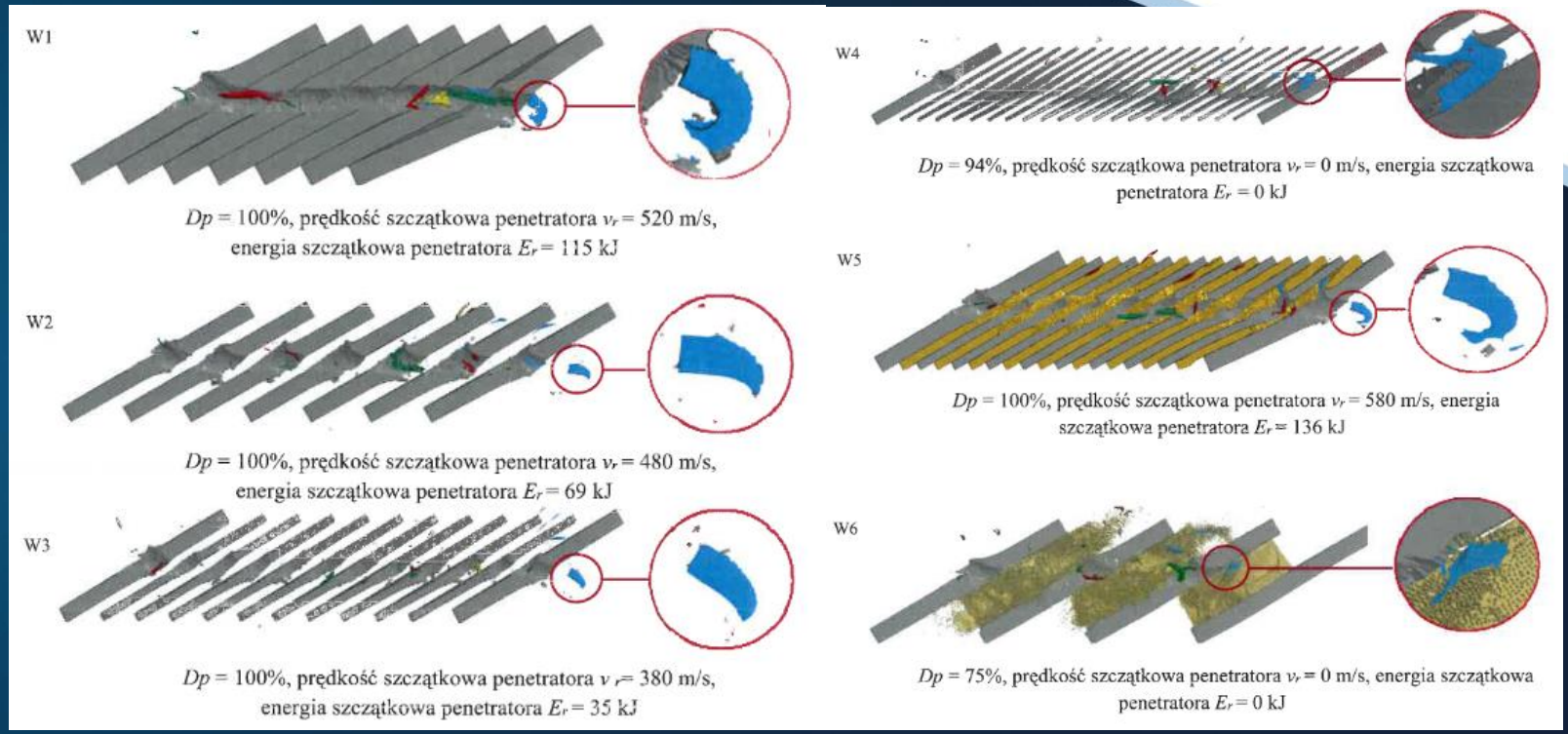
Reduced workforce required

Many material combinations and and designs can be tested simultaneously

Fast design-simulate-redesign cycle

Much better assessment and visualisation of the projectile-armour or blast wave-structure interaction

Requires validation




https://twitter.com/Zbiesu/status/1354027075682889729?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1354027075682889729%7Ctwgr%5Ee6a1d9b12bc944a4c013fdfe5f306f433faf8092%7Ctwcon%5Es1_&ref_url=https%3A%2F%2Fsturgeonshouse.ipbhost.com%2Findex.php%3Fapp%3Dcoremodule%3Dsystemcontroller%3Dembedurl%3Dhttps%3A%2F%2Ftwitter.com%2FZbiesu%2Fstatus%2F1354027075682889729

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# Additional Impact Modelling Applications

## Vehicle Collisions, Aerospace, Protective Containers, Natural Disasters…

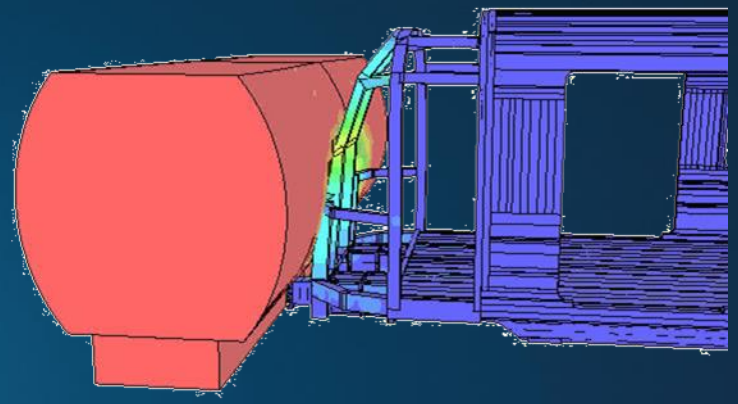
Crash testing and structural integrity of vehicle chassis

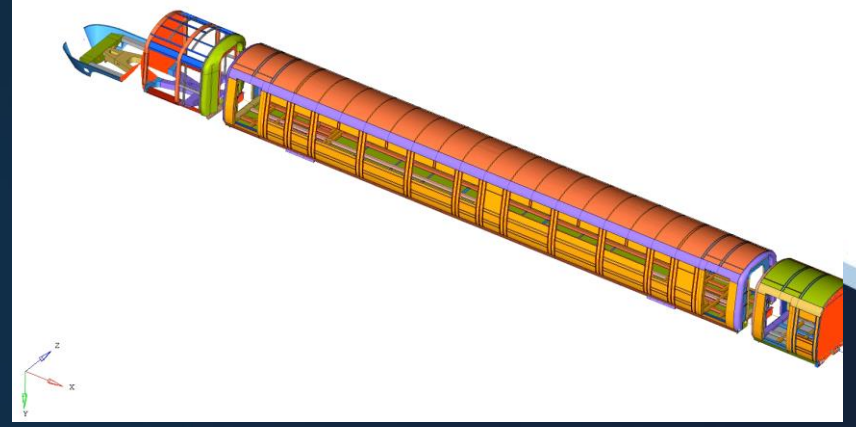
Modelling the effect of bird strikes on aircraft

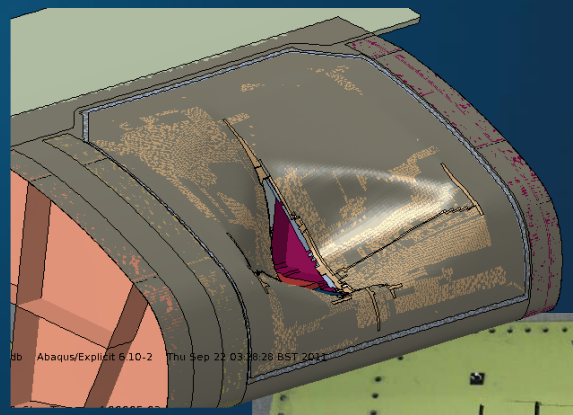
Space debris strikes on satelites

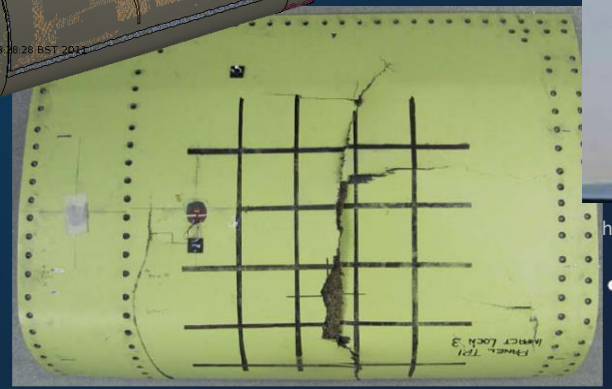
Integrity of containers and their contents

Modelling impacts of hail/hurricane debris on structures









https://nypost.com/2017/09/26/pilot-lands-safely-after-bird-strike-destroys-planes-nose/

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# Blast Modelling Applications

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## Demolition, Hazardous Material Storage, Mining, Warhead Effect, IED/Mine Blast…

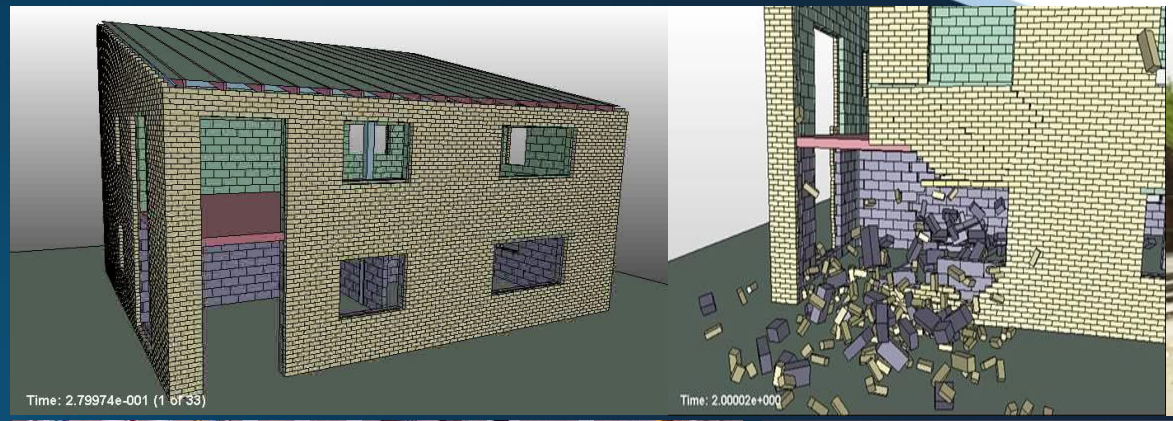
Building demolition/bomb disposal danger zone assessment

Ensuring safety around hazardous material storage facilities

Modelling the effects of a mining blast

Simulating the effect of an explosive warhead

Simulating the effects of IED/mine blasts on structures/vehicles





https://storageterminalsmag.com/oiltanking-announces-operations-begin-on-lpg-storage-tanks-in-europe/

https://ukdefencejournal.org.uk/trophy-active-protection-system-picked-for-challenger-3/

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# Air3D Blast Modelling & Mine Blast Case Study

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https://www.businessinsider.com/us-military-protective-personnel-carrier-the-cougar-withstands-ied-and-bombs-2013-2?r=US&IR=T

https://en.wikipedia.org/wiki/Improvised_explosive_device

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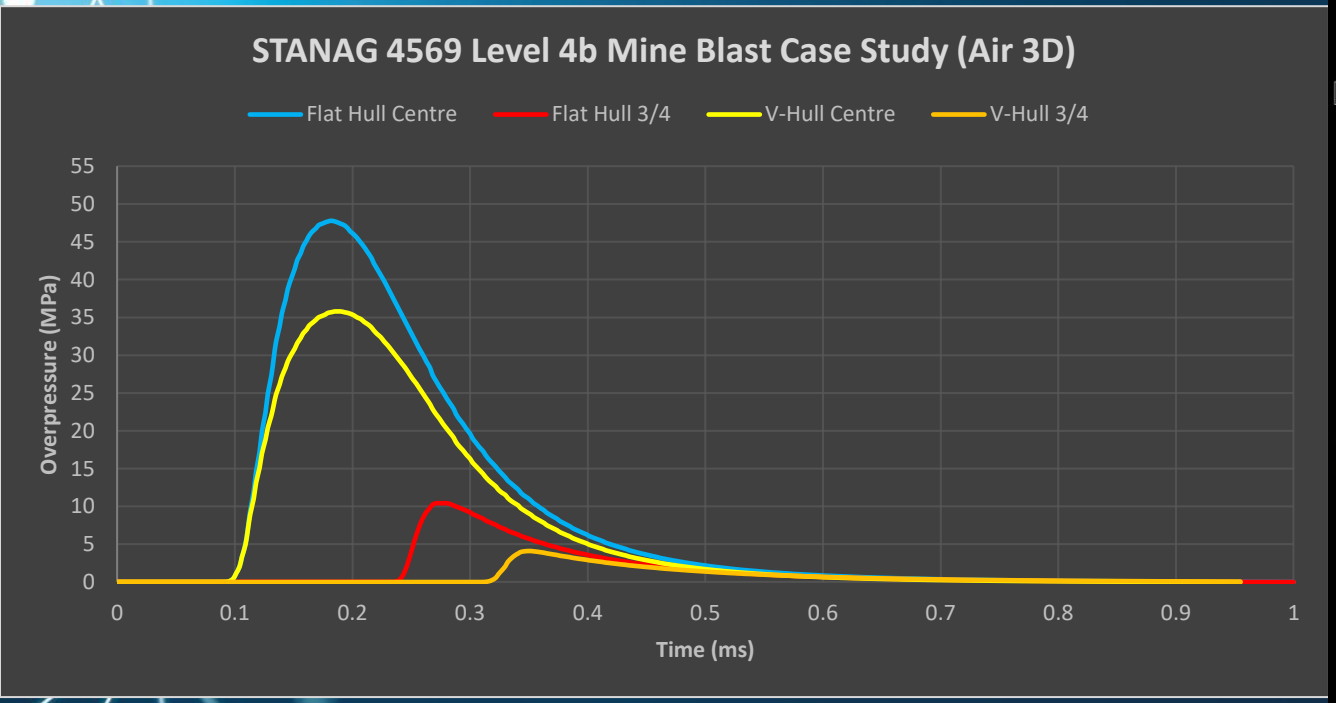
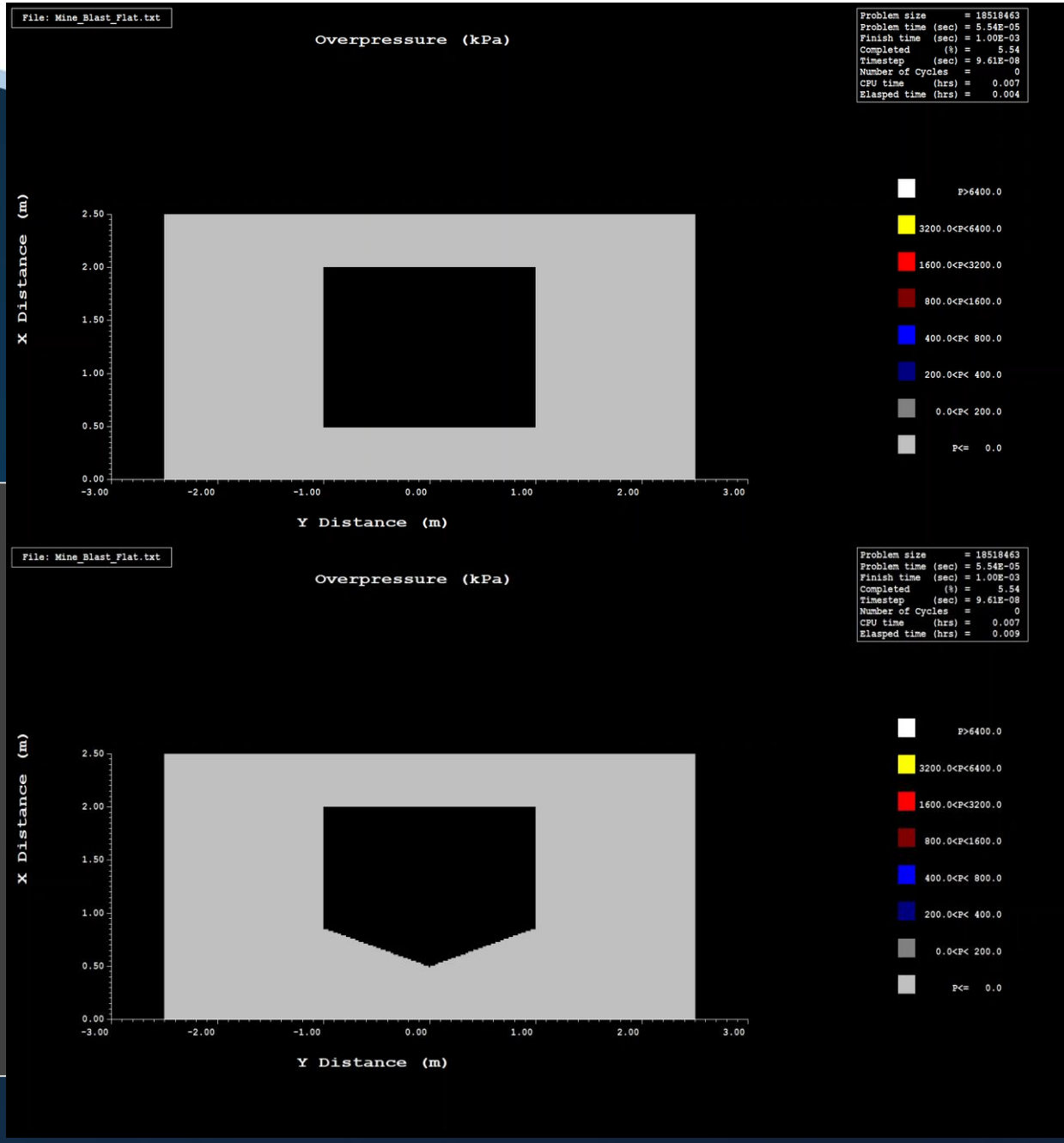
# Air3D Blast Modelling & Mine Blast Case Study

- 10kg TNT under hull centre
  - Representative vehicle hulls with a flat bottom and V-shaped hull
  - 25% reduction in peak pressure



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## Blast & Impact Modelling Going Forward

- Increased functionality, better software, faster computing
- Wider range of companies and sectors

## Where it will take me

- Improving my skills and knowledge of software packages
- Developing Frazer-Nash's modelling capabilities
- Working with a variety of clients on many different projects

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Thank You
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