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AMRDEC Lethality Modeling and Simulation Methodologies for Aerial Targets

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Presented by:

Dustin Clark

SSDD

dustin.h.clark@us.army.mil

256.842.9523

Co-Authors: Dedra Moore

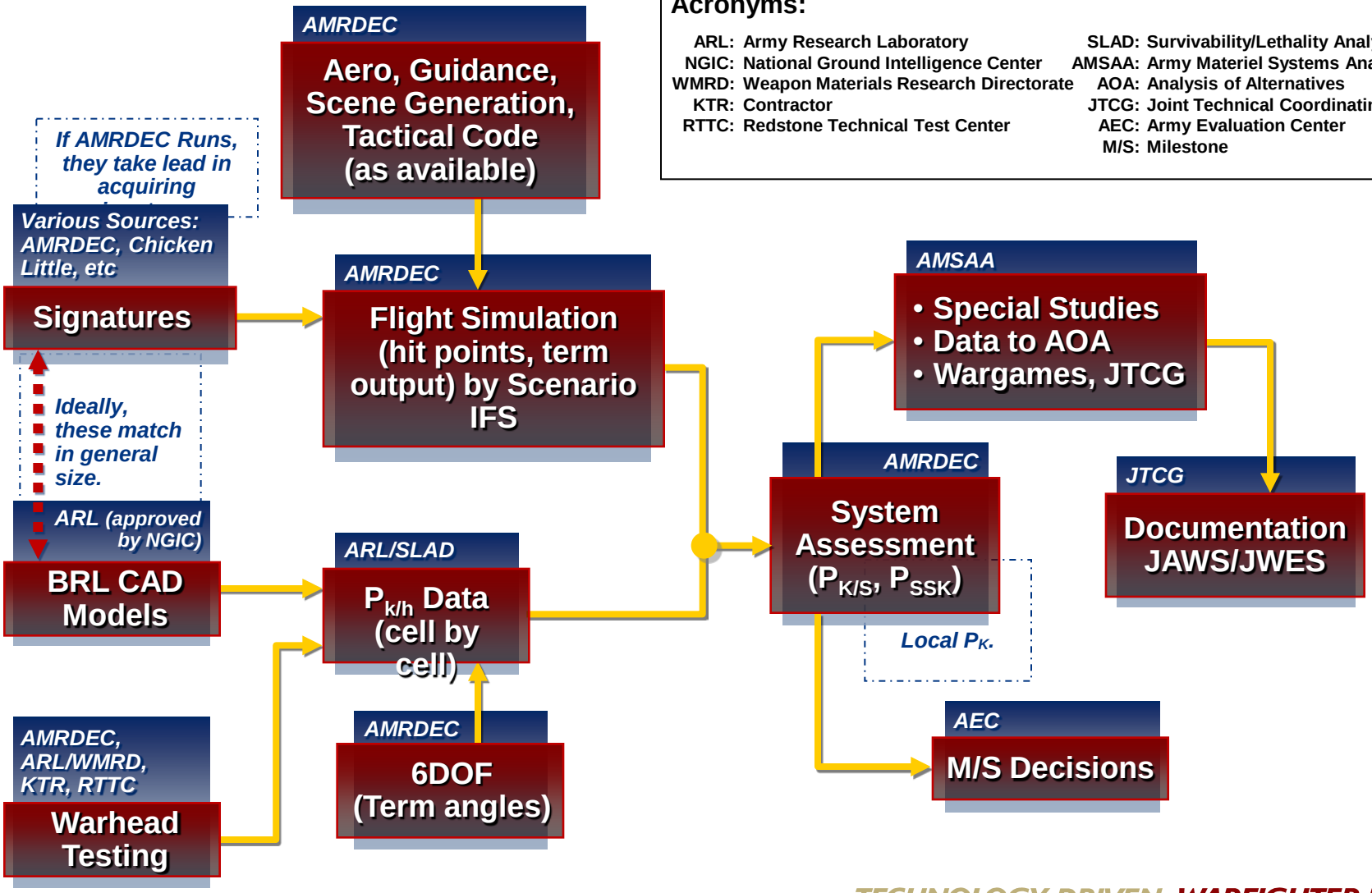
Brent Deerman

U.S. Army Aviation and Missile Research, Development, and Engineering Center

System Assessment Process

Acronyms:

ARL:	Army Research Laboratory	SLAD:	Survivability/Lethality Analysis Directorate
NGIC:	National Ground Intelligence Center	AMSAA:	Army Materiel Systems Analysis Activity
WMRD:	Weapon Materials Research Directorate	AOA:	Analysis of Alternatives
KTR:	Contractor	JTCG:	Joint Technical Coordinating Group
RTTC:	Redstone Technical Test Center	AEC:	Army Evaluation Center
		M/S:	Milestone



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

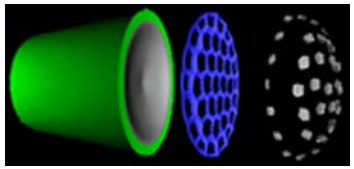
Types of Aerial Targets – AD/AP

AIR DEFENSE

Large Number of Fragments to Increase Probability of Hit on Target

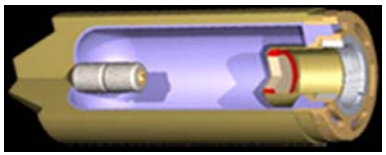
AREA PROTECTION (RAM)

Kinetic Energy with Multiple Hits on Target



Multiple EFP

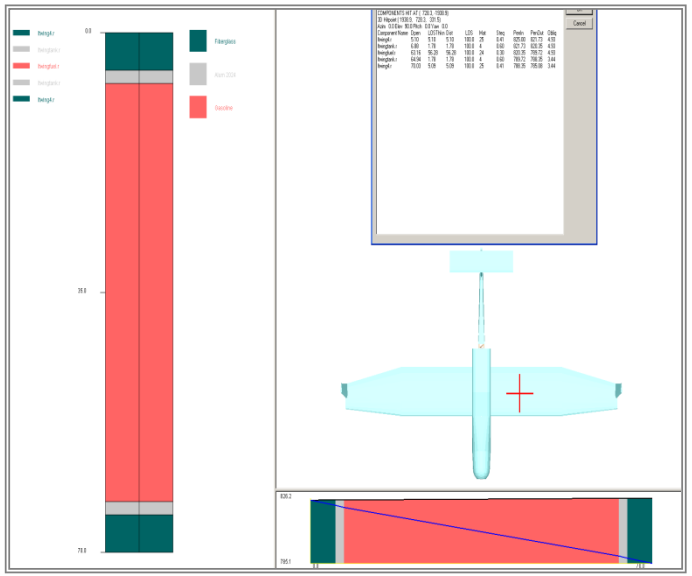
Blast/Frag



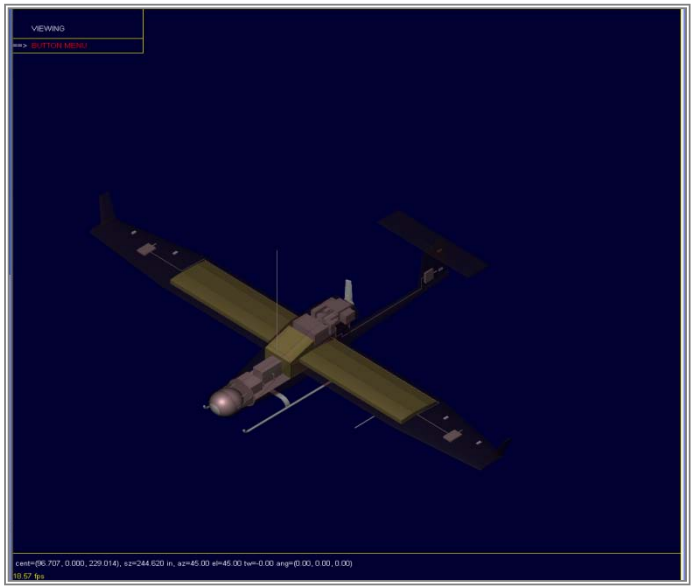
Target Modeling

- **BRL-CAD™ was developed by what is now the US Army Research Laboratory's Survivability/Lethality Analysis Directorate (ARL/SLAD) in the 1980s**
- **The ARL resolution standard for target geometric modeling is down to the wiring and hydraulic lines level**

Sample Shotline with Material

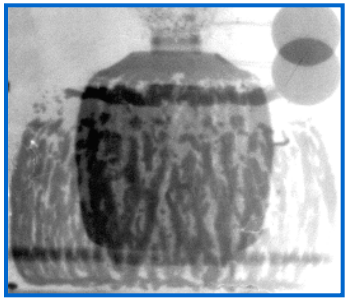


Sample Model Ghosted to Show Components



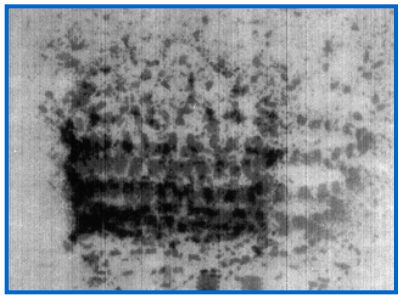
Fragmentation Technology

Natural Fragmentation



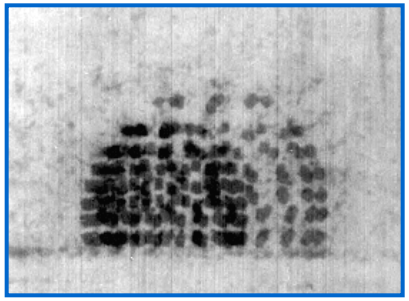
Wasted Mass/Energy

Embossed Fragmentation



Less Wasted Mass/Energy
Improved Lethality,
Low Cost

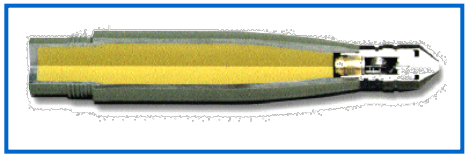
Preformed Fragmentation



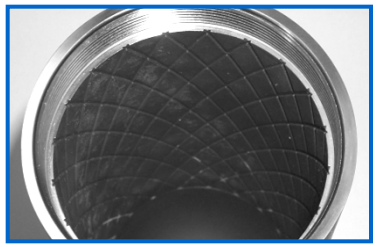
Efficient Mass/Energy
Optimized Lethality, More Cost

Least Cost — ***Most Cost***

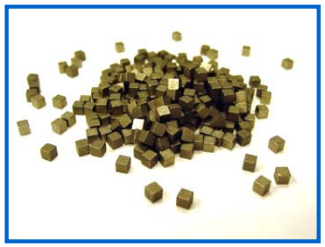
Least Mass Efficient — ***Most Mass Efficient***



M151 Warhead



Pearson or V-Notch Scoring

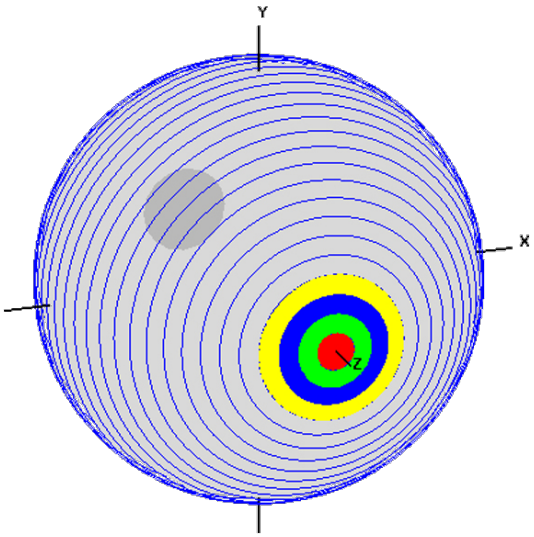


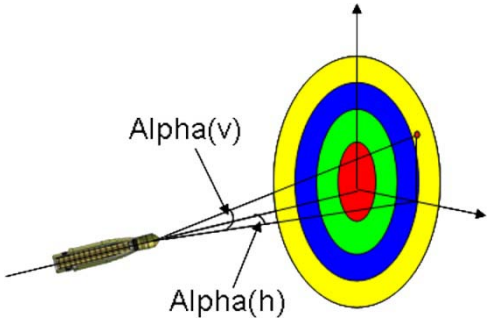
Tungsten Fragments

Optimization Balances Cost and Performance

Courtesy of Dr. Ernest Baker, ARDEC

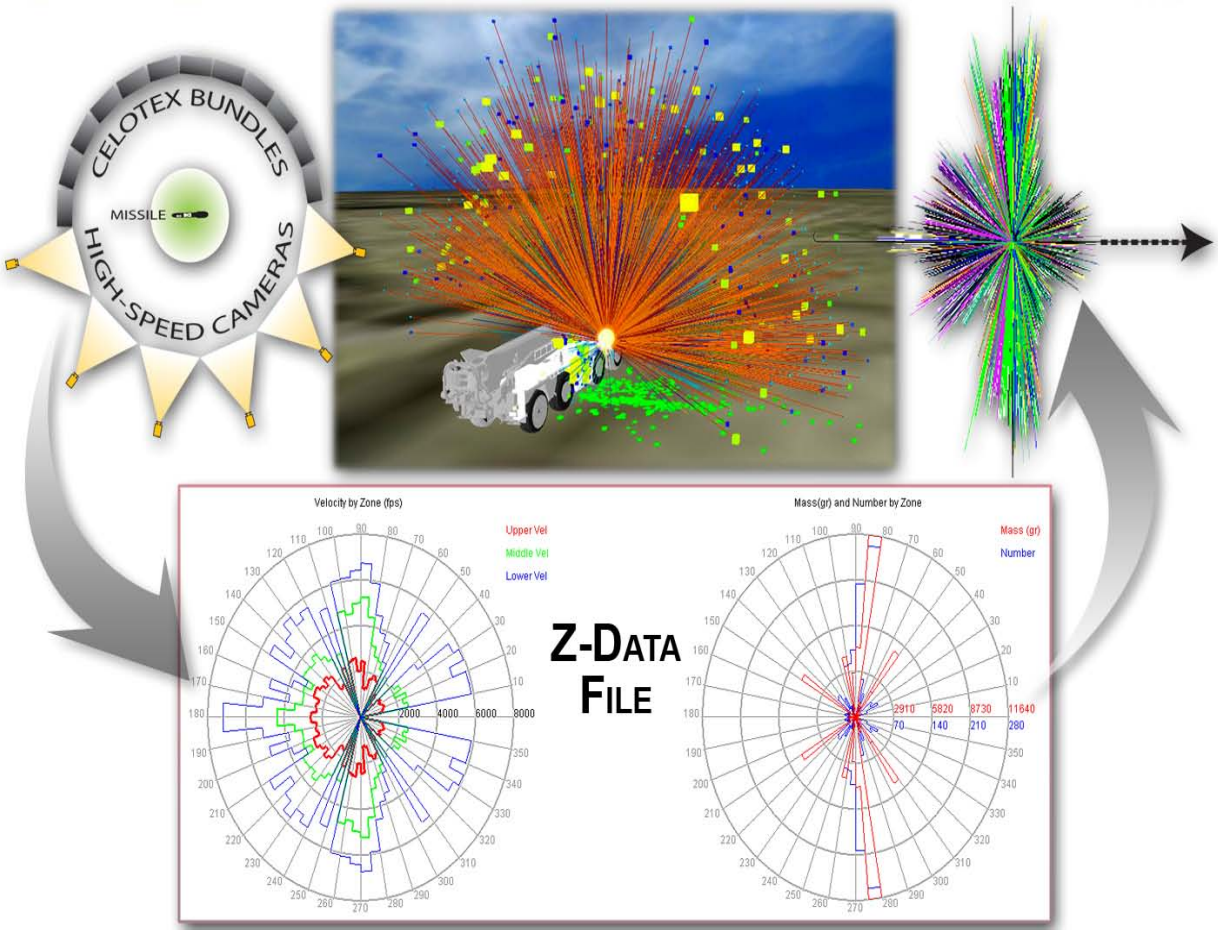
Arena Test Setup





- **Fragments are collected in bins that represent polar angles around the rocket/missile**

Warhead Fragmentation Modeling

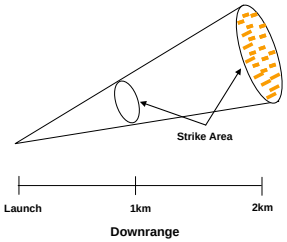


- **Fragments are modeled to represent size, mass and material type**

System Lethality Assessment Process

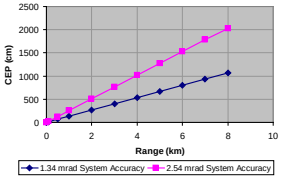
Lethal Mechanism Model Development

- Pre-Release/Detonation Characteristics
- Detonation Characteristics with Statistical Variation Estimate



System Error Characterization

- Sensor / Aiming Errors
- Fuzing Errors
- Mechanical Errors



System Kinematic / Scenario Analysis

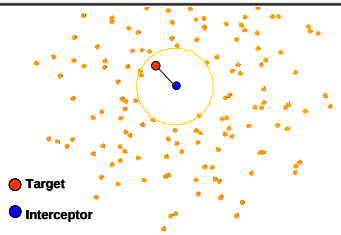
- Velocity / Range Estimates
- Engagement Scenario Development
- Miss Distance Characterization

Analysis Development

Revisions Based Upon New Data or Observations

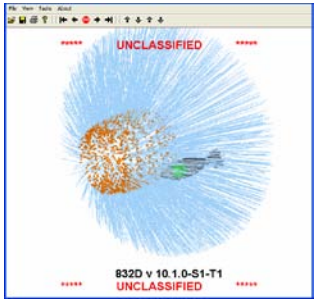
Downrange (km)	Flechettes on Fuze*	Flechettes on Target*	PK – Objective Criteria
Target 1			
1	5.8	23.34	0.15
2	1.95	7.76	0.0
Target 2			
1	3.83	37.5	0.0
2	2.73	20.19	0.0
Target 3			
1	4.25	68.02	0.27
2	2.59	32.37	0.0
Target 4			
1	5.69	74.23	0.0
2	3.14	35.04	0.0

*Flechette Hits: Total over round burst



Data Reduction and Analysis

- Visual Inspection
- Lethality Extraction
- Comparison to Expectations
- Comparison Between Systems



End Game Lethality Simulation Analyses

- Monte-Carlo Scenario Variation
- Threat Suite
- Lethal Mechanism-Specific Effects

Analysis Performance

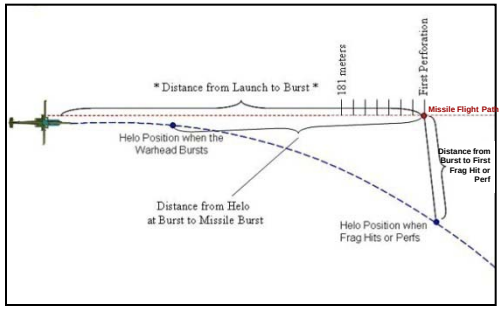
RAM Targets

- **Mortars are Quite Difficult to Kill Due To Their Simplicity:**
  - Generally Small Targets Flying For Short Periods of Time
  - No Guidance & Control or Electronics to Disable
  - Thick Casing Surrounding Payload
  - Threats Have Low Velocity Reducing Contribution to Overall Energy Available at End Game
- **A Recognizable Detonation of the Mortar is the Desired Kill Mechanism as the Defeat is Immediately Recognized by the Warfighter. This is Driven by:**
  - Explosive
  - Impacting Projectile
  - Case Surrounding the Explosive
- **Dudding the Mortar is Not a Perferred Option as the Warfighter Cannot Distinguish Mission Success Until the Mortar Strikes the Ground.**

Mortar Arena Test – Fragment Penetration with No Mortar Response

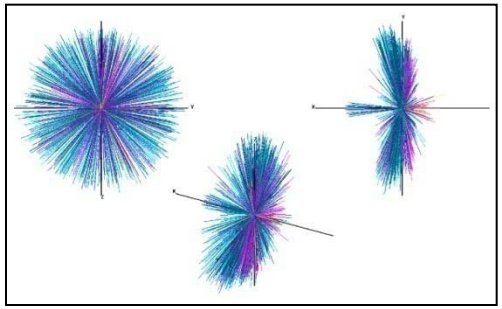
Fast-Running Models Require Accurate Modeling of the Defensive System Performance and the Conditions at the Point of Engagement

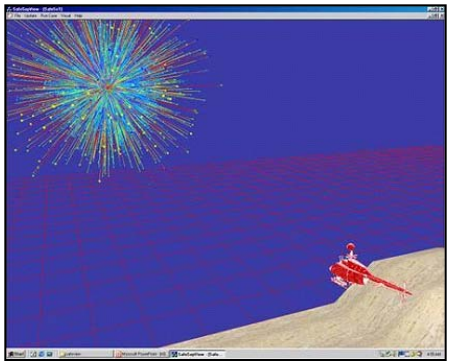
Safe Separation Inputs



INPUT

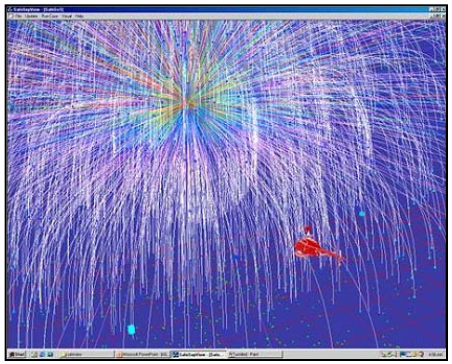
- Z Data File
- Missile Flight Trajectories
- Helicopter Geometries

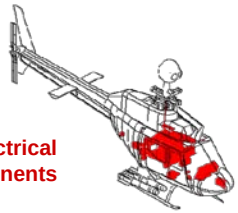




SIMULATION

- Random Draw on Fragment Pattern & Missile Trajectory
- Motion of Helicopter (Hover, Running, Diving)
- Fragment Impact (Trajectory Computation Including Drag/Gravity)
- Fragment Penetration Project (THOR Equations & BRL-CAD™ Ray-Tracing)





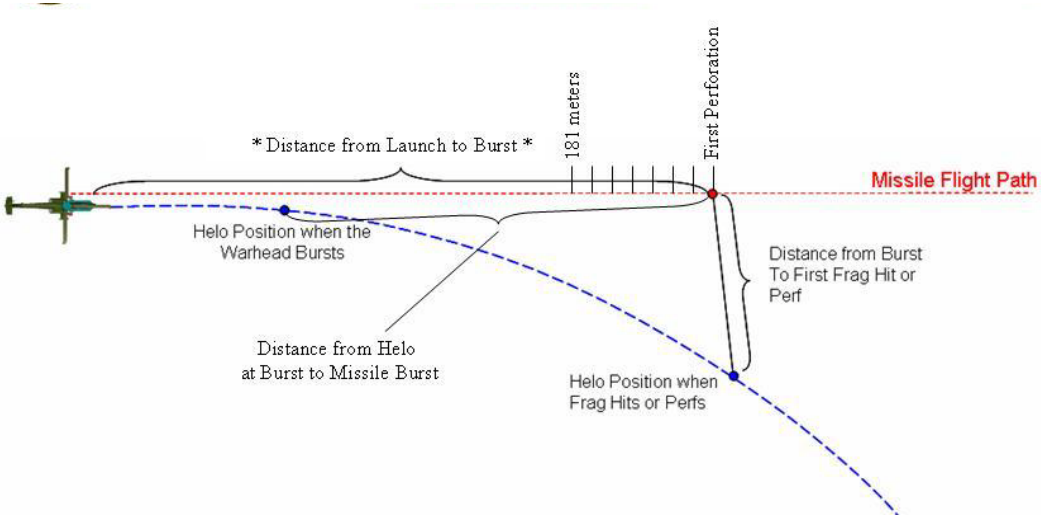
Critical Electrical Components

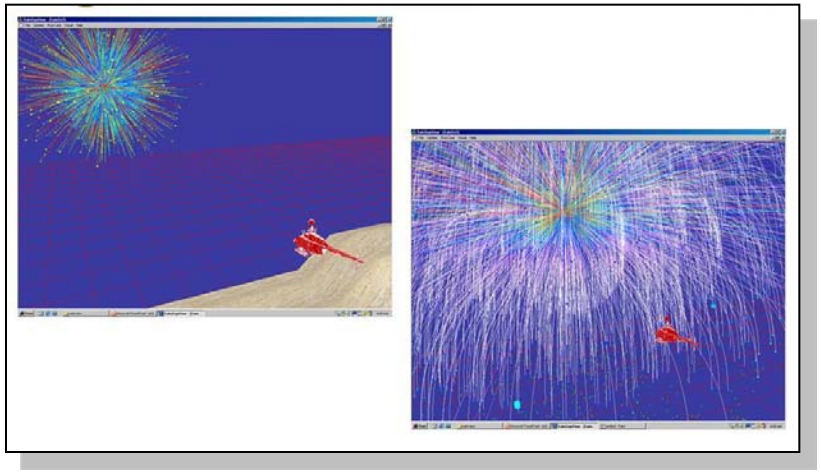
- Determination of Critical Components (SME Opinion)
- Computation of Statistics on Performance of Critical Components

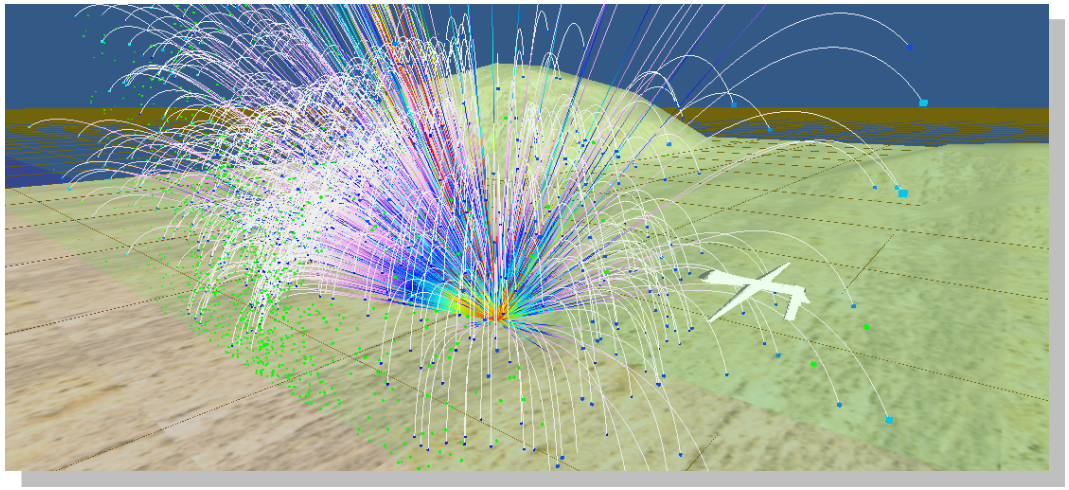
POST PROCESSING

Critical Flight Control Components

Safe Separation Methodology and Analysis







- **High Fidelity Simulation Run in Monte Carlo Mode**
- **Scenario Repeated From Specified Trajectory Location Back to Minimum Arming Distance**
- **Fragment Hits on ALL Critical Components Analyzed**

UAV Vulnerability Characterization

Purpose:

- **Determine the vulnerability of UAVs to fragment impact and blast effects**

Payoff:

- **Determine effectiveness of air defense warheads against UAVs (both lethality and survivability)**
- **Determine safe separation distance of armed U.S. UAVs**