Distribution unlimited;
Approved for public release

U.S. Army Research, Development and Engineering Command

The Impact of High Accuracy Target Geometry in Modeling and Simulation to Support Live-Fire Test & Evaluation

16 March 2011

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Scott Hornung, 410.278.3263 (DSN:298.3263), scott.hornung@arl.army.mil

Ballistics & NBC Division

U.S. Army Research Laboratory, Survivability/Lethality Analysis Directorate

Overview

- Analysis Background
- Modeling Process Overview
    - The MUVES-S2 Model for Ballistic Vulnerability / Lethality (V/L) Analysis
    - The Model Process
    - The Importance of Highly Detailed Target Geometry
- Target Geometry Development
    - System Representation
    - Shot-Line Sequence
    - Conversion of Vendor CAD Files
    - Building High-Fidelity CAD Geometry
- Conclusions

Analysis Background

• All vulnerability/lethality efforts follow the same “general” analysis procedures.

• Inputs, models, and methodologies are tailored to fit particular needs of the customer:
- — acquisition decisions (PMs / PEOs, LFT&E Community)
- — system design / armoring initiatives (PMs, rapid fielding initiatives)
- — personnel survivability studies (PMs / PEOs)
- — AoAs, Army Studies (AMSAA, TRADOC, CAA)
- — weaponeering decisions (JTCG)

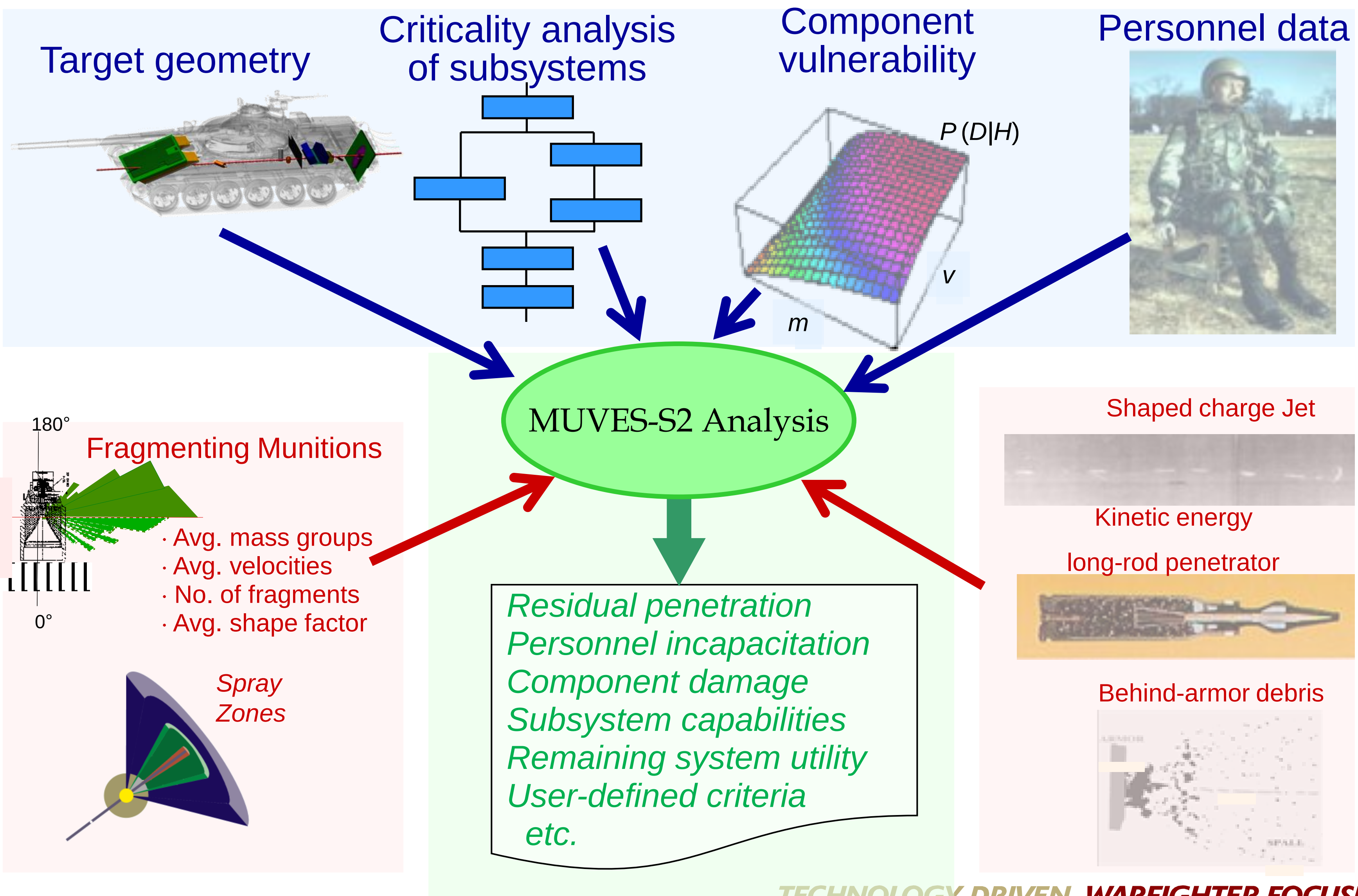
• Fidelity of analysis varies from a high level of detail, as in component-level analyses, to a lower level of detail as dictated by customer requirements.

• Benefits of modeling and simulation (M&S) to the LFT&E community:
- — Provides a “global” interrogation of the target, utilizing results of live-fire events to validate MUVES-S2 M&S results.
- — Supplements (not substitutes) the LFT&E process with a more global interrogation of the vehicle.

• Results are highly dependent on the fidelity of the inputs.
- — Computer aided design (CAD) geometry is the foundation of these inputs.

Modeling Process Overview

The MUVES-S2 Model for Ballistic Vulnerability/Lethality Analysis



The Model Process

Construct 3-D solid-geometry model of system
- Native CAD Conversion (Vendor Provided)
- Vehicle Interrogation (Measure/Build – Metrology)

→ Target Geometry Development

Characterize target/threat interaction
- Penetration Tests
- Behind-Armor Debris Tests
- Shock/Pressure Characterization

→ Threat/Armor Characterization

Model effect of damage on components
- Component Tests for Various Damage Effects

Characterize effect of component failure on subsystem capability (Fault trees)
- Controlled Damage Tests
- Subsystem Tests
- Intelligence Data
- Manuals

→ Engineering Criticality Analysis

Characterize system functionality (Mobility, Firepower,…)

→ Analysis Input/Output & Deliverables

The Importance of Highly Detailed Target Geometry

• MUVES-S2 analyses interrogate the target utilizing multiple shot-lines. Examples include:

— Artillery rounds create multiple shot-lines that generate more opportunity to interact with subtle details of the geometry.

— Behind armor debris evaluates interior components of the vehicle as the threat and all secondary effects interact with the vehicle geometry.

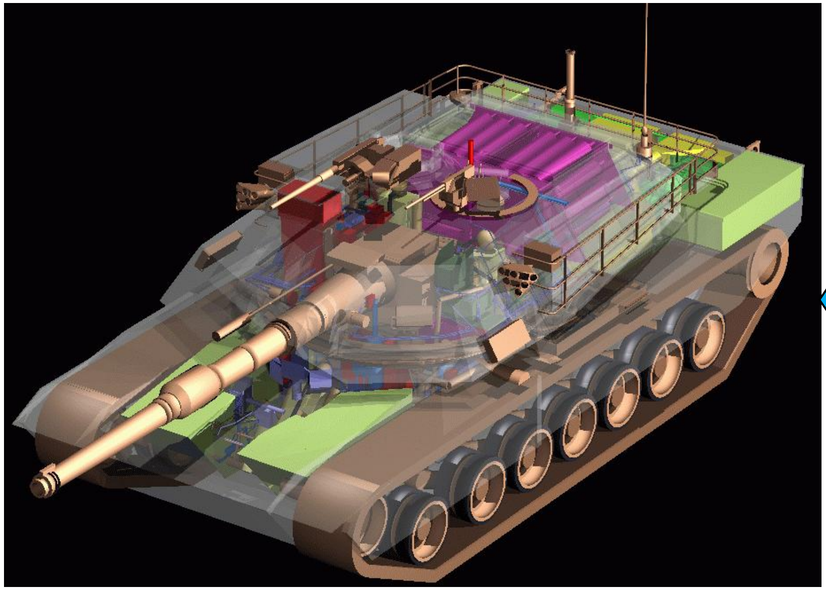
• Accurate geometry is essential to generate quality results.

US ARMY RDECOM

Target Geometry Development

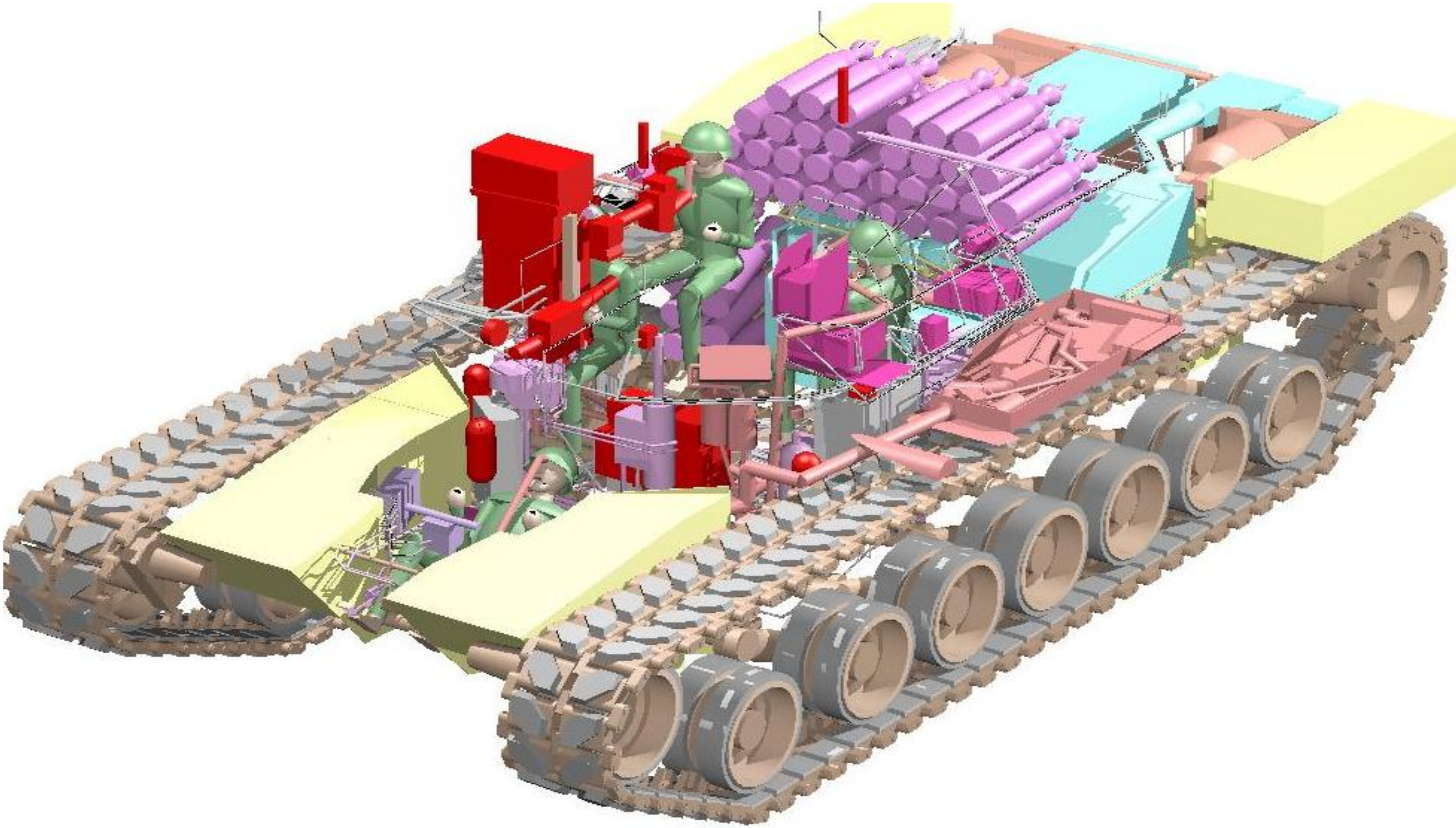
System Representation

Abrams Tank on Aberdeen Test Center Test Pad

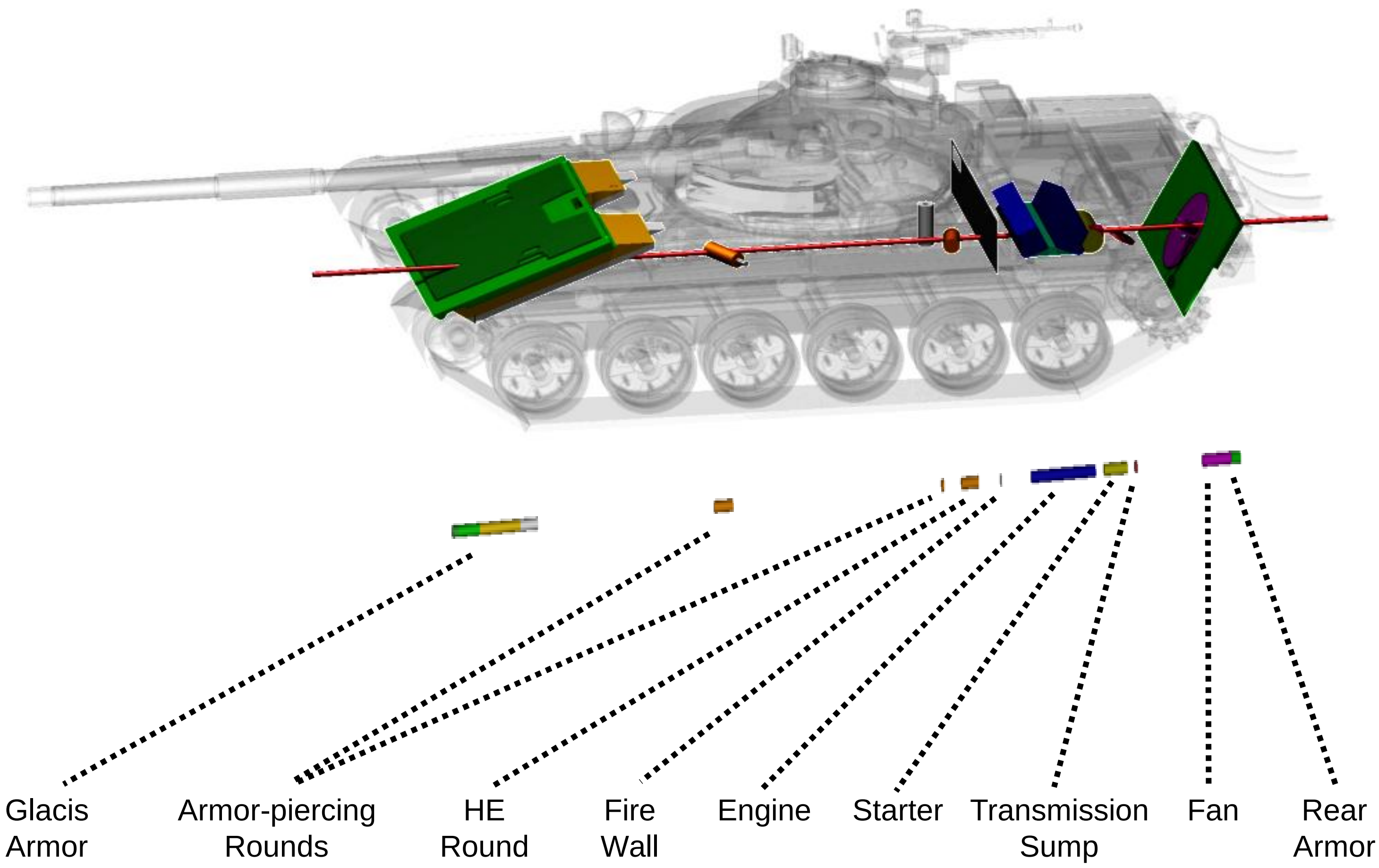


Construct 3D solid geometric model of system

High-Detail BRL-CAD^{TM} Representation



Sample Shot-Line Sequence

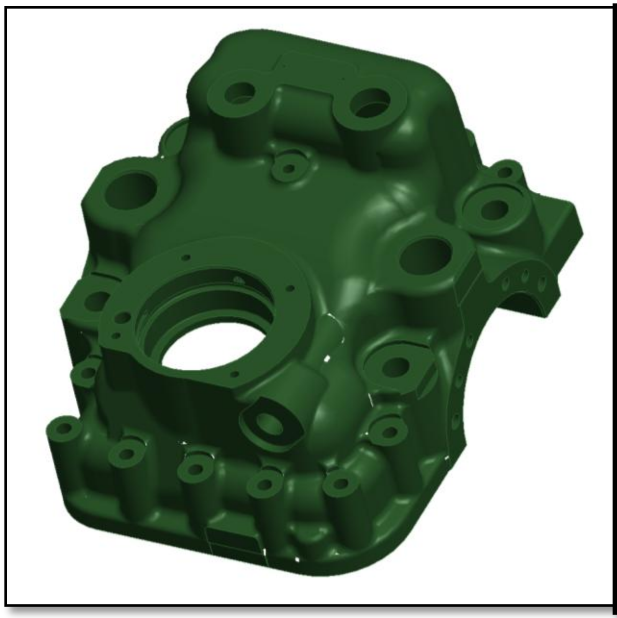


Conversion of Vendor CAD Files

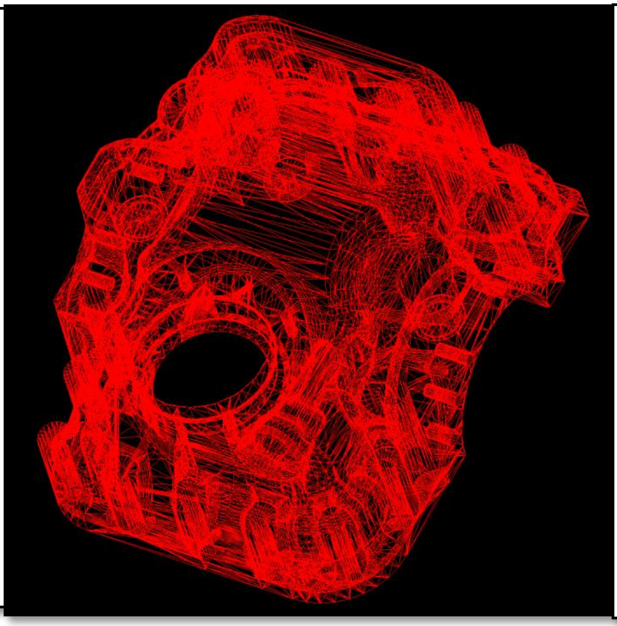
• Native CAD files provide ARL/SLAD with higher resolution source data that facilitates the conversion into higher resolution BRL-CAD™ for M&S analyses.

— Vendor CAD files are preferred method of geometry development.

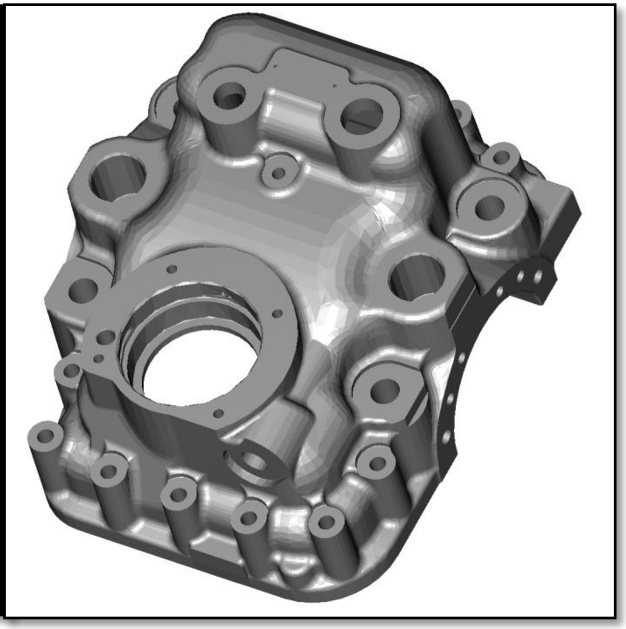
— ARL/SLAD has the tools to receive and convert multiple formats of CAD.



Vendor Provided Pro/E CAD



Wireframe Model



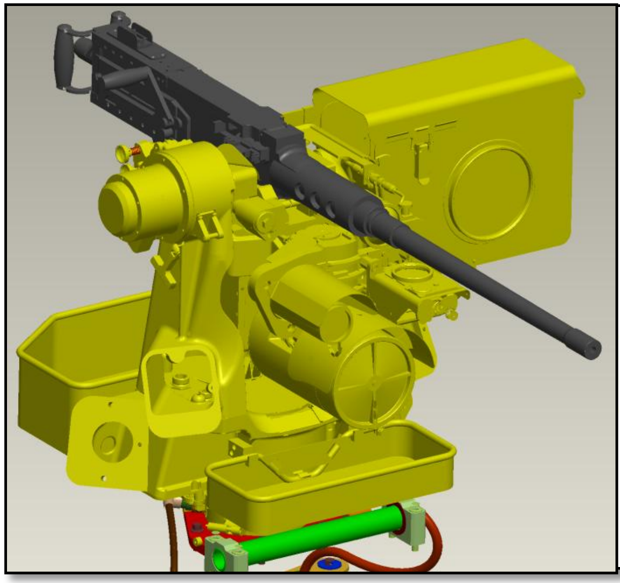
Final BRL-CAD™ Rendering

Conversion of Vendor CAD Files

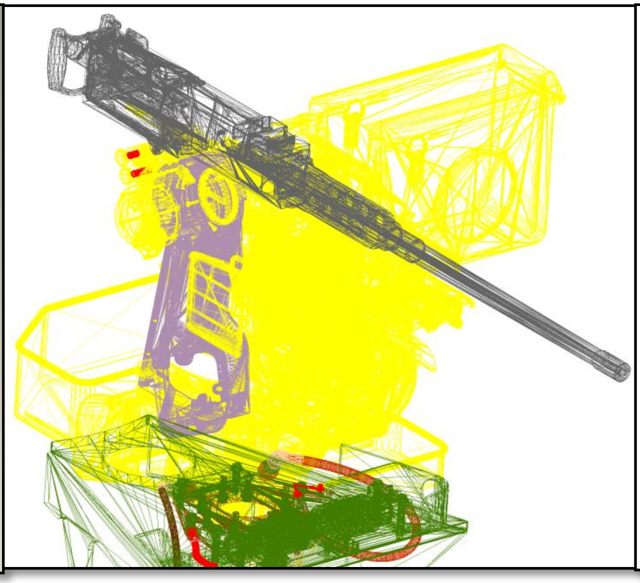
• A highly detailed component model, comprised of multiple solids, is reliant on a thorough understanding of that component's design.

• The quality of the resulting BRL-CAD™ geometry is highly dependent on the quality of the CAD that is provided.

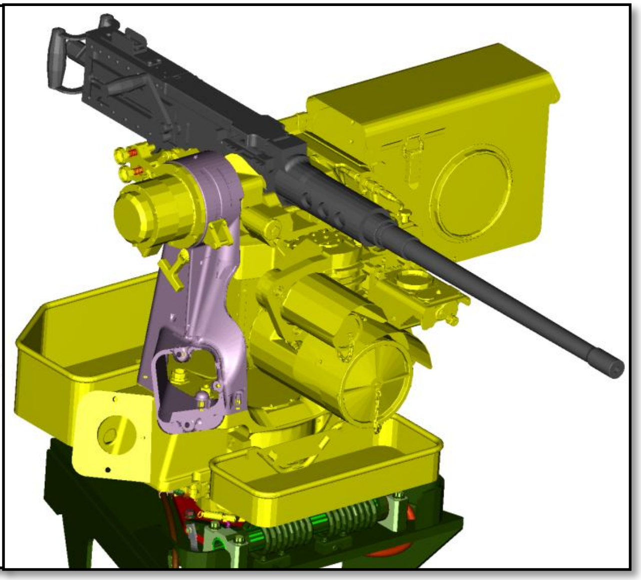
• Accurate component characteristics to include dimensions, thickness, and materials is desired and achievable with CAD files that include more detail than just surfaces (i.e., non-shrink wrapped source CAD).



Vendor Provided Pro/E CAD



Wireframe Model
More detail than just a surface model

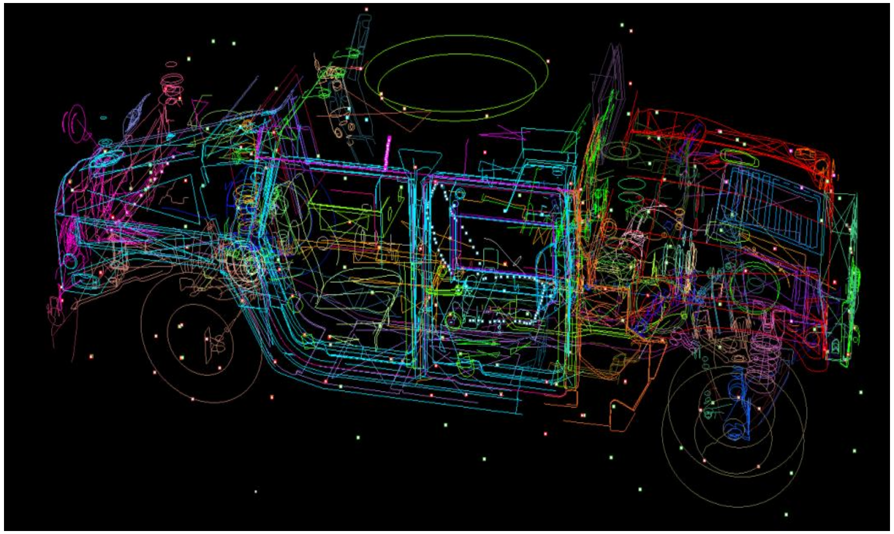


Final BRL-CAD™ Rendering

Building High-Fidelity CAD Geometry

- Utilization of various metrology equipment facilitates a high degree of accuracy in data collection.
    - — This process requires an extended period of time with the vehicle in a “stable” or semi-controlled environment.
    - — In order for the data collection process to be efficient, multiple personnel with various pieces of equipment are required.

Data Collection on M1151A1 HMMWV in ARL/SLAD Facility



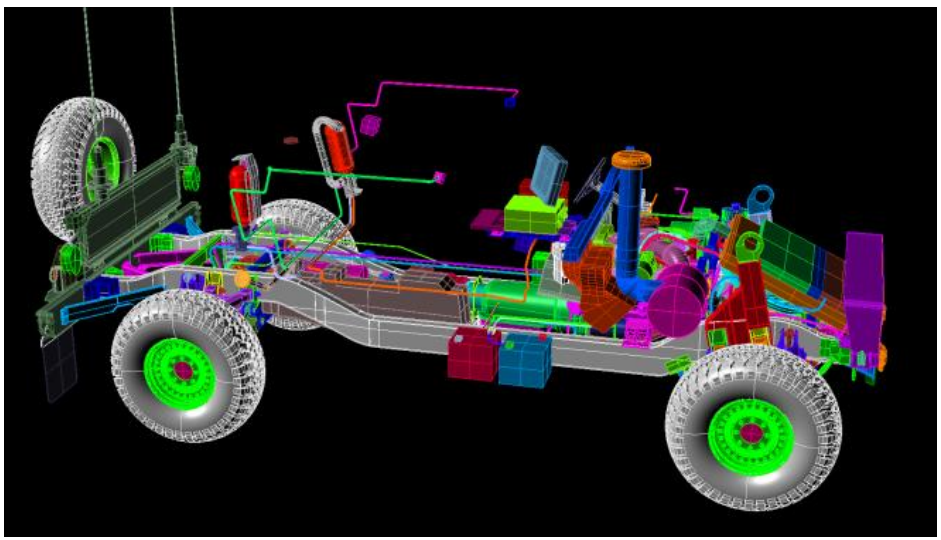
Raw Data Collected In Commercial CAD Software

Building High-Fidelity CAD Geometry

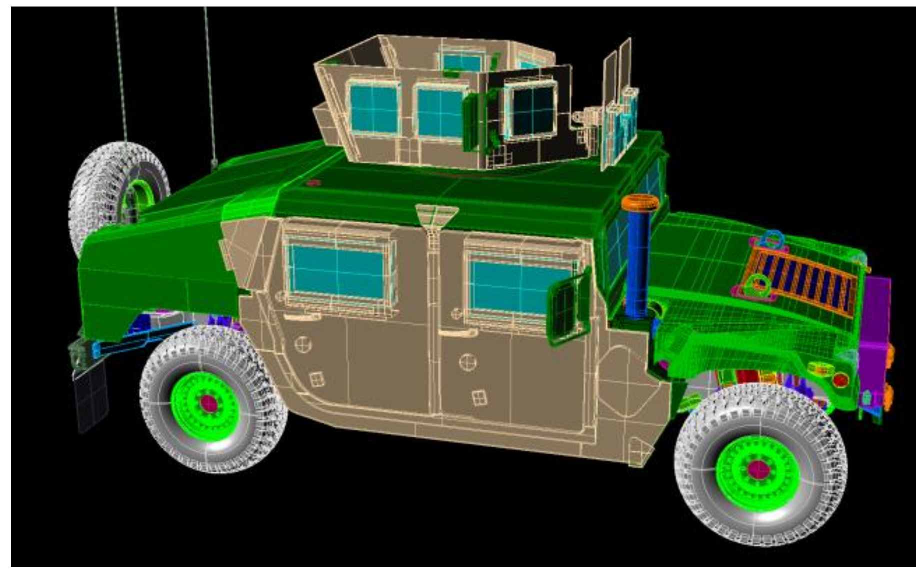
• While not the preferred form of geometry development, data collection through metrology equipment has seen advancements.

— Longer lead-time than conversion, but faster and much more accurate than older "hand measurement" techniques.

— Facilitates conversion from commercial CAD packages to BRL-CAD™ (necessary format for MUVES-S2 simulation).



M1151A1 HMMWV Subsystems Solids in Commercial CAD Software



Completed M1151A1 HMMWV Vehicle in Commercial CAD Software

Conclusions

- Modeling and simulation can supplement, but is not a substitute for, live-fire testing to provide a more thorough evaluation of vehicle vulnerabilities and armor design.
  - — Provides a "global" interrogation of the target, saving assets (minimizing cost) as well as maximizing data while minimizing the test schedule.

- Accurate target geometry is the foundation to a MUVES-S2 analysis.
  - — Accuracy is achieved by attaining quality vendor CAD geometry to convert into BRL-CAD™.
  - — Adequate time on a representative asset is required to facilitate the necessary vehicle interrogation for geometry development.

Questions?