Optimizing Cost & Time Effectiveness of Test & Evaluation Using Knowledge-Based Simulations

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Modeling & Simulation will never *replace* Test & Evaluation

- There is no substitute for experience
- Even the most accurate simulations require understanding that is either obtained or validated by experiment
- Simulations that are not validated (VV&A) are about as useful as testing and evaluation techniques that are not validated

Intelligently applied, knowledge-based simulations can enhance the development and acquisition process
In 1992, the Department of Energy faced a perplexing new challenge

- PRESIDENTIAL DIRECTIVE: Certify the performance, safety and reliability of the enduring nuclear deterrent WITHOUT TESTING.
What are knowledge-based simulations?

**Empirical Simulations**

- *Describe* outcomes
  - Use fits or tables derived from data
  - For quick interpolations between data points when variances are intuitive

**Knowledge-Based Simulations**

- *Predict* outcomes
  - Use equations derived from understanding of governing mechanisms
  - For reasonable excursions beyond and between data points when variances aren’t intuitive
Knowledge-based simulations can enhance test & evaluation in different ways

- **Design Tests**
  - Where to “look”
  - What to “look for”
  - What to vary
  - Reduce risk for failure

- **Interpret Tests**
  - Unravel confusing data sets and provide insight about the important phenomena that produce them

- **Supplement Tests**
  - Provide insight where experiments are prohibitively expensive or physically impossible
The missile defense community uses knowledge-based simulations to assess kinetic intercept lethality.

- **Standard Missile -3 (SM-3, AEGIS)**
- **Exoatmospheric Kill Vehicle (EKV, GMD)**
- **Simulated Ground-Based Midcourse Defense (GMD) Intercept**
Debris patterns can be correlated with real-time hit assessment immediately following a flight test.
Missile intercept simulations contribute in all three categories

- Design of Experiments
- Interpretation of Experiments
- Supplement Experiments
Penetration continues to be an important mechanism in weapon lethality.
Predicting lethality requires predicting debris.

Data courtesy of Stephan Bless
University of Texas, Austin

This debris is usually what kills
Generating and propagating fragments is necessary to assess collateral effects.
Ground shock (lethality) is significantly enhanced in a buried detonation

- BLU 116 Advanced Unitary Penetrator
  - Length: 2.4 m
  - Diameter: 25.4 cm
  - Thickness: 50 mm
  - Weight: 770 kg
  - HE weight: 65 kg

Consider the scenario of sequentially delivered penetrators

- Penetration is less effective with successive attempts

- Can this process be optimized?
Insight gained from knowledge-based simulations suggests a modified approach

“Clearing” bomb debris from the crater led to a factor of 1.5 increase in penetration.

Penetration at the surface is 4 times deeper than penetration inside a crater.

Penetration depth in shock-conditioned granite was 3 times greater than it was in virgin rock.

Alternating penetrators with conventional bombs may be more effective.
Knowledge-based simulations provide true value for defense acquisition

• Though M&S cannot replace T&E, they provide enhancements by
  • Optimizing the design of developmental and operational tests
  • Provide guidance in interpreting the results
  • Augment data sets when a test-only approach is cost-prohibitive, time-prohibitive or physically impossible

• These enhancements permit an additional means for exploring alternatives, modifications and “what if’s”

• Intelligently applied, knowledge-based simulations can accelerate discoveries and minimize risks in the development process