96 TW

Advanced Weapons Effects Test Capability (AWETC)

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Overview

96 TW

- Current Arena Test Methodology
- Current Data Limitations
- T&E Need
- Use Case Variants
- AWETC Project Description
- Alternatives for Solutions Development
- Technology Development to Watch
- Project Status

Current Arena Test Methodology

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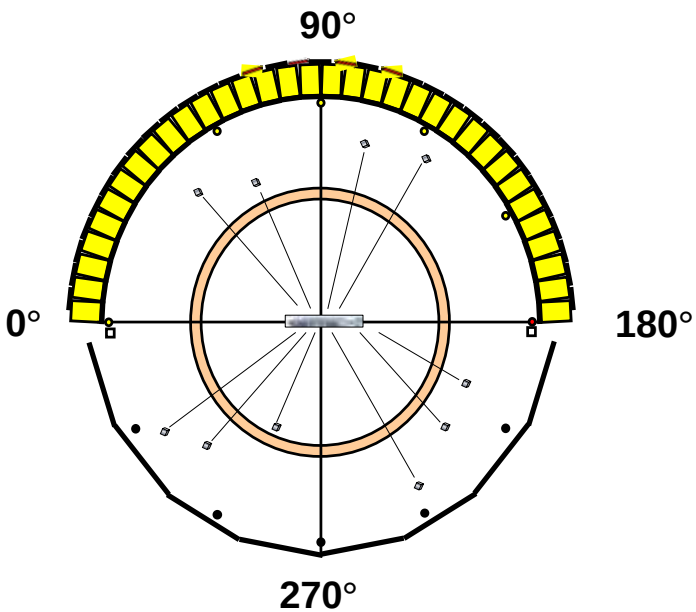
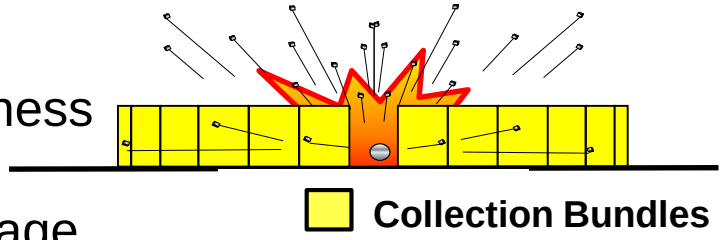
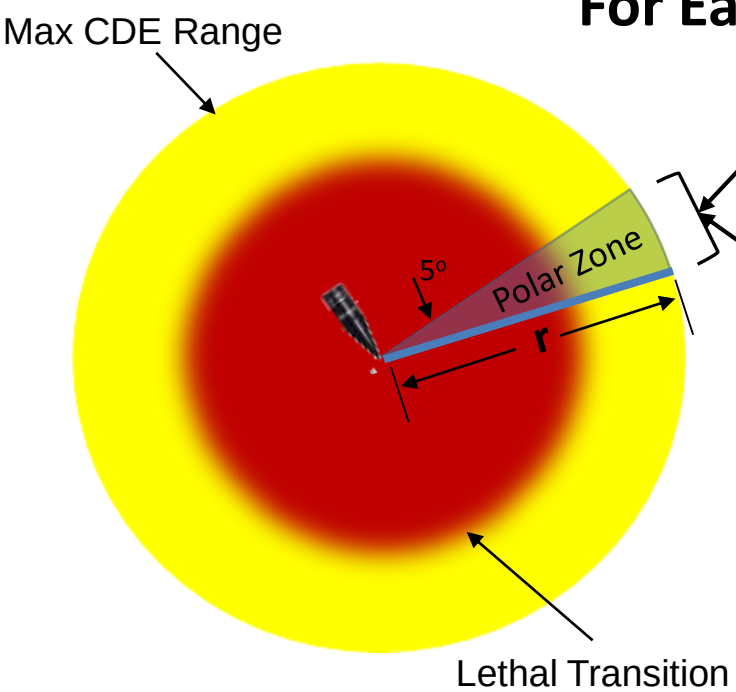
- **Number of Fragments Captured**
  - 15% (40 ft. arena)
  - 200-3000 fragments per test captured
  - Weapon must be rotated and retested
- **Number of Tests Required**
  - Small Munitions (<100 lbs)
    - 3 Horiz, 2 Vert ⇒ $732K, 5 mo.
  - Large Munitions (>100 lbs)
    - 2 Horiz, 2 Vert ⇒ $779K, 5 mo.
- **Data Quality**
  - Methods STILL insufficient to:
    - Adequately assess Weapon Effectiveness (Lethality)
    - Prevent over-cautious Collateral Damage Estimation





Current Arena Data Limitations

For Each Polar Zone



50 Frags collected

Masses: . • ● ● ..... ● ●

7 Velocities measured, no correlation

2500 fps, 3000 fps,……,4000 fps, 4500 fps

Which fragment generates which value? **Unknown**

Max CDE Range (r)

Distance at which largest mass ● can no longer pierce clothing and skin, assuming it starts at largest observed velocity (4500 fps)

2 Problems with Current Arena Data Acquisition:

Incomplete Data: 7 Velocities vs 50 Frags with 0 Correlation (Quality)

Insufficient Data: Celotex Coverage only captures 5-15% of frags (Quantity)

T&E Need

- **Weapon Effects Characterization**
  - **Current Arena Test Methods do not:**
    - Capture sufficient weapon fragmentation data (quantity)
    - Capture the right fragmentation data (quality)
    - Address unique fragmentation characteristics of newer low collateral damage warheads
  - **Resulting In:**
    - Conservative weapon selection for selected target
    - Re-engagement of target – increased risk
- **New Test Methodologies are Needed to:**
  - Determine more accurate CDE* distances
  - Provide a measure of error on lethality/CDE distances

* - Collateral Damage Estimate

T&E Need

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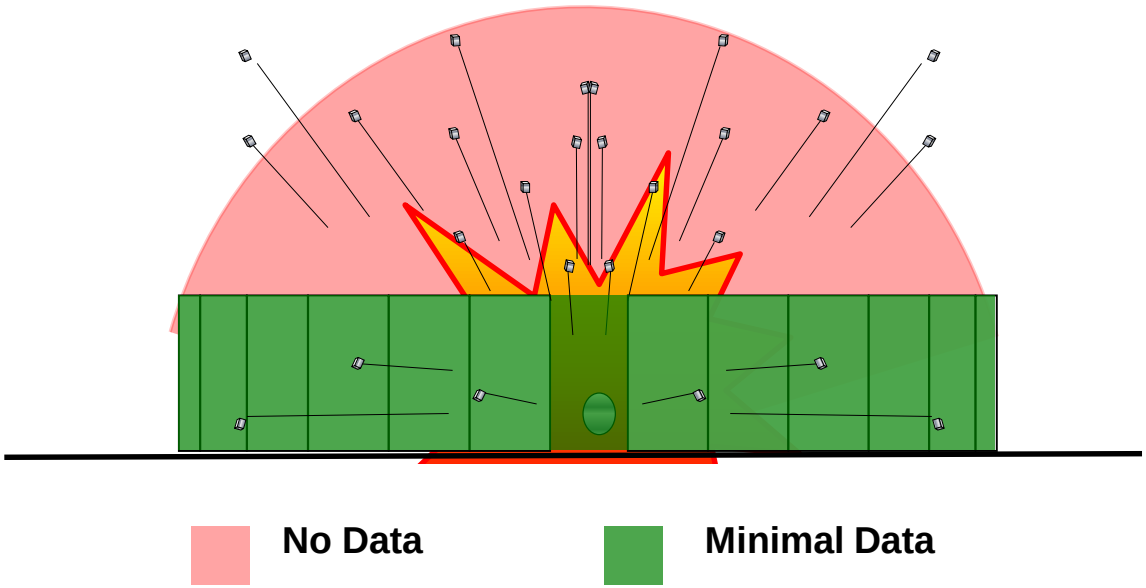

- **Requirement** - Collect sufficient data to properly evaluate weapon effectiveness
    - Fragment position over time
    - Fragment velocity vector – per fragment (speed/trajectory)
    - Physical Characterization – per fragment

AWETC Use Case Variants

- **One AWETC Use Case, Three Variants**
  - Small Warheads
    - ~10 lbs. NEE*
  - Medium Warheads
    - ~100 lbs. NEE
  - Large Warheads
    - ~1000 lbs. NEE
- **Variants based on JMEM**, Site Visits**

* - Net Explosive Equivalent Weight
** - Joint Munitions Effectiveness Manual

AWETC Site Visit Summary

Aberdeen Test Center (ATC) – 21 Aug 2014

- Test Items: Grenades, 60/81120mm mortars, 105 and 155mm artillery shells
- Typical Arena Test Set-up: Square (12-15 ft. from munition to bundles)
- Cameras: 6-7 (velocity measurements)
- Primary Users: Army Modeling and Simulation Agency (AMSAA) and Army Research Laboratory (ARL)

Redstone Test Center (RTC) – 27 Aug 2014

- Test Items: Small tactical missiles
- Typical Arena Test Set-up: 15 ft. radius
- Cameras: Used for velocity measurements
- Primary Users: MSIC and AMRDEC

China Lake (NAWC-WD) – 17 Sep 2014

- Test Items: Can test up to 2000 lbs.
- Typical Arena Test Set-up: Round (10-50’ radius)
- Cameras: Used for velocity measurements
- Primary User: NAWC-WD

Small Arena Test Set-up

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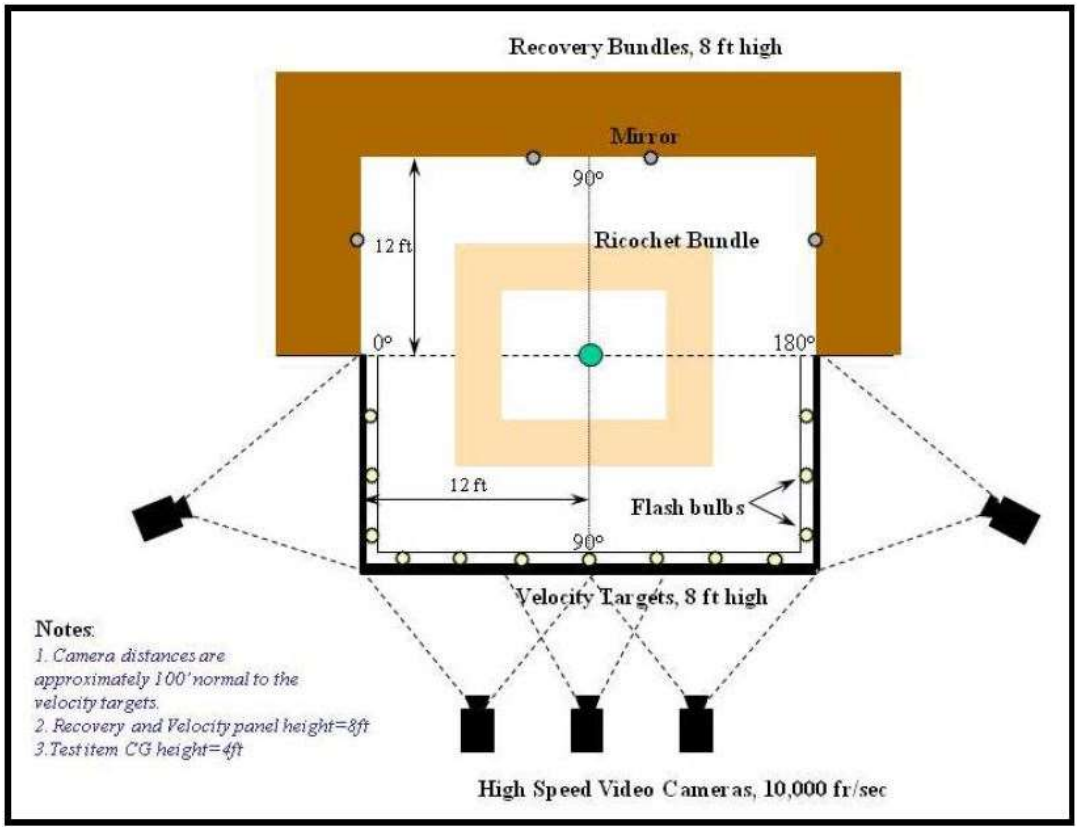

- **Small Warhead Use Case**
  - Based on JMEM Weapon Classes* (~10 lbs. Net Explosive Equivalent (NEE))

Medium Arena Test Set-up

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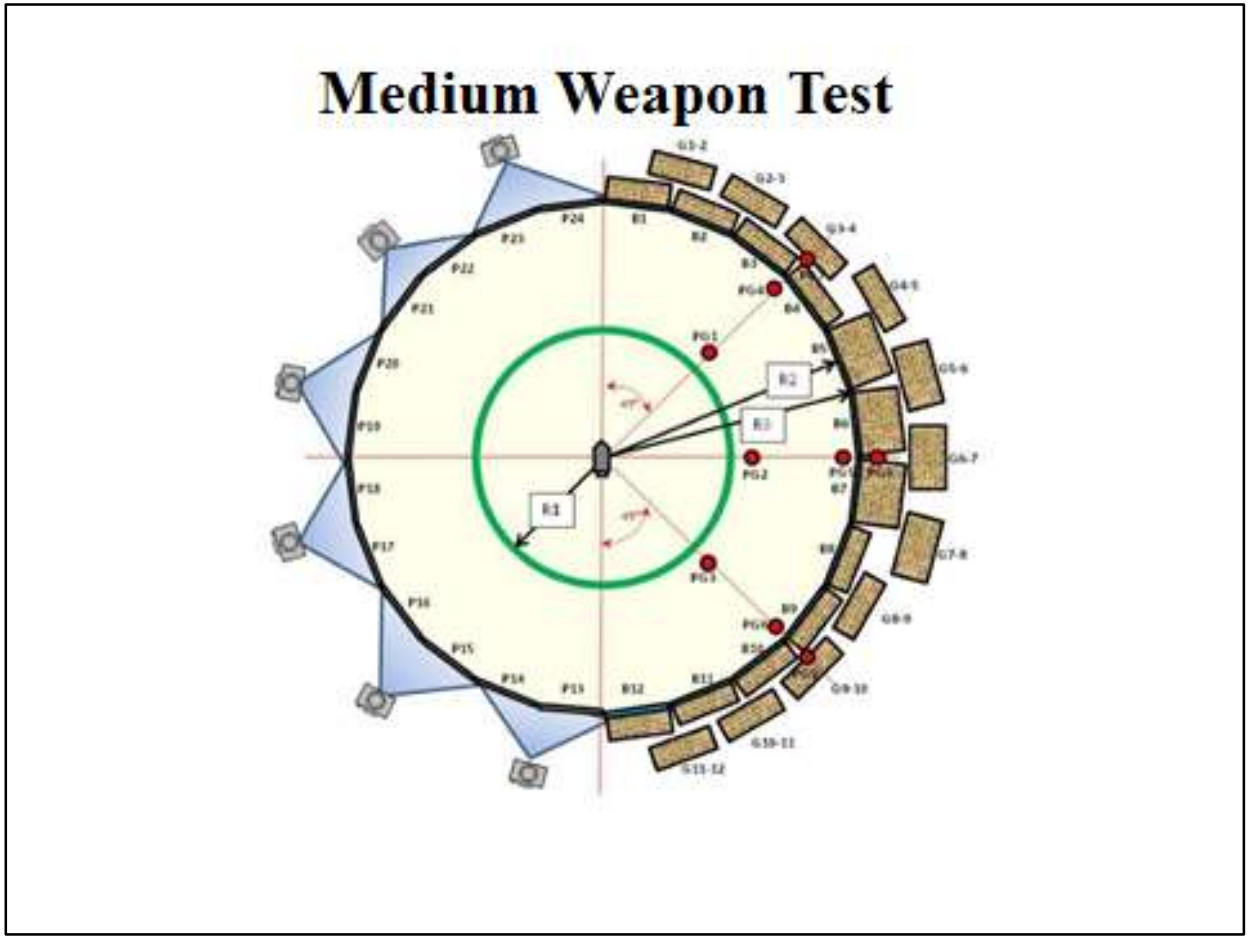

- **Medium Warhead Use Cases**
  - Based on JMEM Weapon Classes (~100 lbs. NEE)

Large Arena Test Set-up

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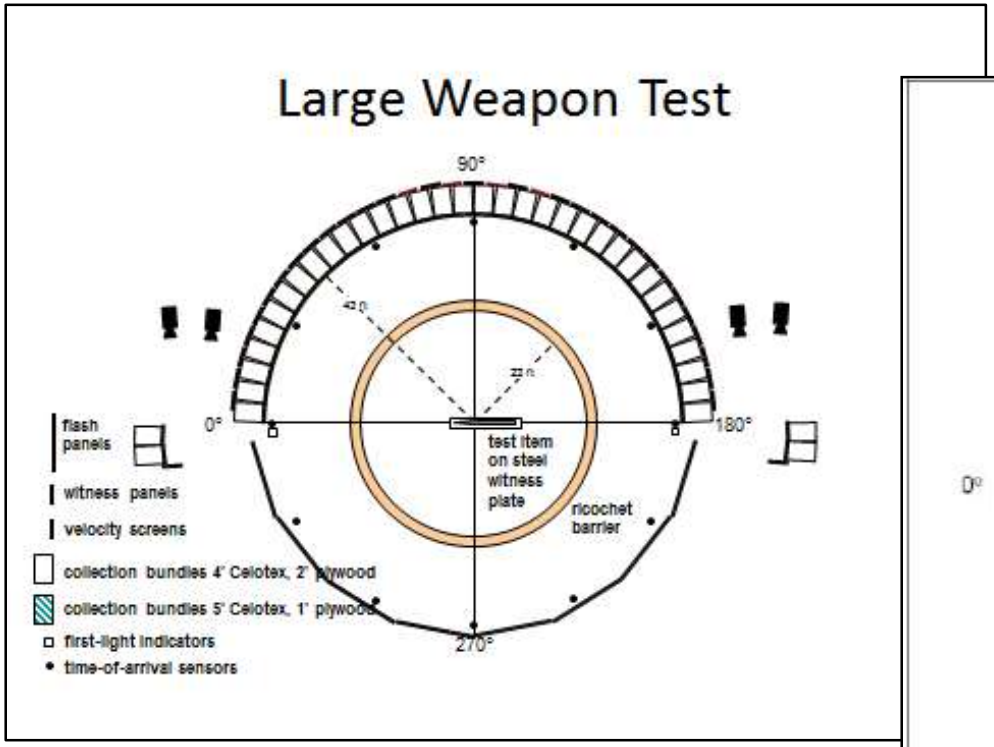

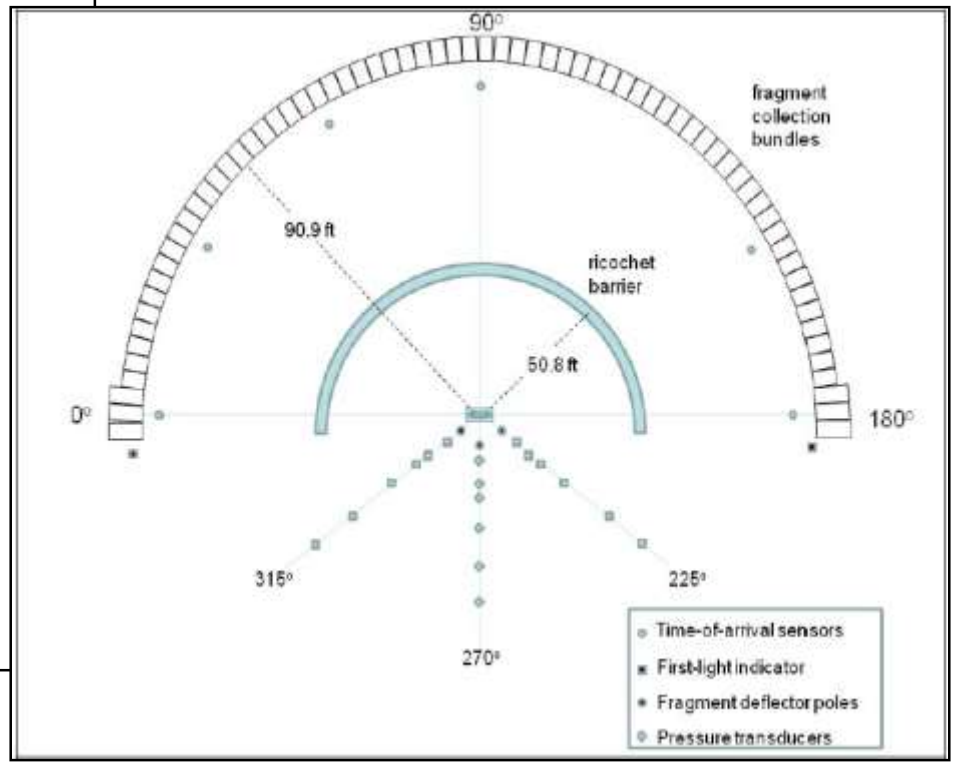

- **Large Warhead Use Cases**
  - Based on JMEM Weapon Classes (~1000 lbs. NEE)

Project Description

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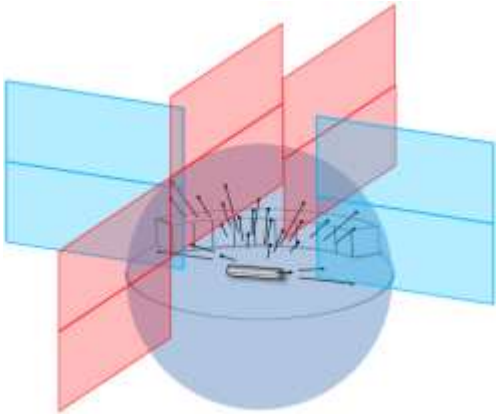
➢ Description

- Robust data collection system for arena testing
- Supports warhead fragmentation characterization, calculation of collateral damage distances, lethality



➢ Technical Objectives

- Match individual fragments to corresponding velocity vectors
- Capability to calculate individual fragment characteristics
- Reduce use of traditional capture medium

Core Capabilities To Be Developed

Capability 1	Capability 2	Capability 3
➢ More complete coverage of the arena range (33% of the blast hemisphere)	➢ Ability to correlate individual fragments to their corresponding velocities; ability to determine characteristics such as size and shape on much larger number of fragments	➢ Ability to provide unprecedented robust source data to the Weapons Effectiveness Community

Alternatives for Solution Development

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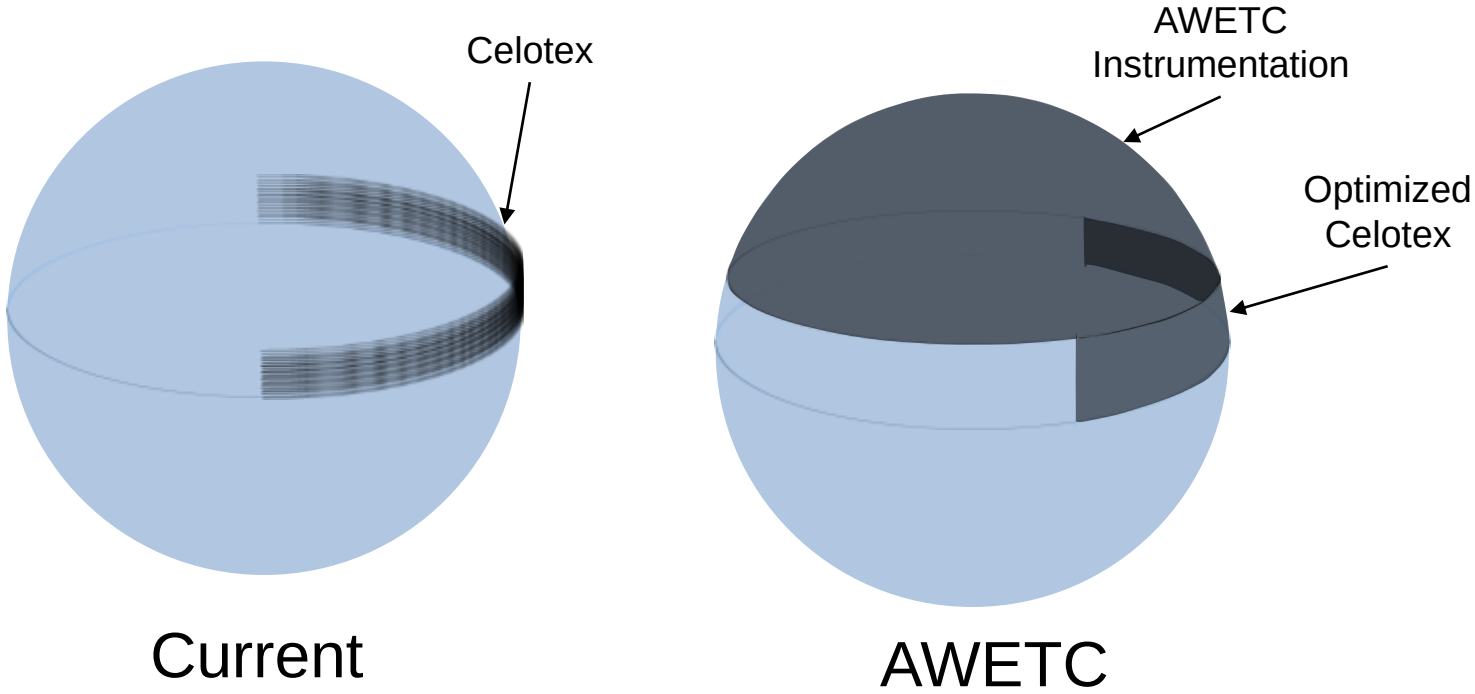
- **Radar**
  - Signal to noise ratio not favorable
  - Only large fragments (1-2 cm) can be detected
  - Large numbers of systems required for minimal capability
  - Prohibitively expensive (~$24M)

- **Acoustic and Shock Wave Detection**
  - Low TRL
  - Cannot determine fragment size
  - Imprecise location and velocity determination
  - Number of systems required and exposed to high-speed fragmentation environment drives a “disposable instrumentation” solution

- **Multi-Spectral Detection**
  - Multiple wavelength detectors show promise for the ability to look inside a fireball
  - Currently have insufficient data acquisition rates to capture data on individual fragments

- **Optical Solutions**
  - Cameras now possess sufficient resolution, frame rate, and shutter speeds
  - Algorithms now exist to process large amounts of video for determination of position over time, fragment size, and derivation of fragment mass

Coverage and Sample Size



Technology Development Efforts

- **AWETC Task: Monitor Relevant S&T and SBIR Efforts**
- **Examples:**
  - Fragment Tracking Algorithms
  - Collateral Effects – Secondary Debris
  - High Speed Stereo Shadowgraph Imaging
  - Blast Characterization: Visible and multi-band IR stereo tracking

AWETC Project Status

- **Enhanced Solutions Phase**
  - All Tasks Complete
- **Phase 0**
  - Working to Gain “New Start” Status
  - Phase 0 work includes PMP*, Acquisition Strategy
- **Coordination**
  - Will continue working with service partners
  - Will maintain connection w/FIT and JTCG/ME

* - Project Management Plan

BACK-UP

Aberdeen Test Center

- **Types of Testing**
  - Less-than-lethal grenades
  - 60/81/120mm mortars
  - 105mm and 155 artillery shells
  - Most recent testing of less-than-lethal grenades incorporating rubber balls as projectiles.
    - Requires swapping Celotex for foam board to capture “fragments”

- **Typical Arena Setup**
  - Square (12-15 feet)
  - Setup employs 6-7 cameras, mainly for velocity measurement
  - Velocity captured on opposite side of Celotex w/ cameras & modified flash panel setup

- **Typical Arena Test**
  - Majority of testing is tank rounds
    - Newest variants are generally multi-purpose (frag and penetrator.)
    - Occasionally frag packs are included with test munitions, but not common
    - Rounds are commonly scored or solid cased

Aberdeen Test Center

- **Analysis**
  - Frag Capture:
    - Celotex primary for frag capture with 8' high by 4' thick bundles
    - Fires are usually not a problem since detonation is not close enough to the bundles and/or the fragments aren't hot enough to be a hazard
  - Fragment analysis (frag picking)
    - Team is assembled under direction/careful oversight of lead fragment engineers
    - Depending upon the density of the fragment spray, bundles (4'x8'x4') can be scored at 1-2 per week or 1-2 per day
  - Velocity Measurement:
    - Frags not expected to generate a flash as they penetrate membrane
      - Flash bulbs illuminate inside arena
      - Cameras outside the measurement membrane document light coming through
      - This timing gives average velocity from the detonation
    - Membrane is typically naugahyde or paper (inside of membrane is normally coated with aluminum foil to increase amount of light seen when fragment passes through)
      - Paper allows visualization of smaller fragments
      - Significant advantage over velocity screens which must generally disregard velocity data after shock passage due to instrumentation damage

- **Primary Customers**
  - Anti-personnel analysts at Army Modeling & Simulation Analysis Agency (AMSAA)
  - Army Research Laboratory (Military Operations in Urban Terrain)

Redstone Test Center

- **Types of Testing**
  - Largely composed of small tactical missile work
  - Capability to perform testing up to and including 50 pounds of explosive equivalent
  - Large amount of sled track testing

- **Typical Arena Setup**
  - Setup is round (15 foot radius)
  - Velocity captured on opposite side of Celotex with cameras and flash panels
  - Pressure transducers used to evaluate shock for ~20% of testing
  - Typical setup uses high-speed cameras for data collection & for timing of flashes from flash panels
  - Fires in these setups are usually not a problem, since the detonation is not close enough to the bundles and/or the fragments aren't hot enough to be a hazard

- **Typical Arena Test**
  - Small tactical missile work to include Hellfire, Javelin and Longbow -- capable of performing testing up to and including 50 pounds of explosive equivalent

Redstone Test Center

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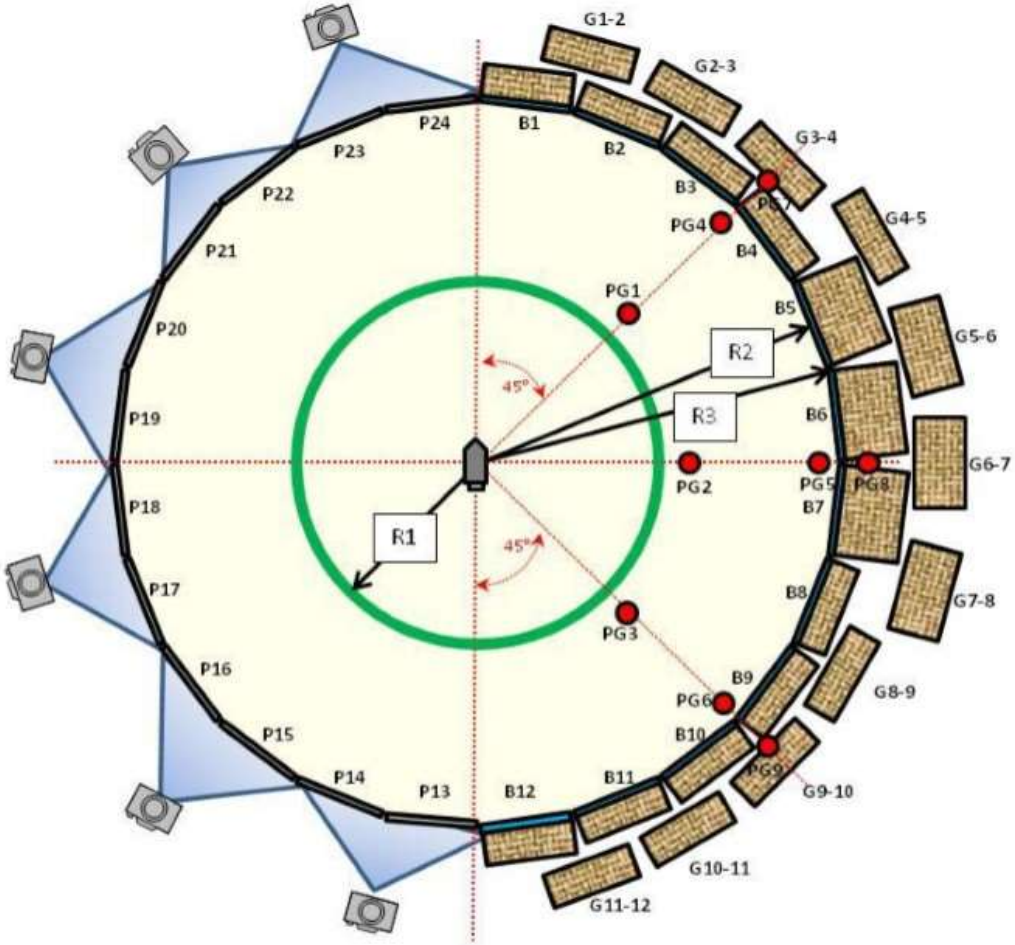

Redstone Test Center

- **Analysis**
  - Frag Capture
    - Celotex is primary for fragment capture with 8’ high by 4’ thick bundles
  - Fragment analysis (frag picking)
    - Team assembled under direction/careful oversight of lead fragment engineers
    - Frag picking and data analysis are done by the customers (MSIC and AMRDEC, using Dynetics as contract support)
  - Velocity Measurement:
    - Velocity captured on opposite side of Celotex with cameras and flash panels
    - Flash panels are 1/15” to 1/8” steel or aluminum
    - As with flash panels in other locations, this yields average velocity per polar zone

- **Primary Customers**
  - Primary consumers//MSIC and AMRDEC, using Dynetics as contract support

China Lake

- **Types of Testing**
  - Testing of any size munition up to #2000, but recent work has been primarily AIM-9 warheads (difference between Dahlgren & CL is that Dahlgren primarily handles shipborne gun munitions)
  - Analysis group also evaluates dynamic testing data from sled tracks

- **Typical Arena Setup**
  - Setup is round (10-50' radius)
  - Celotex is primary for fragment capture 8' high by 4' thick bundles
  - Occasionally, setups will include bundles up to 12' in height
  - Horizontal weapon tests are typically half Celotex and half flash panels, while verticals are 1/3 Celotex, 1/3 flash panel and 1/3 pressure transducers
  - China Lake and Eglin have been the only sites that assess the strength and movement of the blast shock--China Lake does not typically take temperature data during arena tests
  - Velocity captured using cameras and flash panels, much the same way as Redstone and Eglin
  - Some tests use a spiral flash panel setup to get a better look at how fragment velocities change at different ranges from the blast
    - Relies on symmetry of blast, as no single fragment is tracked
    - Timing derived from flash panel instrumentation is consolidated into average velocity from the detonation for z-data file input
    - High speed cameras used to observe flashes and aid in determining average velocities

Eglin AFB

- **Types of Testing**
  - Testing of any size munition up to 3,000 NEE
    - Will go larger by exception

- **Typical Arena Setup**
  - Setup is round and 20’ - 80’ radius
    - Less than 20’ normally square
  - Celotex is primary for fragment capture 16’ high by 4’ thick bundles with 2” of plywood behind
    - Supported by steel racks
  - Horizontal weapon tests are typically 180° Celotex (no flash panels)
  - Vertical weapon tests are typically 90° Celotex (no flash panels & generally no pressure transducers unless specifically requested)
  - Normally use velocity screens (VALTS)
    - No flash panels unless specifically requested by customer
  - China Lake & Eglin have been the only sites that assess strength/movement of the blast shock

- Typical Arena Test
  - Recent work has been primarily MK-82-size weapons

Eglin AFB

- Analysis
  - Done similarly to other services' arenas
  - Frag Capture
    - Celotex is primary for fragment capture
    - 16' high by 4' thick bundles with 2' plywood backing (on steel stands)
  - Fragment analysis (frag picking)
    - Team assembled under direction/careful oversight of lead fragment engineer
    - Frag retrieval capacity = 6 to 7 bundles per day, per crew (2 crews)
      - High density frags = 2 to 3 bundles per week, per crew (2 crews)
  - Velocity Measurement
    - Velocity captured on opposite side of Celotex with cameras and flash panels
    - Flash panels are 1/15" to 1/8" steel or aluminum
    - As with flash panels in other locations, this yields average velocity per polar zone

- **Primary Customers**
  - Weapon Programs

Key Performance Parameters

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Key Performance Parameter (KPP)	Threshold	Objective
1. Fragment Tracking	Minimum Fragment Size of Interest: 7 mm (large weapon test) matched to individual velocity 5 mm (medium weapon test) matched to individual velocity 2 mm (small weapon test) matched to individual velocity	2 mm (all arena / weapon sizes) matched to individual velocity
2. Fragment Velocity	Up to 6000 fps	Up to 8,000 fps
3. Fragment 3D Position Error	+/- 4% of distance from point of detonation to fragment measurement point	+/- 2% of distance from point of detonation to fragment measurement point
4. Arena Coverage	33% of the upper hemisphere	50% of the upper hemisphere