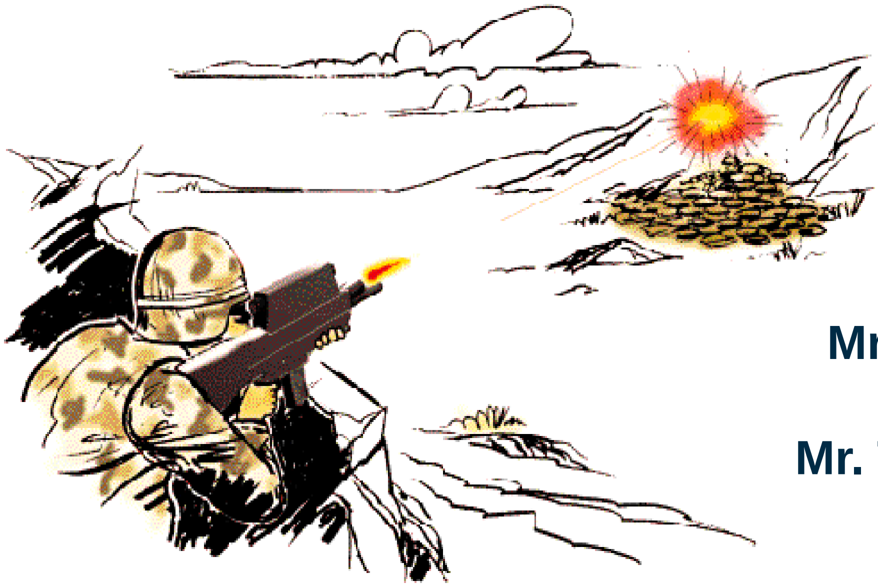
DARPA SCORPION Program Transition to Army Lethality ATO Program: A Success Story



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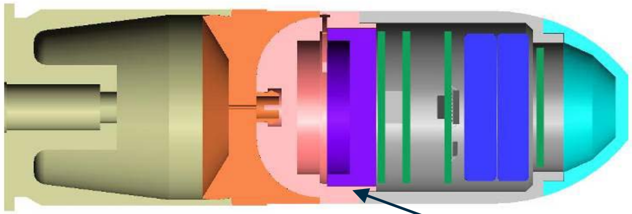
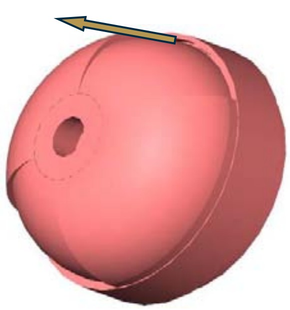
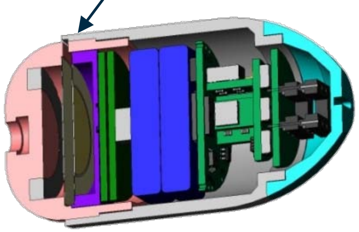
SCORPION Program

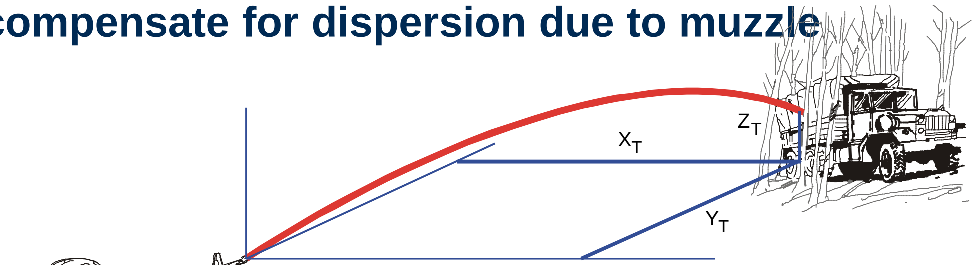
- **DARPA supported *Self-Correcting Projectile for Infantry Operation* --*(2001 to 2007)***
- **Participants: Georgia Tech Research Institute, Georgia Institute of Technology and U.S. Army Research Laboratory**
- **Demonstrated controlled flight of a 40 mm projectile with steering forces generated by piezo-based actuators sufficient to compensate for dispersion due to muzzle velocity variations.**

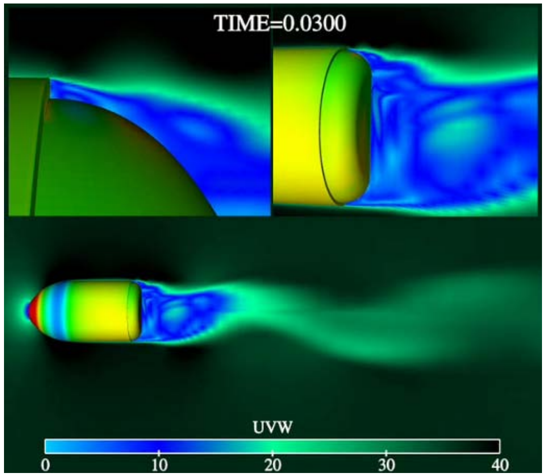


Piezo Disks







SCORPION Electronics

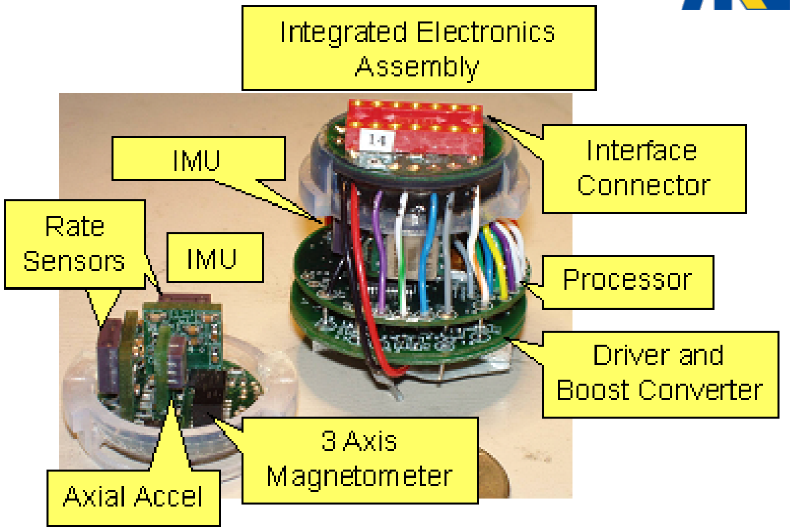
Onboard Sensors include:

•**Axial and 2-axis Radial Accelerometer (3Components of Translational Accelerations)**

•**3-axis Magnetometer (Along Projectile Principal Axes – Same as Accelerometers)**

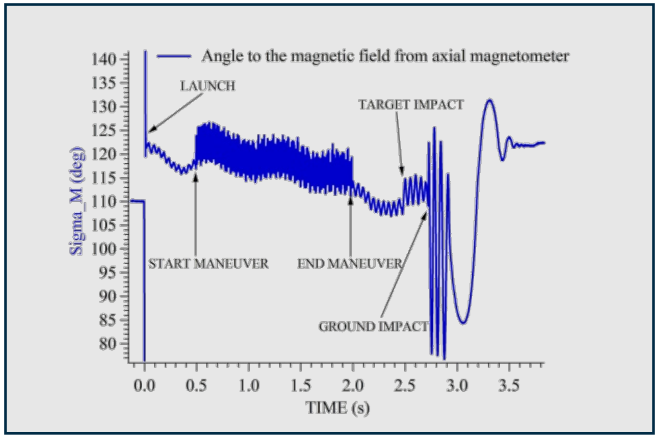
•**Pitch and Yaw Rate Sensors**

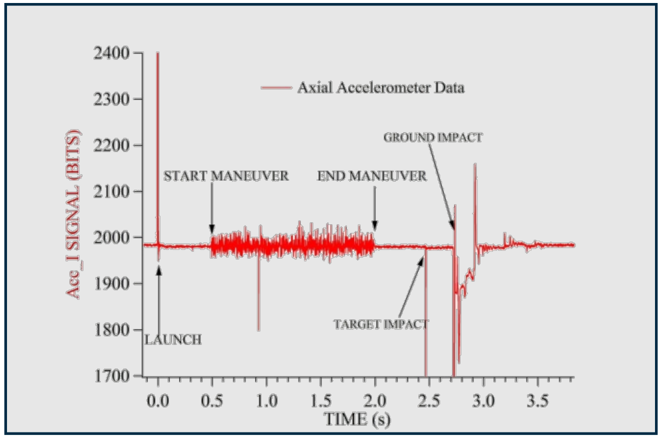
•**2 Centripetal Acceleration Sensors (Roll Rate)**



The inertial sensors respond to the projectile dynamics of launch and flight and provide measurements needed for projectile guidance.

The sequence of events in a typical maneuvering Scorpion flight are readily apparent in the sensor data.





SCORPION Transition Plan

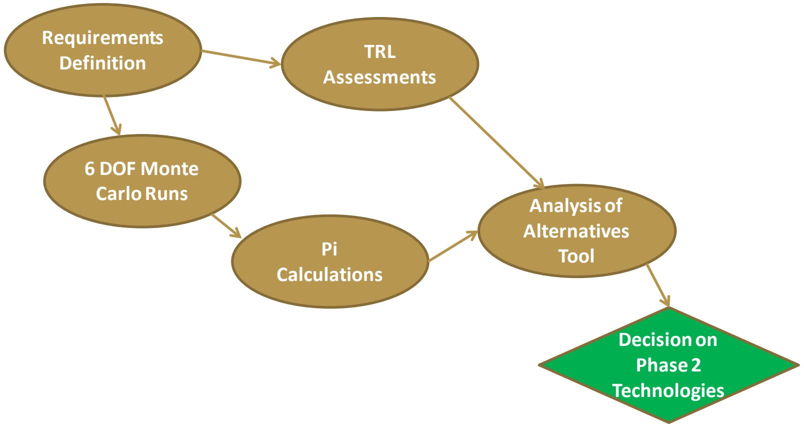
- During SCORPION program, an IPT was formed to explore transitioning DARPA program
- IPT membership included USAIC DCD, US Marines, SOCOM, JSSAP/ARDEC, PM-Soldier Weapons, PM-MAS, US ARL, GTRI, DARPA and OSD
- IPT engaged the user community including US Army Infantry School, SOCOM and US Marines
- IPT briefed Army PM's, ARDEC and ONR to determine interest and support

Precision 40 mm Grenade Program

- Three Phase Program—2009 to Present
  - Phase I – Concept Study, 9 months
  - Phase II – System Design, 9 months
  - Phase III – Integration and Test, 12 months
- Integration of Maneuver Technology with
  - Range Estimation
  - Trajectory Correction
  - On-Board Sensors and Processing

Precision 40 mm Grenade Program Phase 1

- Looked at contribution of error sources to dispersion
- Assessed the application of different technologies to reduce dispersion
- Evaluated technologies on basis of technical maturity and risk and dispersion reduction
- Analysis flow included requirements definition, simulation, Pi calculations, TRL assessment and Alternatives Analysis



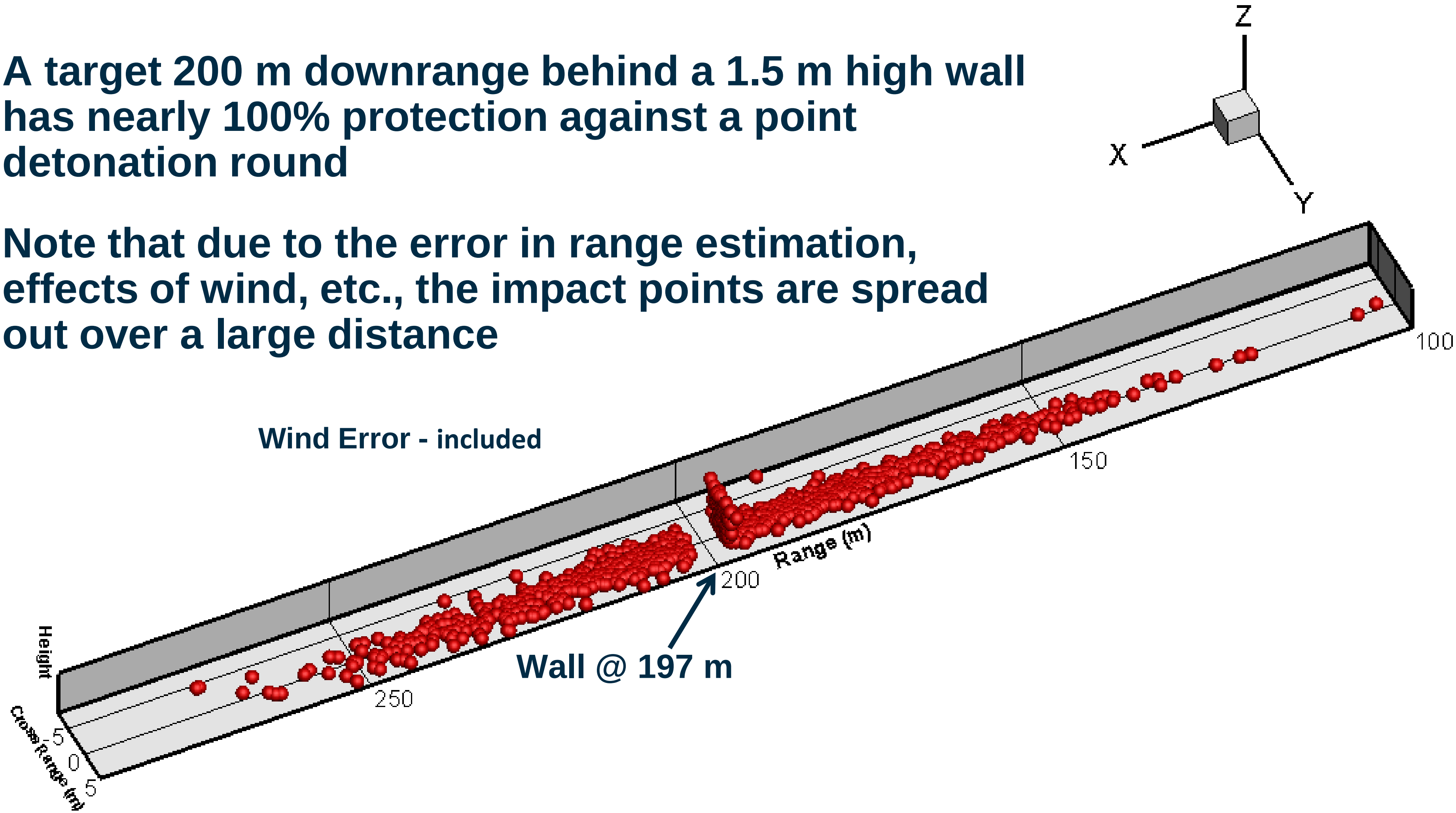
Sources of Error and Effect

- Different sources of error stack up to produce inaccuracy at long range
- If we knew all of these we could have perfect aiming

Source	Effect
Pointing (Az and El)	Gunner inability to hold weapon steady
Muzzle Exit Conditions	Muzzle velocity variation
Environmental Factors	Changes in density affect drag and wind affects flight
Range to Target	Error in gunner estimate of range
Physical Properties of Round	Round to Round Variations can affect drag coefficient, mass, stability, muzzle jump

Monte Carlo Analysis for Standard Grenade

- **A target 200 m downrange behind a 1.5 m high wall has nearly 100% protection against a point detonation round**
- **Note that due to the error in range estimation, effects of wind, etc., the impact points are spread out over a large distance**



Technology Improvements

Technology	Effect on Error
Range Finder	Ranging Error → ± 0.5%
Feedback Elevation to Gunner	Pointing Error El → ± 0.6%
Active Pointing Error Correction	Effective QE → ± TBD%
Muzzle Velocity Compensation	Muz Vel Error → ± 0.6%

Information from Fire Control

QE, Az, Temp & Pressure Sensors
Provides gun orientation and density measurement

Aiming Aid
Provides QE feedback to shooter

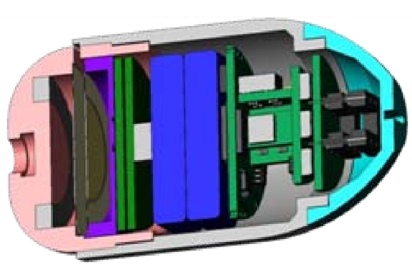
Range Finder
Provides range to target

Muzzle Velocity
Magnets produce a local field measured by on-board magnetometers

Communications
Initializes round with gun orientation, target range

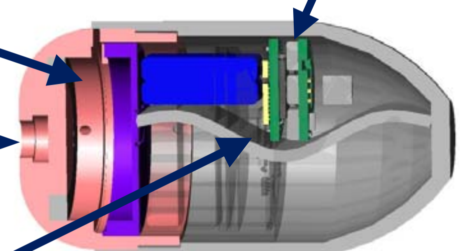
Course Correction, Fuze Timing, and Sensor Suite
Pointing error compensation, muzzle velocity correction, Senses orientation of round Calculates time for fuze

Maneuver Actuator
Synthetic Jet



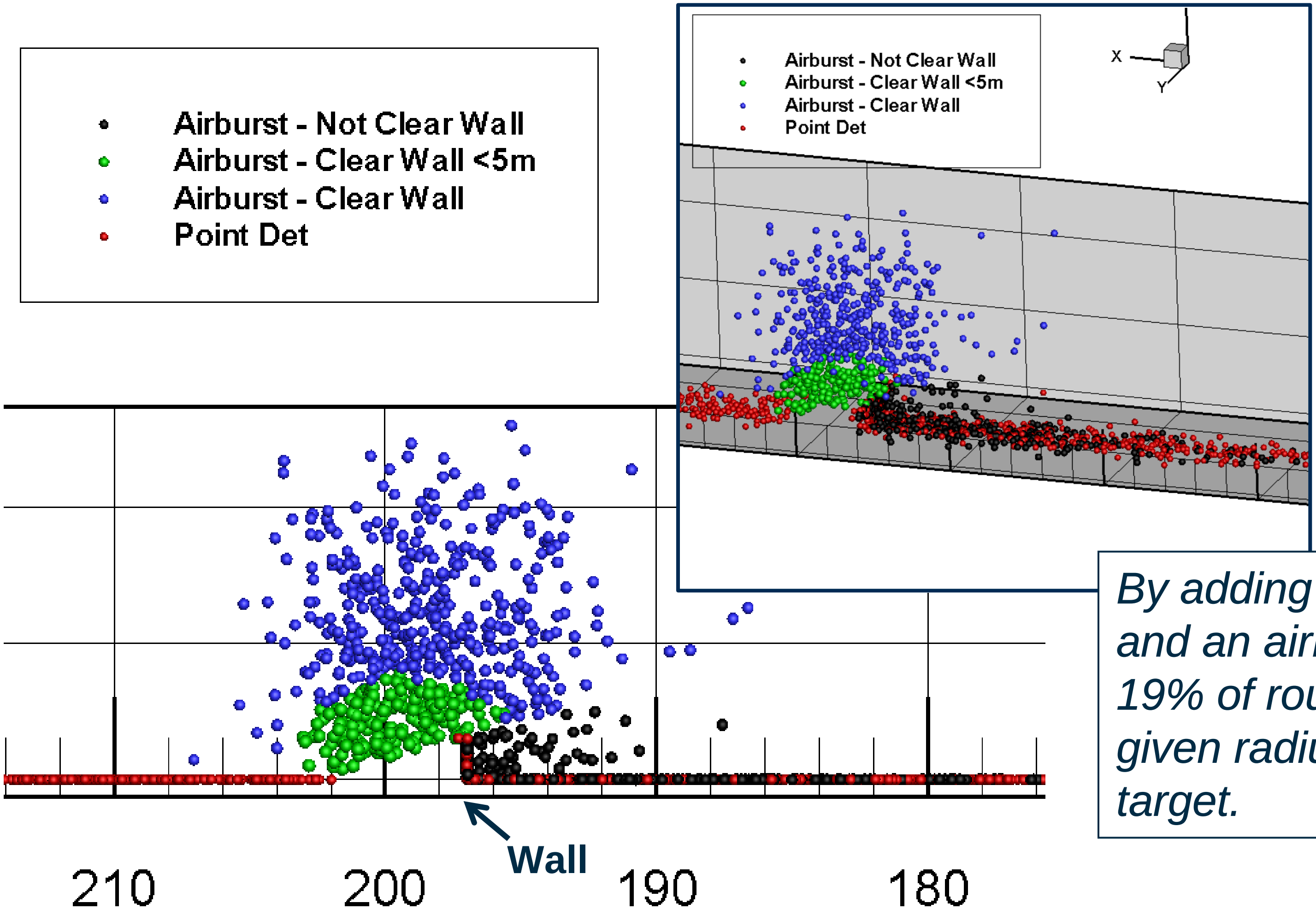
SCORPION Round

Electronics
Reduced volume for payload integration



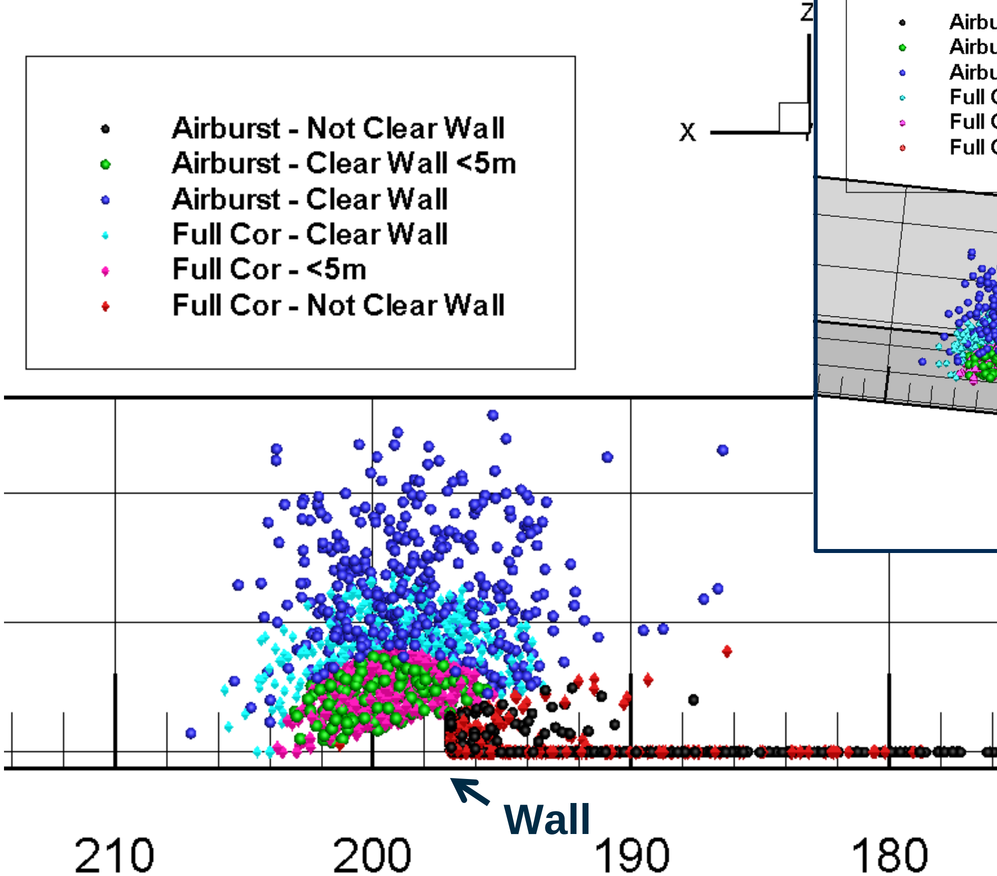
Precision 40 mm Technology Demonstrator

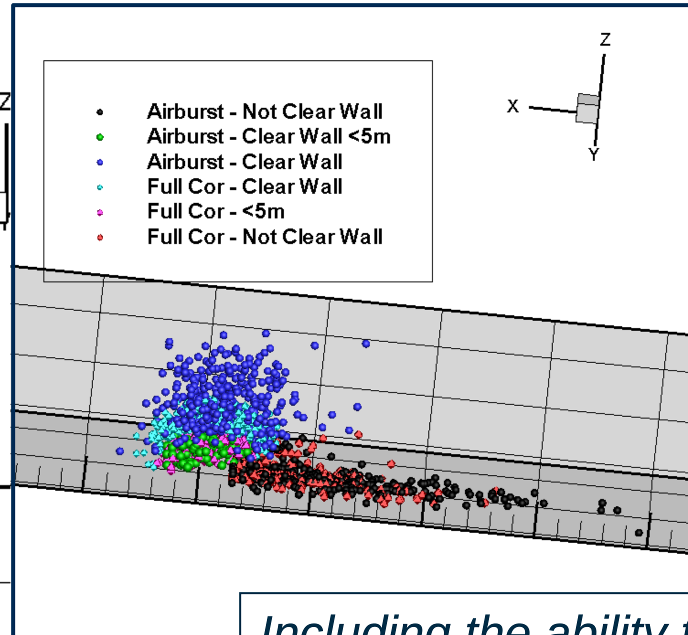
Effect of Including Range Finder and Airburst



By adding a range finder and an airburst capability, 19% of rounds fuze within given radius of defilade target.

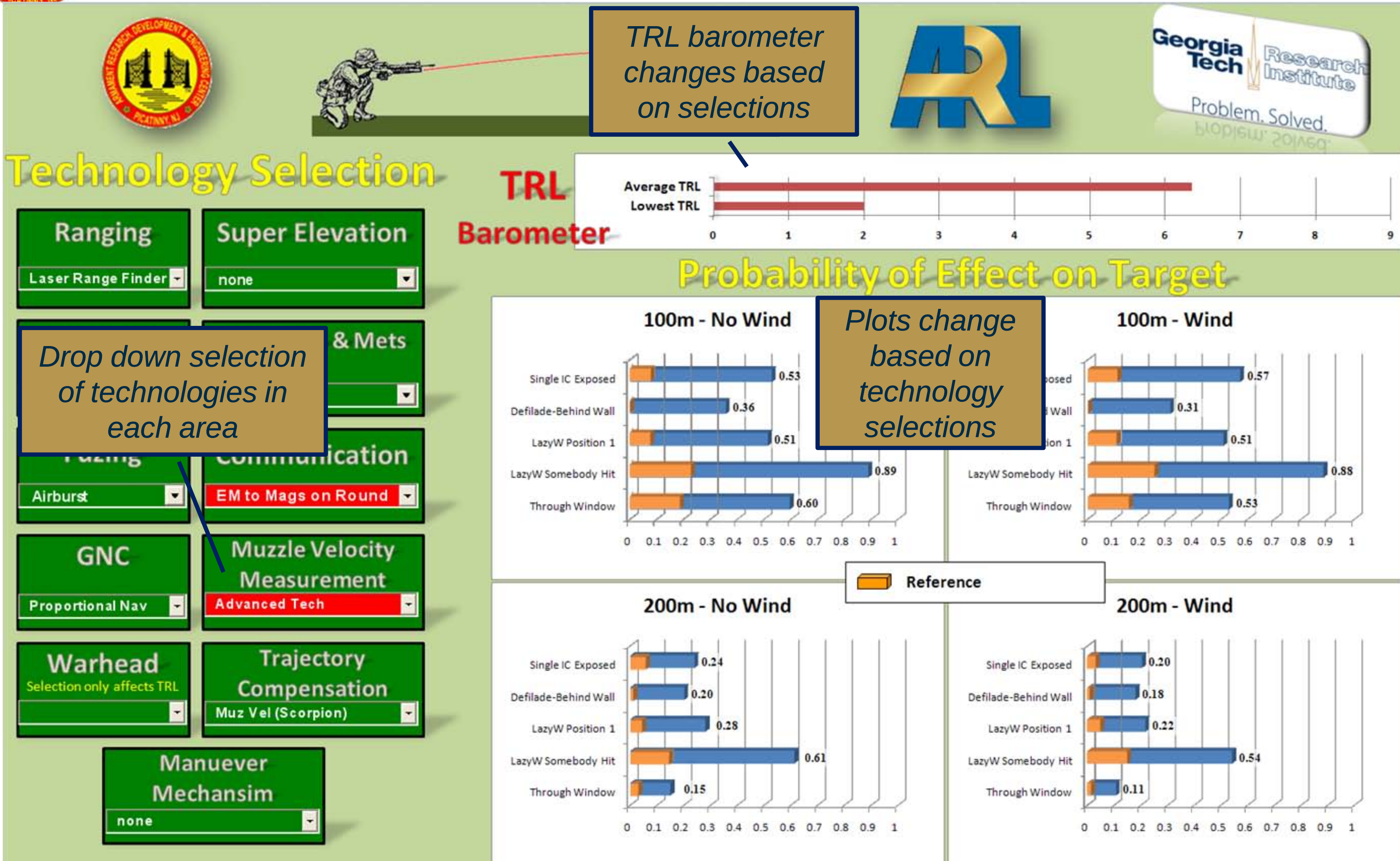
Effect of Compensating for Muzzle Velocity and Pointing Errors





Including the ability to perform in flight corrections to compensate for muzzle velocity variations and pointing errors, allows 34% of rounds fuze within given radius of defilade target.

Analysis of Alternatives Tool



Summary

- **The current 40 mm systems could be enhanced for increased effectiveness.**
  - **A series of technological improvements to the grenade and launcher system would enable a system to be effective against targets in defilade.**
  - **The combination of Monte Carlo error modeling and 6-DOF simulations provides a useful way to explore the benefits of each technology.**
  - **An Analysis of Alternatives tool allows for rapid comparison of the different technology combinations.**
  - **Technologies to be carried forward in Phase 2 include airburst, gunner aiming aid and active compensation.**

Acknowledgments

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