Characterisation of terrain effects as part of Explosive Ordnance quantitative risk assessments using computational fluid dynamic (CFD) analysis

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PARARI Symposium 2024

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PRESENTATION OVERVIEW

1. Background of EO Storage / Terrain Effects
2. Intro to Field Deployable Explosive Siting & Licensing Tool
3. Case Study 1 – Automated Traverse Recognition
4. Case Study 2 – ML/AI Assessment of Terrain Effects
5. Case Study 3 – Effect of Slope Angle on Peak Pressure
6. Case Study 4 – CFD Blast Analysis Showing Terrain Effects
7. Conclusions

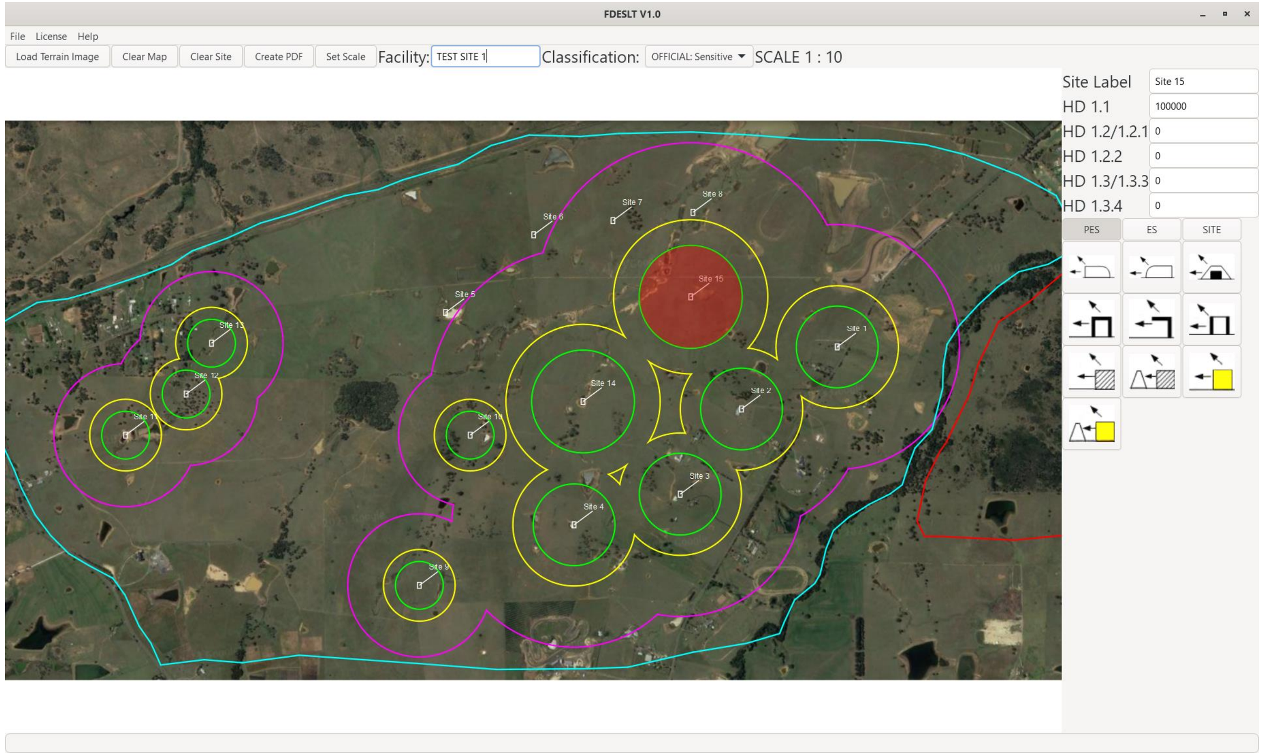
BACKGROUND / PROBLEM DESCRIPTION

- GWEO requires significant amount of additional EO storage in Australia.
- Limited storage capacity at existing facilities while maintaining QD rules.
- Consider incorporating quantitative risk assessments to look at opportunities to increase storage capacity on existing sites.

- $850 million in partnership with Kongsberg Defence Australia to manufacture and maintain the Naval Strike Missile and the Joint Strike Missile from 2027 at a new facility to be built at Williamtown, near Newcastle;
- $37.4 million in partnership with Lockheed Martin Australia to enable an initial batch of Guided Multiple Launch Rocket Systems (GMLRS) missiles to be manufactured in Australia from 2025;
- $7 billion agreement with the United States to acquire the Standard Missile 2 Block IIIC (SM-2 IIIC) and Standard Missile 6 (SM-6) long-range missiles;
- $142 million for the accelerated acquisition of the Joint Strike Missile, to be delivered from 2025;
- up to $60 million over five years to develop hypersonic and long-range strike capabilities; and
- $22 million over three years to seek options from industry to establish a manufacturing complex for the production of rocket motors in Australia.

BACKGROUND / PROBLEM DESCRIPTION

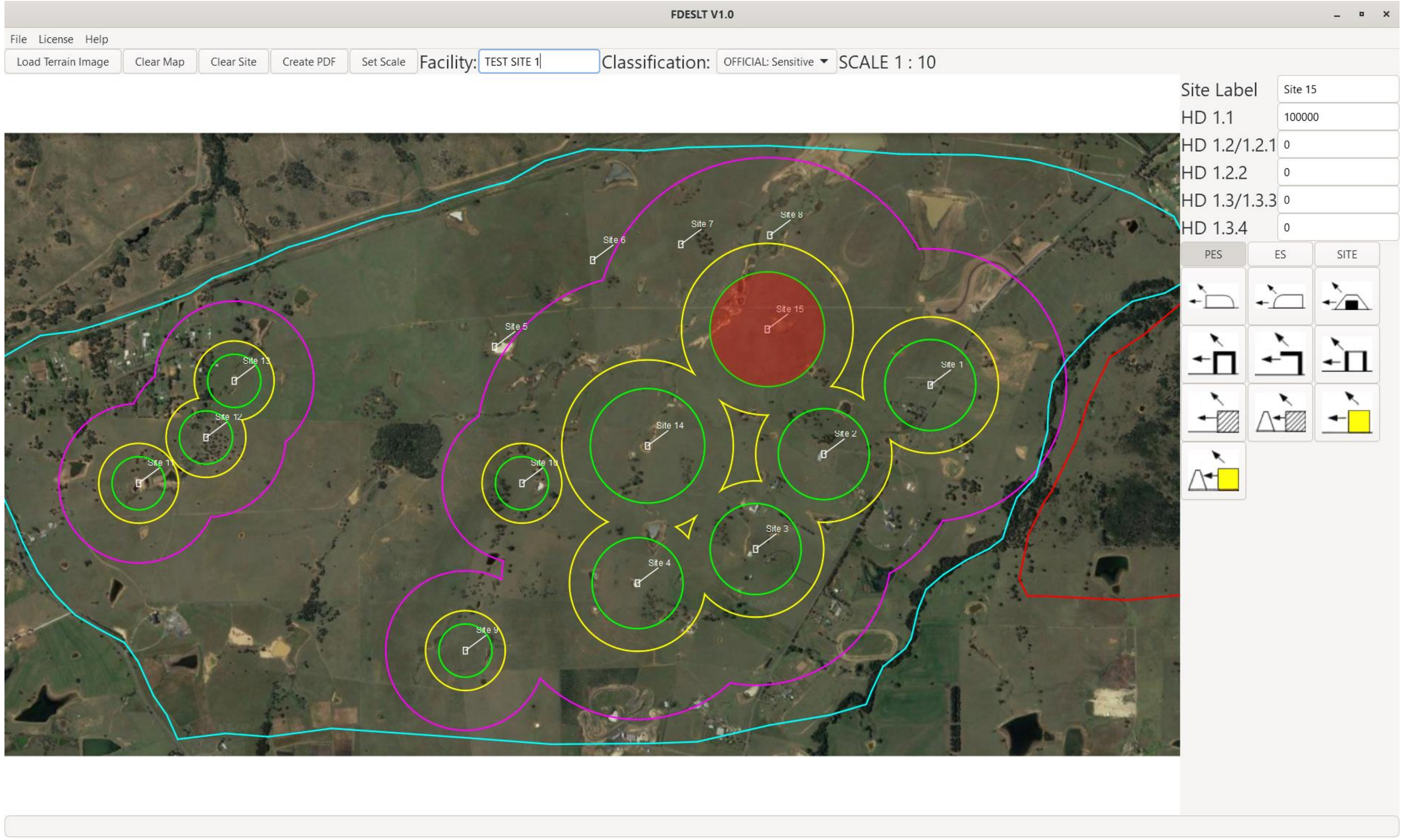
- QD Rules and consequence analysis does not account for effect of terrain on blast loading.
- Terrain may provide benefits in terms of reducing blast loading or could increase it due to channeling or reflections.
- Currently no empirical formula available to include effect of terrain in relation to blast loading.



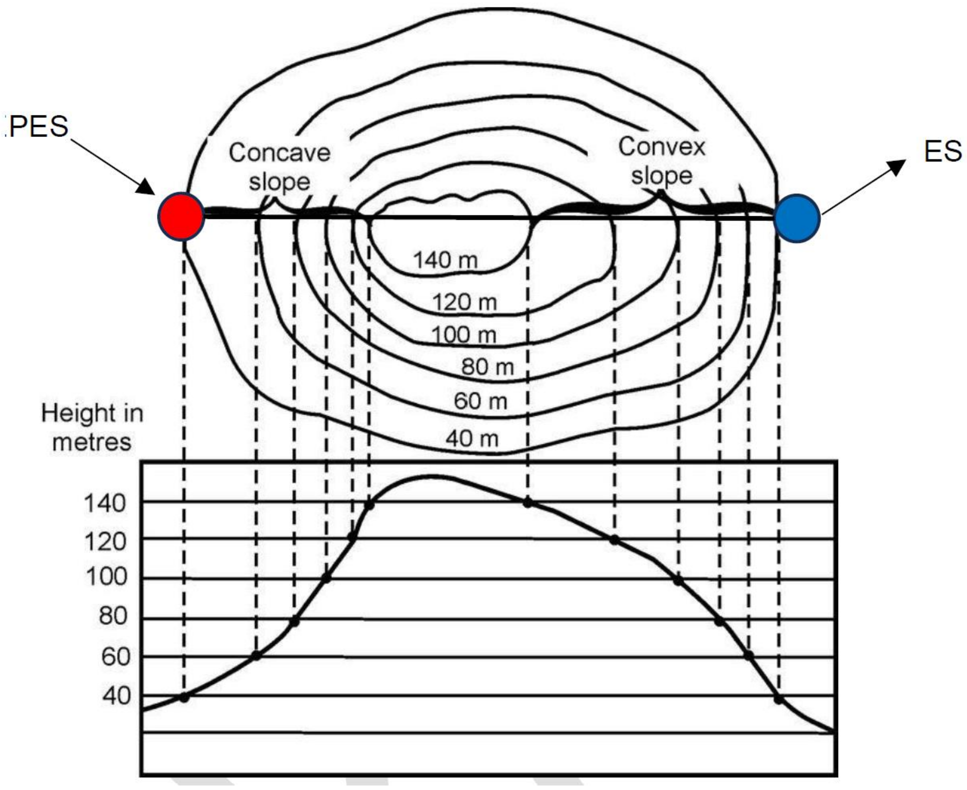
Can incorporating terrain effects enable additional storage on existing sites? And/or reduce the risk profile?

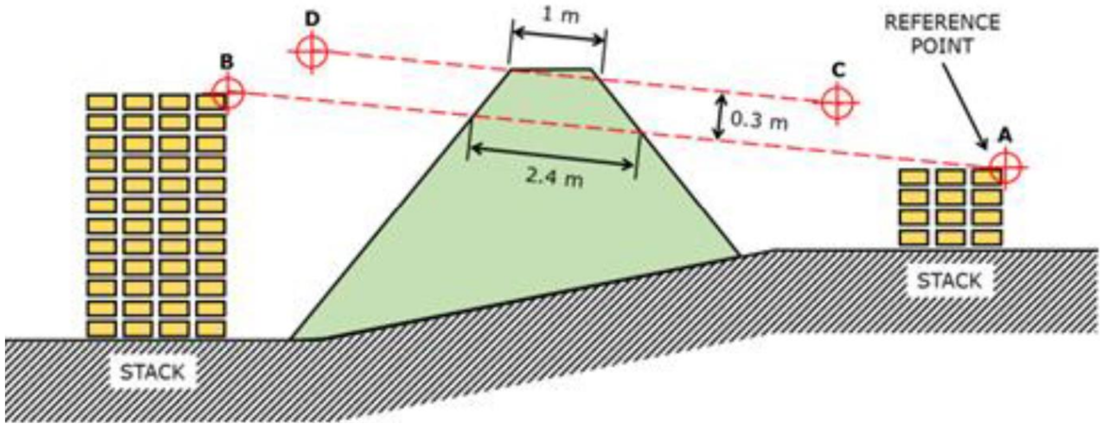
FDESLT OVERVIEW

- Field Deployable Explosive Siting and Licensing Tool
- Exemplar version delivered to Defence.
- Developing version which includes licensing and QERA tool.
- Capabilities will include:
    - Satellite image and GIS inputs
    - DEOP 101 and AASTP rules
    - DOS endorsed semi-QERA approach
    - Real-time updates to sites
    - Produce safeguarding and field licensing documents



CASE STUDY 1 – TRAVERSE DEFINITION





Automatic assessment of terrain for natural traverse in FDESLT.

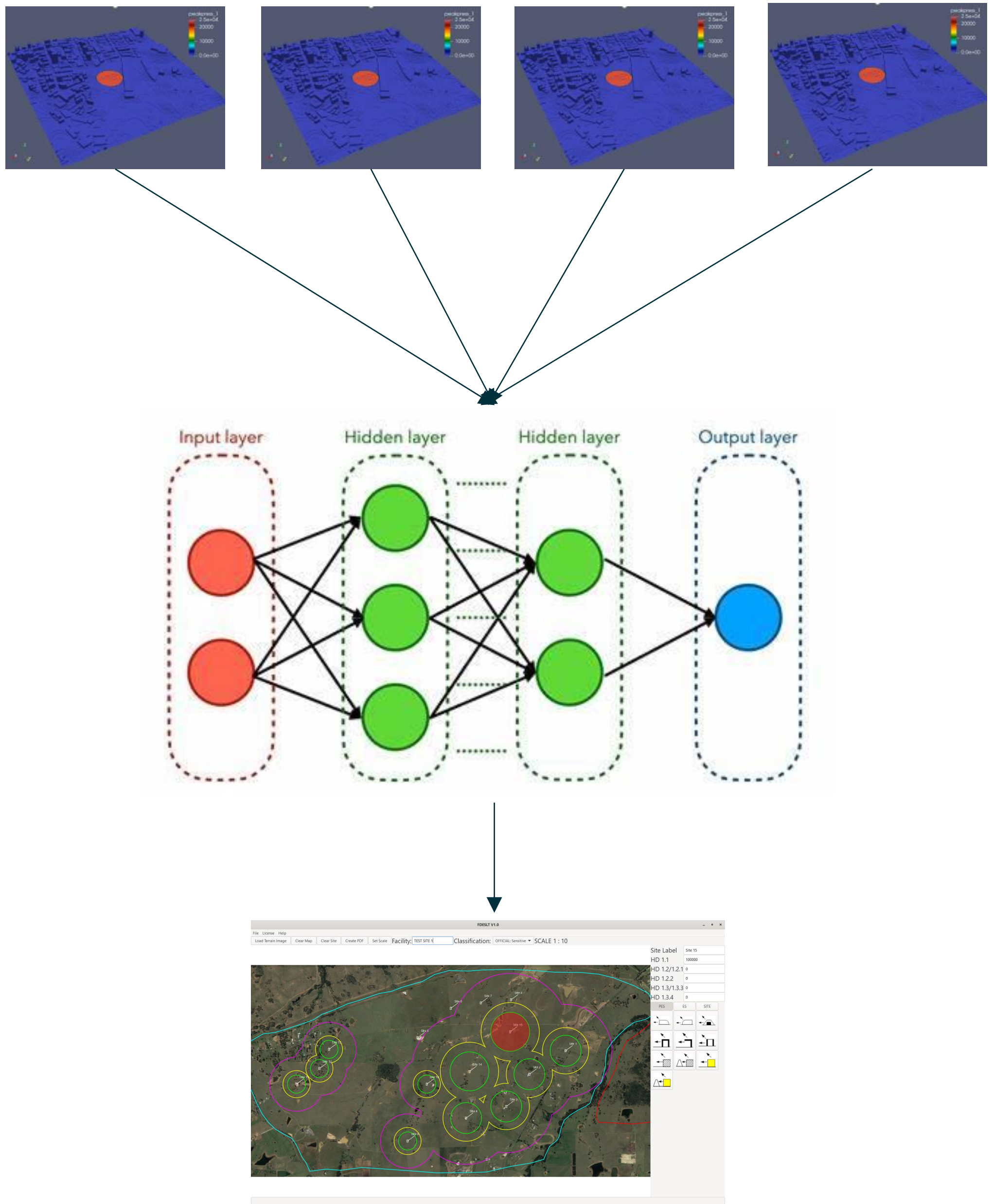
CASE STUDY 2 – ML/AI FAST RUNNING MODEL

1. Run a range of CFD models for blast loading scenarios relevant to EO storage and include a wide variety of terrain effects.

Note: Validation of modelling would ideally be performed.

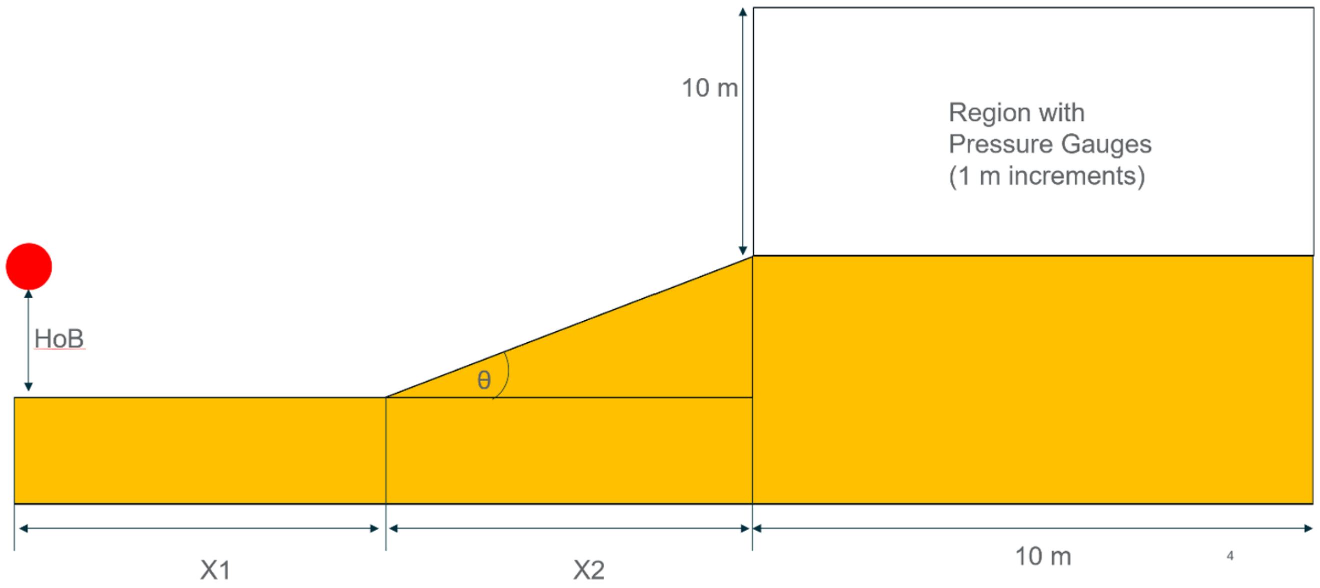
2. Use results to train a ML/AI algorithm to predict the effects of different terrain types.

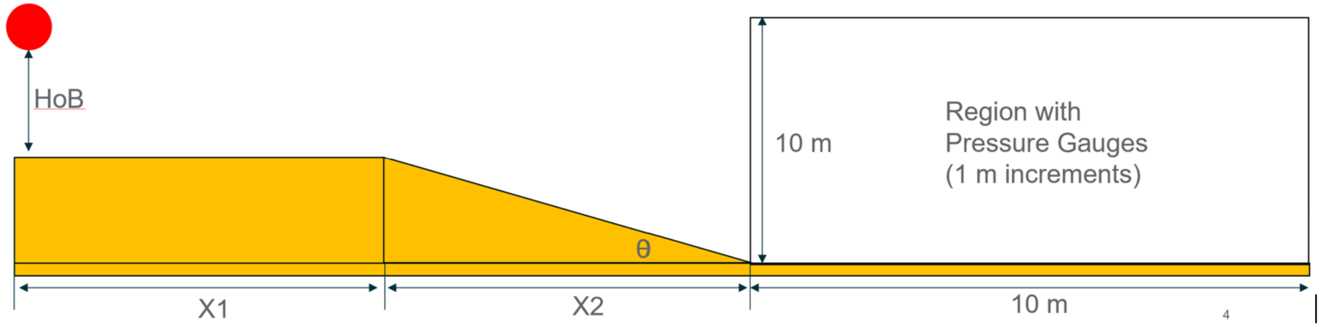
3. Implement ML/AI algorithm in EO safety software tool.



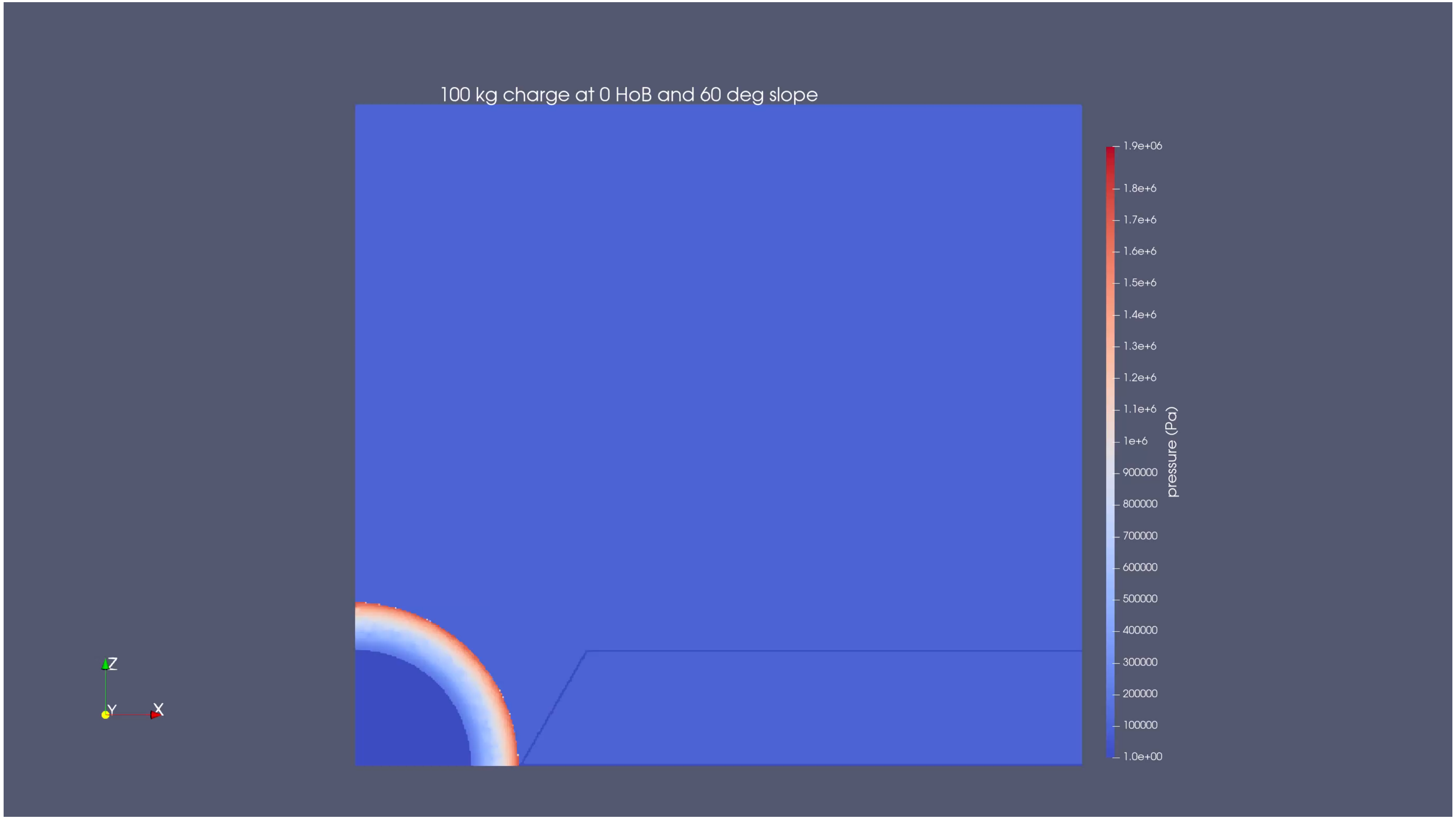
CASE STUDY 2 - DESCRIPTION

- **Height of Burst (0 m, 1 m, 2 m, 3 m)**
- **Charge Size (50 kg, 100 kg, 150 kg, 200 kg)**
- **X1 distance (3 m, 5 m, 10 m)**
- **X2 distance (2 m, 5 m, 10 m)**
- **Angles ($\pm 15^0$, $\pm 30^0$, $\pm 45^0$, $\pm 60^0$, $\pm 75^0$)**



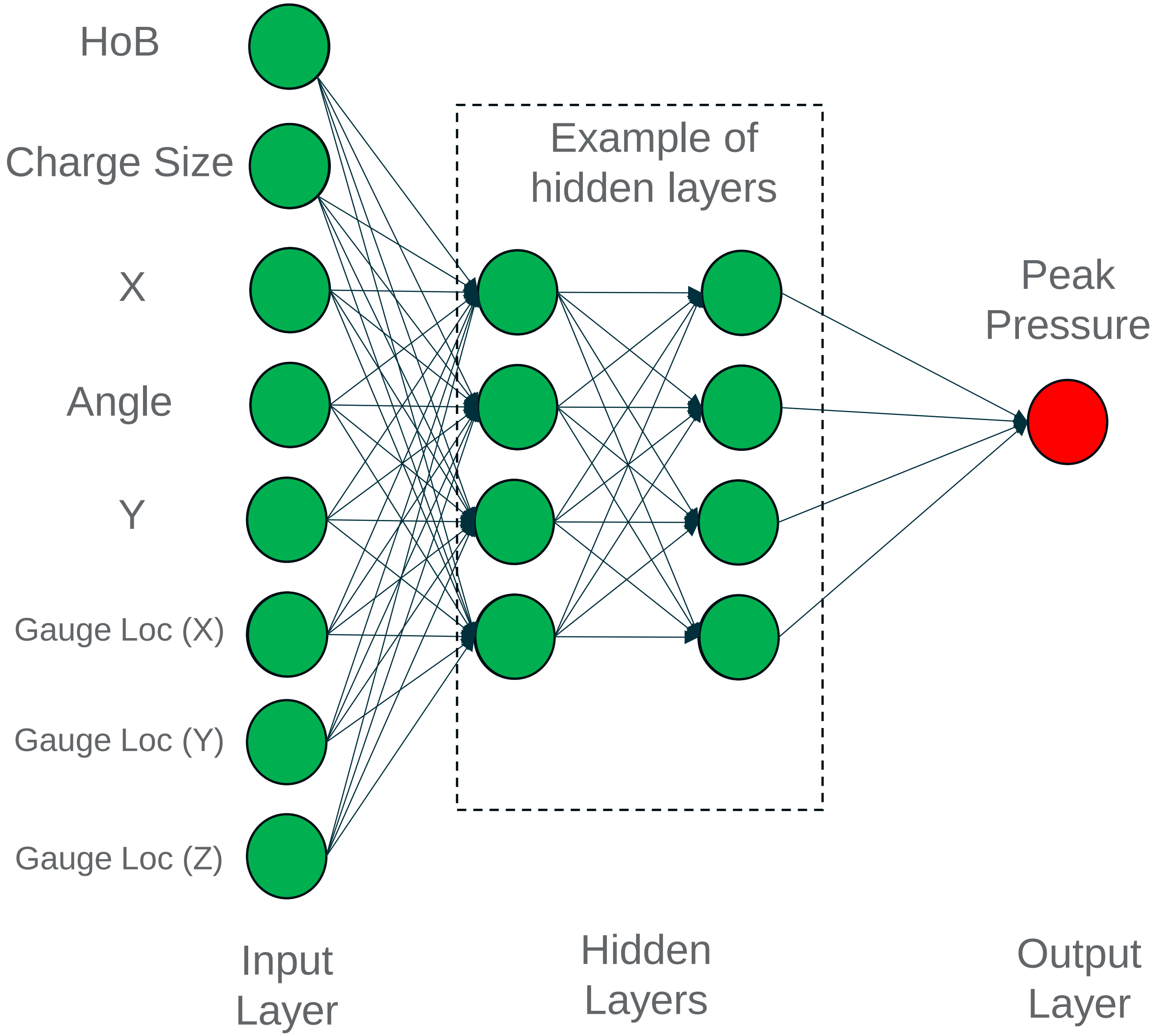


CASE STUDY 2 – EXAMPLE CFD MODEL



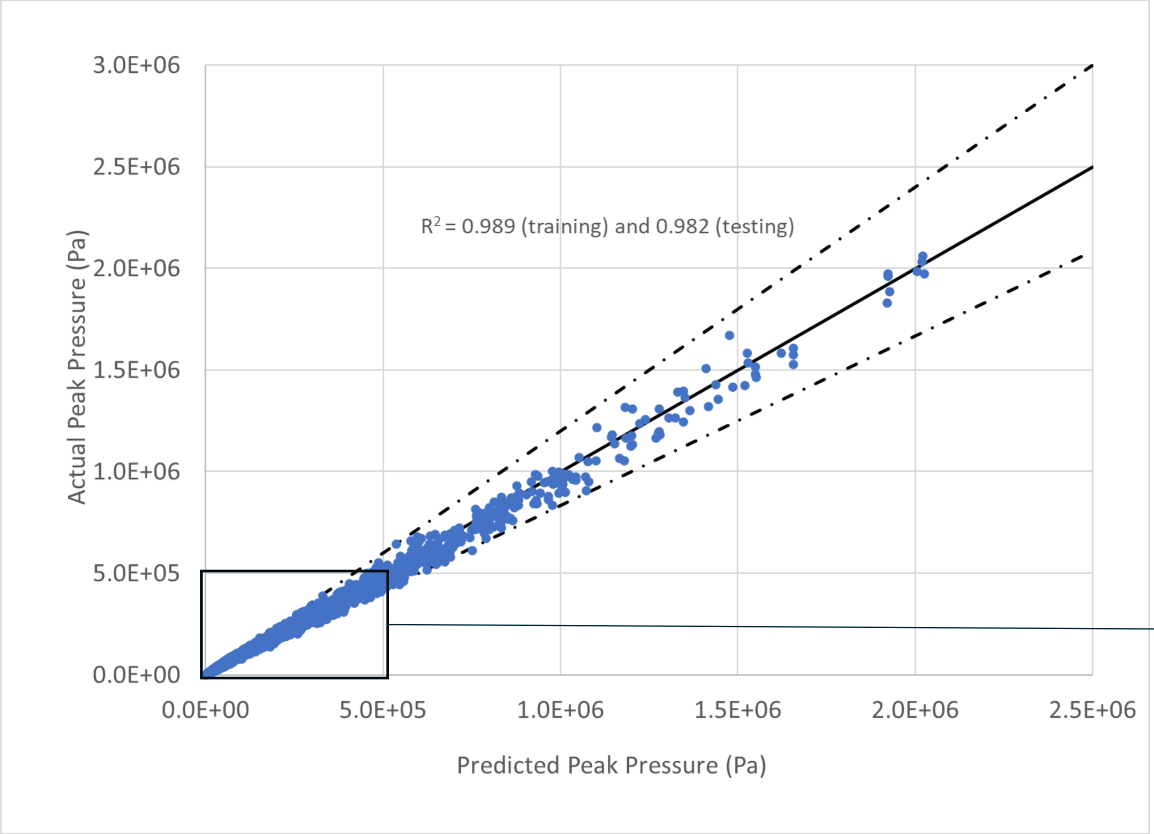
CASE STUDY 2 – ANN DESCRIPTION

- 150 simulations (configurations)
- 100 pressure gauge locations
  (X, Y, Z Location from end of slope)
- 5200 data points for training.
- MLP model used
- Number of nodes in hidden layers varied.

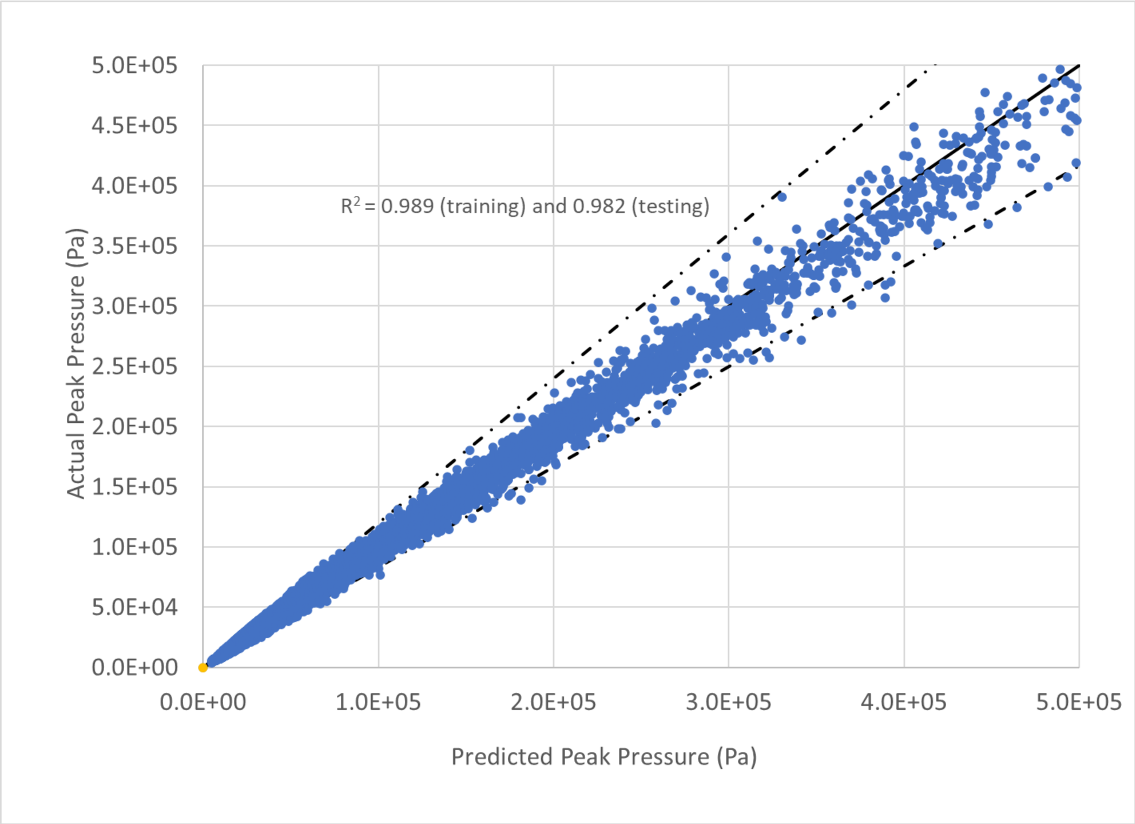


CASE STUDY 2 – ML/AI RESULTS

Full Set of Data



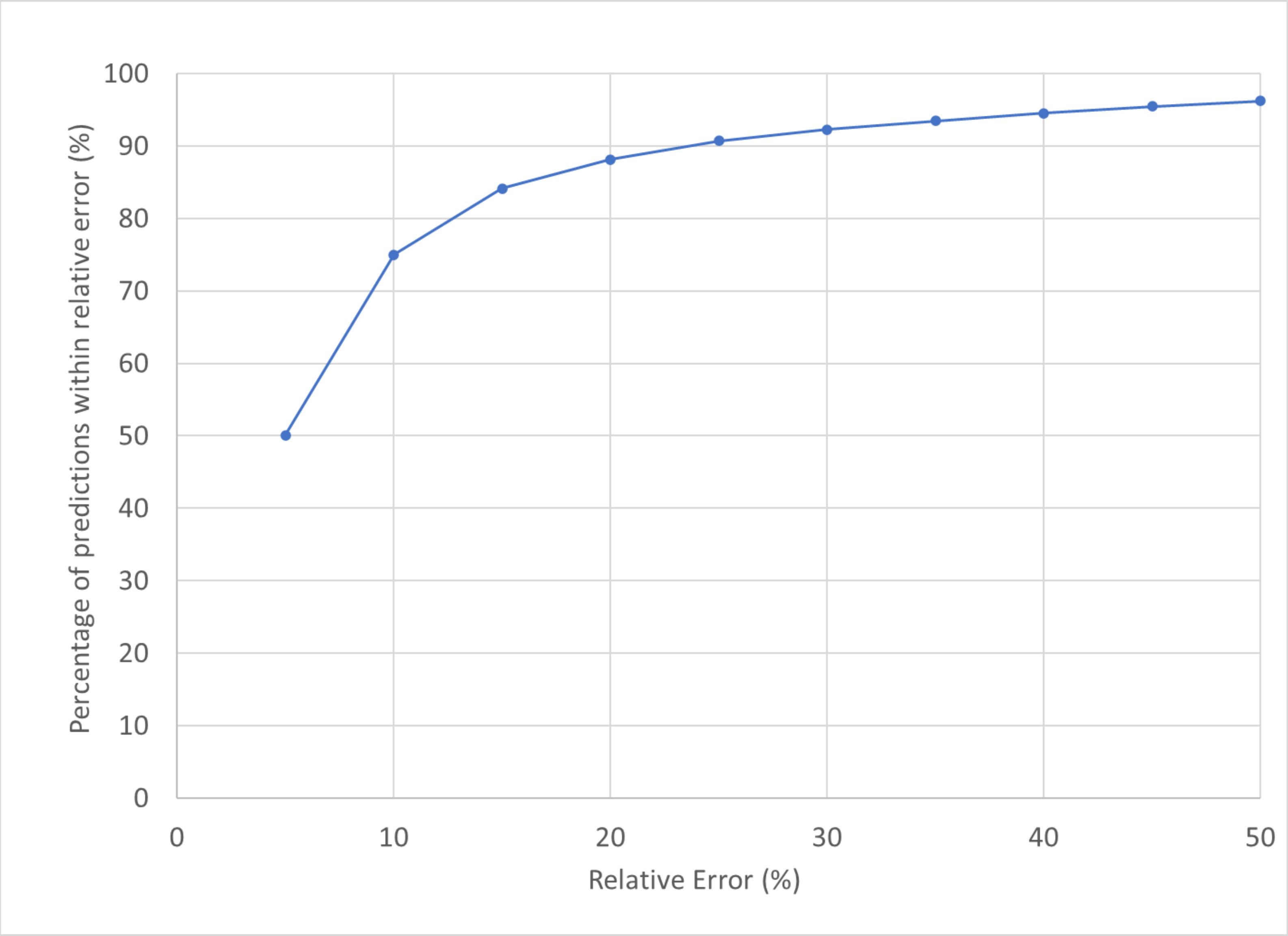
Zoomed in smaller region



Dotted lines are 20% relative error bands

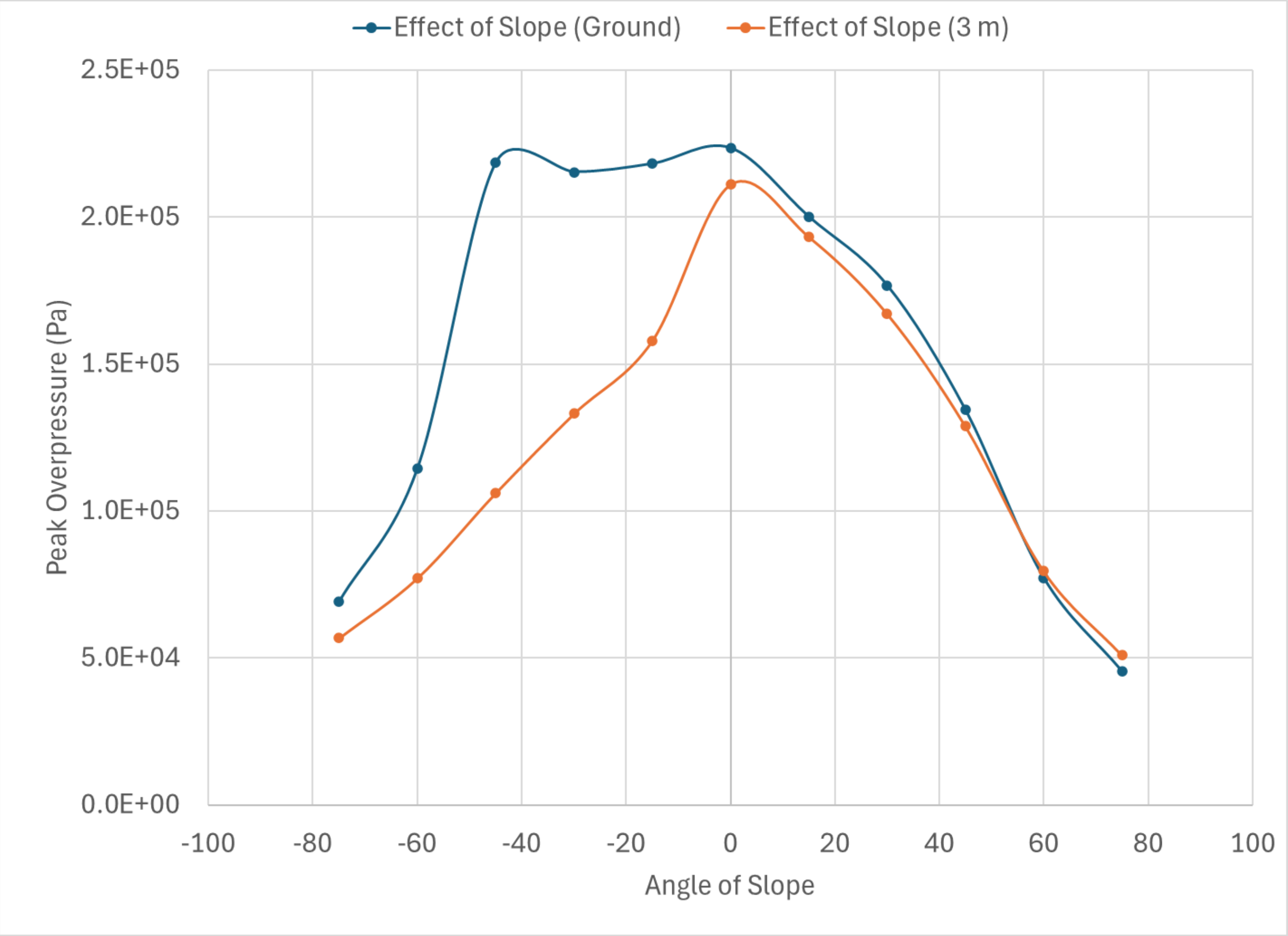
The model fit is good for an empirical model based on the R^2 value.

CASE STUDY 2 – ML/AI RESULTS



CASE STUDY 3 – EFFECT OF BASIC SLOPE

- Same setup as ML/AI case.
- 200 kg charge.
- Slope was 5 m long.
- Results show significant reduction in peak pressure for simple cases.



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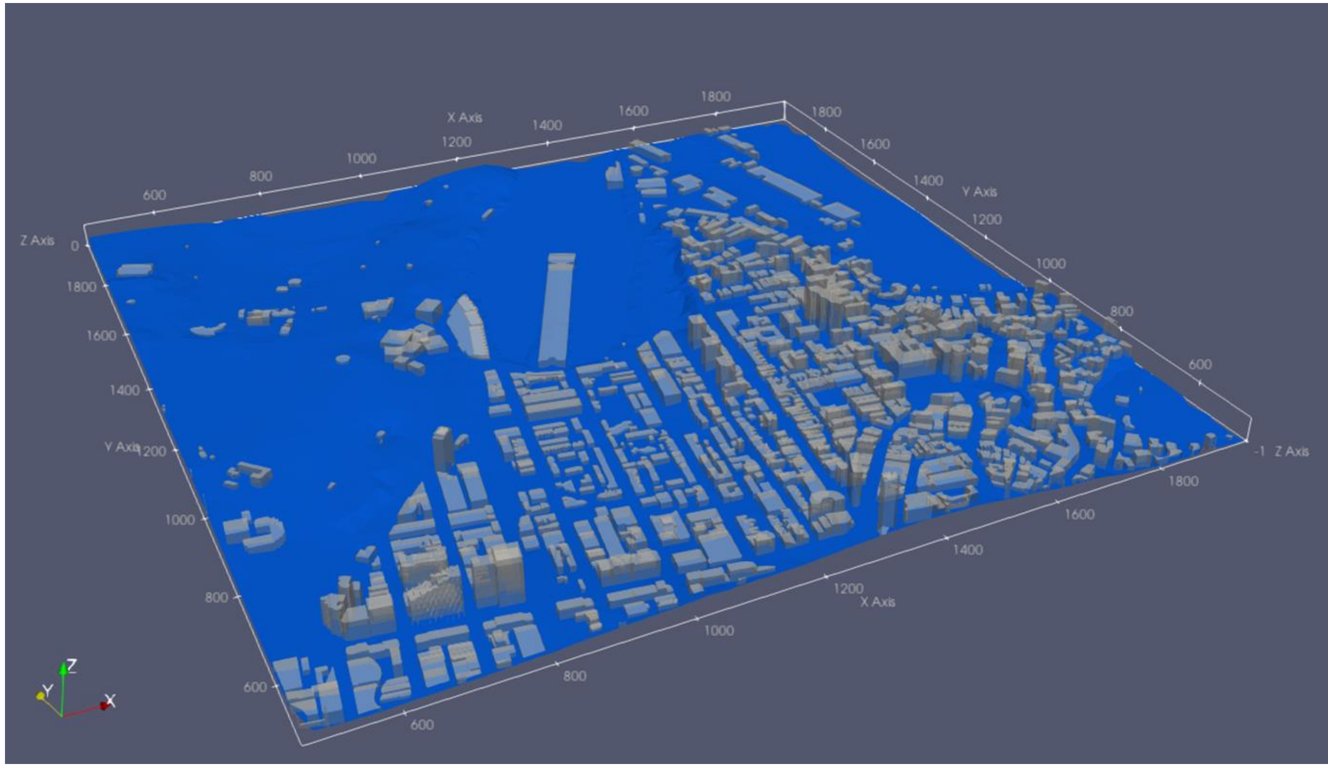
CASE STUDY 4 - CFD ANALYSIS OF TERRAIN

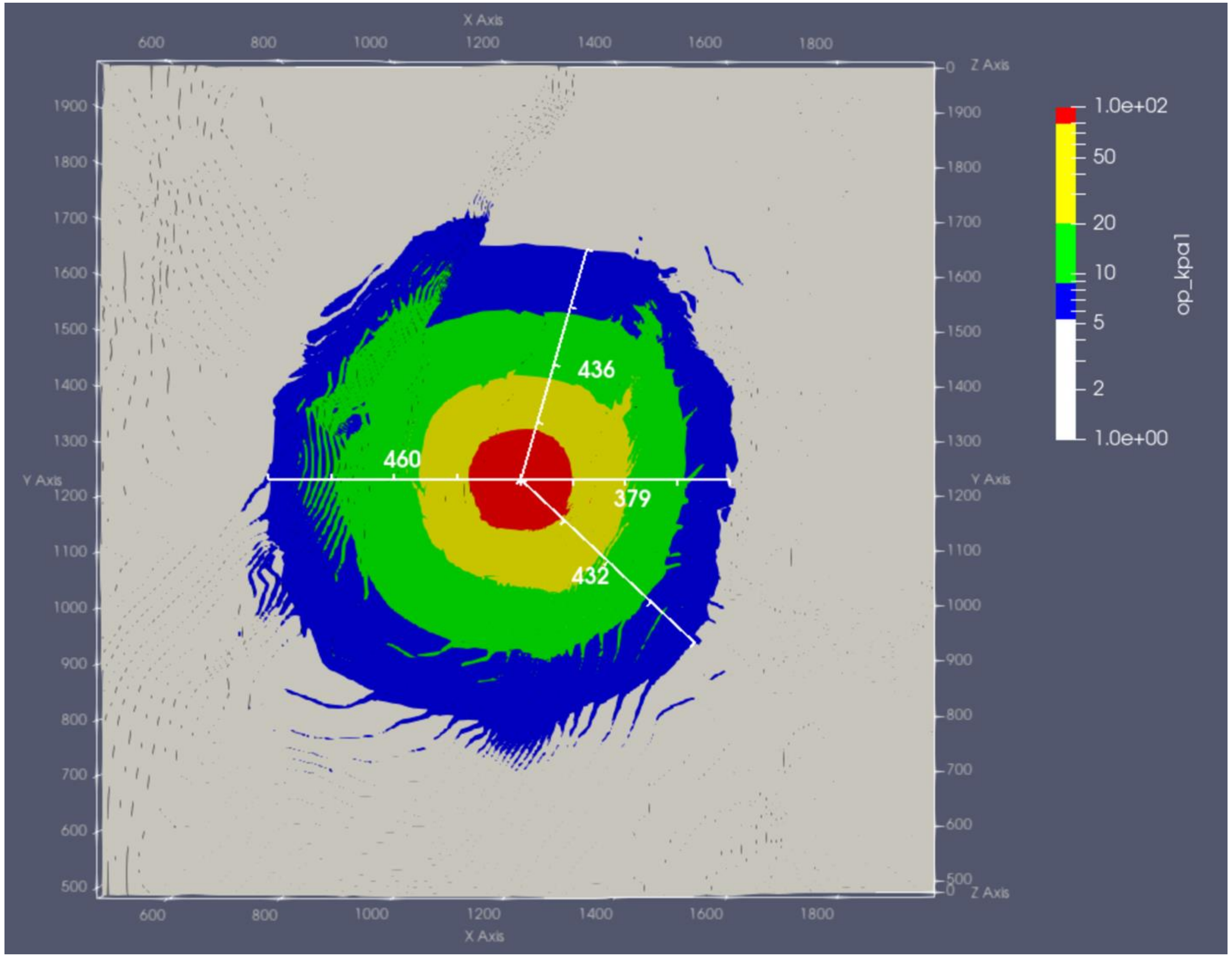
- CFD model run using WALAIR++
- 2D to 3D remapping.
- Multiple 3D remaps.
- Model did not include building to focus on terrain effects.
- Assessed pressure contours on surface for different building damage criteria. (PI Diagrams)



CASE STUDY 4 - CFD ANALYSIS OF TERRAIN

- Blue and Grey represents the IBD.
- Clear reduction in calculated IBD in one direction.

  Note: 436 m is essentially flat terrain
- Not as significant reductions as simplified cases.
- Terrain used in case study is not as significant as other locations.



CONCLUSIONS

- GWEO program will put a strain on existing sites in terms of EO storage.
- Quantitative risk assessments represent opportunity to best utilise both existing as well as new sites.
- Terrain effects are not currently included in assessments (no empirical model) but can have an important effect.
- CFD blast modelling shown to provide benefit when used as part of a quantitative explosive risk assessment.
- ML/AI shown to be a viable approach to developing algorithm to account for terrain effect in explosive safety.

QUESTIONS

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