



# AAAV 30mm HE Lethality Testing



*Test procedures and casualty models*

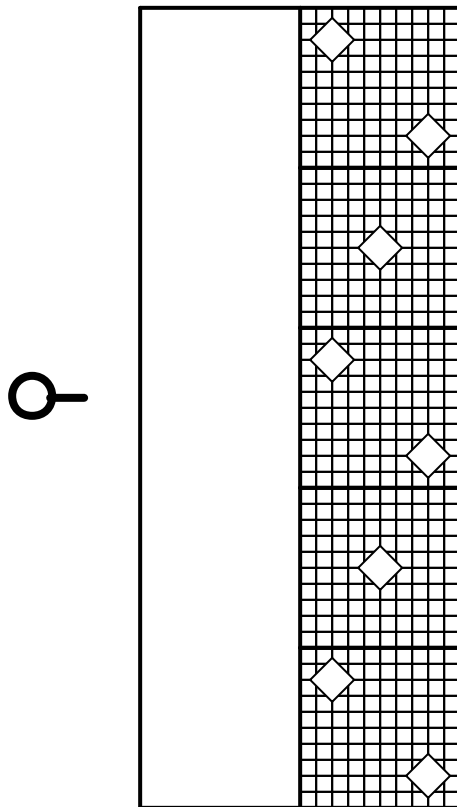


# Outline

- Target
- Test Objectives
- Test Set-up
- Models Used
  - JMEM
  - ComputerMan
  - ORCA
- Data Collection
- Model Results
- Data Evaluation and Results
- Summary



# AAAV ORD Infantry Target



- Eight man infantry squad on line
- Infantry deployed in 10 x 50 meter area, with preceding 10 x 50 meters as part of target area
- Range 1500 meters



# Test Objective

Determine the most effective high explosive round  
or combination of rounds  
against the AAAV ORD Infantry target



# Test Ammunition

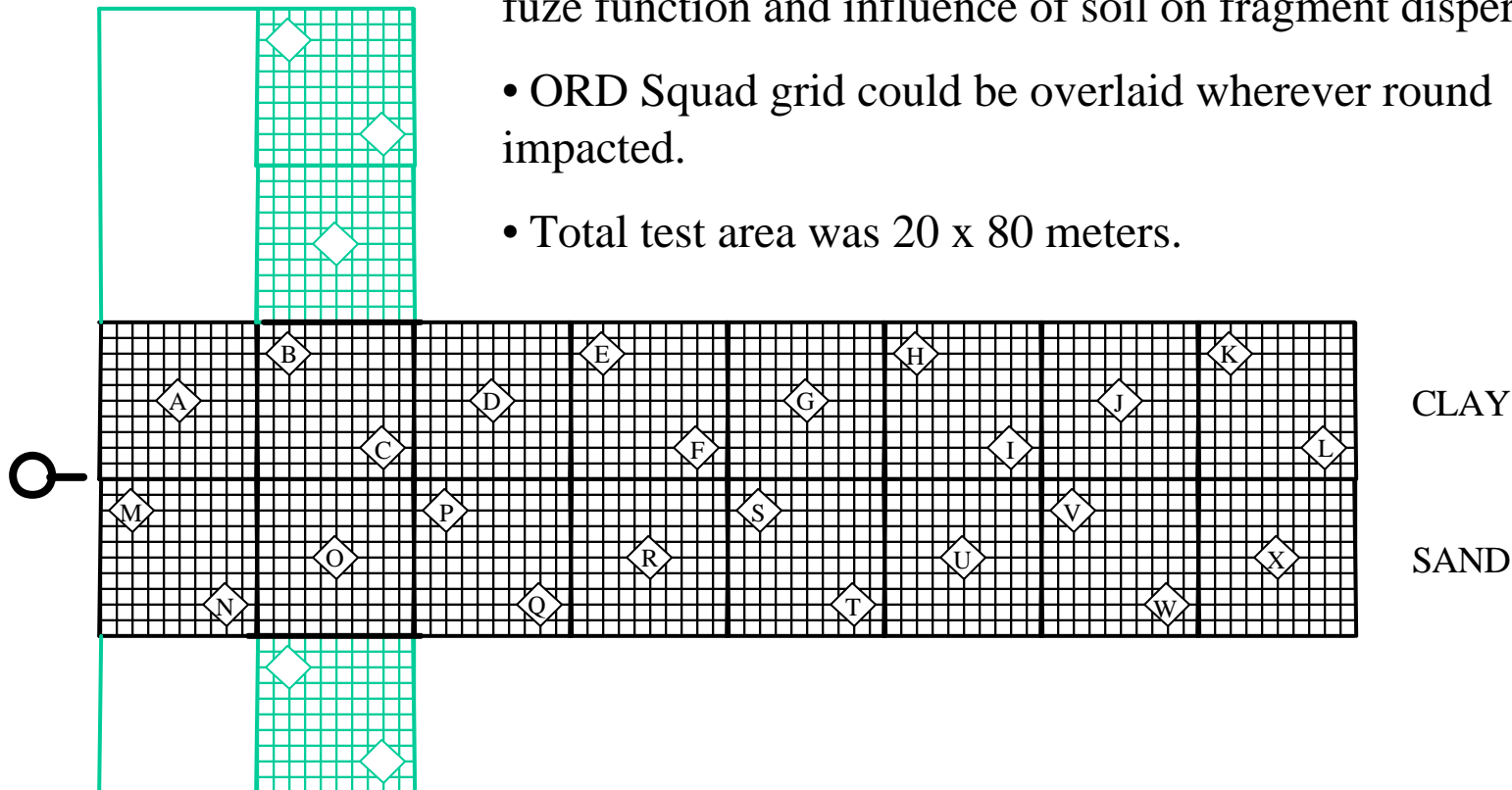


Tested eight different types of HE rounds or combination of rounds



# Test Set-up

- 20 meter wide section of squad stacked in depth to increase probability of round impact within test area.
- Left column on hard clay road, right column in soft sand. Goal was equal number of rounds in each column, evaluate fuze function and influence of soil on fragment dispersion.
- ORD Squad grid could be overlaid wherever round impacted.
- Total test area was 20 x 80 meters.





# Test Mannequins



- Ballistic mannequins constructed of 7-ply marine grade plywood.
- Each mannequin equipped with Kevlar PASGT vest and helmet.



# Three Models – Three Flavors



- **Dummy General**
  - Produces JMEM Result
  - Expected Level of Incapacitation given a hit or series of hits
  - Averaged result for a gross anatomical part
  - Preprocessor for ComputerMan and ORCA
- **ComputerMan**
  - Produces a Probability of a Level of Incapacitation for a given tactical scenario at a certain post-injury time
  - Relies on post-injury Limb State/Limb Incapacitation
- **ORCA**
  - Compares insult severity to ability to accomplish certain defined tasks
  - Weighed Task Average provides a ratio of tasks that can be completed versus the total number of tasks to be completed



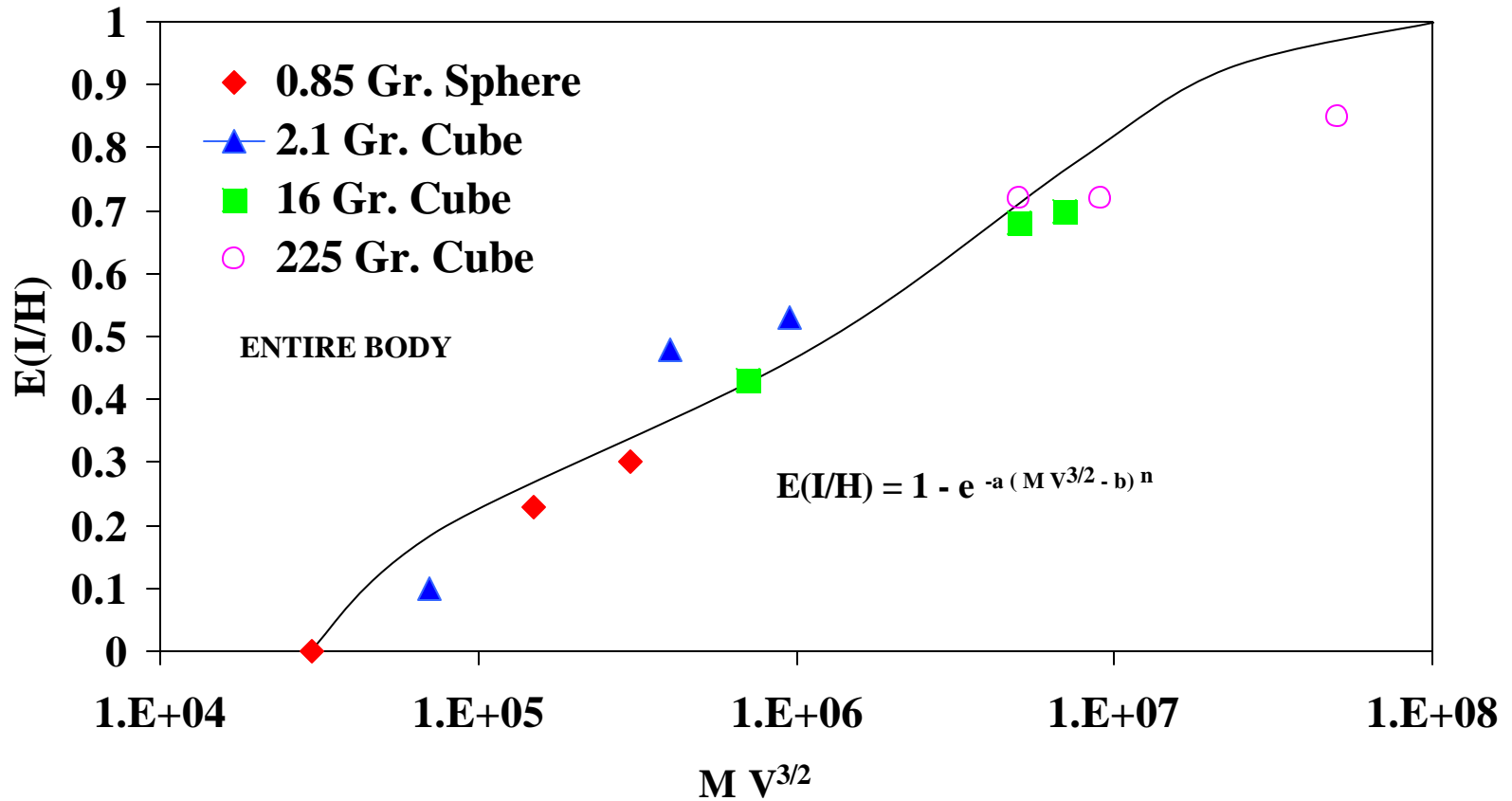


# Dummy General (DumGen)

- Calculates fragment mass and striking velocity
- JMEM Result for both Assault 5 minute & Supply 12 hour tactical role
- Each strike produces an averaged result over an entire body section
- Output is an accumulated result for all strikes on target



# The Incapacitating Effects of Fragment Impacts (Kokinakis & Sperrazza, c. 1965)





# ComputerMan Model

- Discrete shot-line resolution compared to JMEM averaged result
- Detailed anatomical geometry
- Penetration insult only
- Probability of a level of incapacitation for a given tactical scenario
- Requires fragment mass, striking velocity & location
- Requires azimuth and elevation angles for each fragment strike
- Some interpretation required to translate strike location from mannequin to model



# ComputerMan Screenshots

ComputerMan PC v1.0

File View Tools Help

Two Points  
 One Point and Angle

Entrance Point (mm): 331 235 1334

Azimuth and Elevation (deg): 30 10

Radius of Uncertainty (mm): 38

OUTPUT FILENAMES

STDOUT No: StdOut.txt

STDERR No: StdErr.txt

Overwrite if exist

Process Shot

Corrupt All Shots

RIGHT FRONT LEFT

x = 298 y = 245 z = 1284 section = 28

Rotate x Rotate y

Ready

results\_s3lms\_120500.txt - Notepad

File Edit Format Help

Total number of shots: 1

Post-wounding Time Probability of Incapacitation for Assault role for given Performance Degradation

Post-wounding Time	0 %	25 %	50 %	75 %	100 %
30 sec	0.167	0.000	0.083	0.750	0.000
5 min	0.083	0.000	0.083	0.833	0.000
30 min	0.083	0.000	0.083	0.500	0.333
12 hrs	0.083	0.000	0.083	0.833	0.000
24 hrs	0.167	0.000	0.083	0.750	0.000
5 days	0.167	0.000	0.083	0.750	0.000

Post-wounding Time Probability of Incapacitation for Defense Role for given Performance Degradation

Post-wounding Time	0 %	25 %	50 %	75 %	100 %
30 sec	0.167	0.083	0.000	0.750	0.000
5 min	0.083	0.167	0.000	0.750	0.000
30 min	0.083	0.083	0.000	0.833	0.000
12 hrs	0.083	0.167	0.000	0.750	0.000
24 hrs	0.167	0.083	0.000	0.750	0.000
5 days	0.167	0.083	0.000	0.750	0.000

Post-wounding Time Probability of Incapacitation for Reserve Role for given Performance Degradation

Post-wounding Time	0 %	25 %	50 %	75 %	100 %
30 sec	0.167	0.000	0.000	0.083	0.750
5 min	0.083	0.000	0.000	0.083	0.833
30 min	0.083	0.000	0.000	0.083	0.833
12 hrs	0.083	0.000	0.000	0.083	0.833
24 hrs	0.167	0.000	0.000	0.083	0.750
5 days	0.167	0.000	0.000	0.083	0.750

Post-wounding Time Probability of Incapacitation for supply role for given Performance Degradation

Post-wounding Time	0 %	25 %	50 %	75 %	100 %
30 sec	0.167	0.083	0.000	0.750	0.000
5 min	0.083	0.083	0.083	0.750	0.000
30 min	0.083	0.083	0.000	0.500	0.333
12 hrs	0.083	0.083	0.083	0.750	0.000
24 hrs	0.167	0.083	0.000	0.750	0.000
5 days	0.167	0.083	0.000	0.750	0.000

Survival Probability (using AP): 0.983

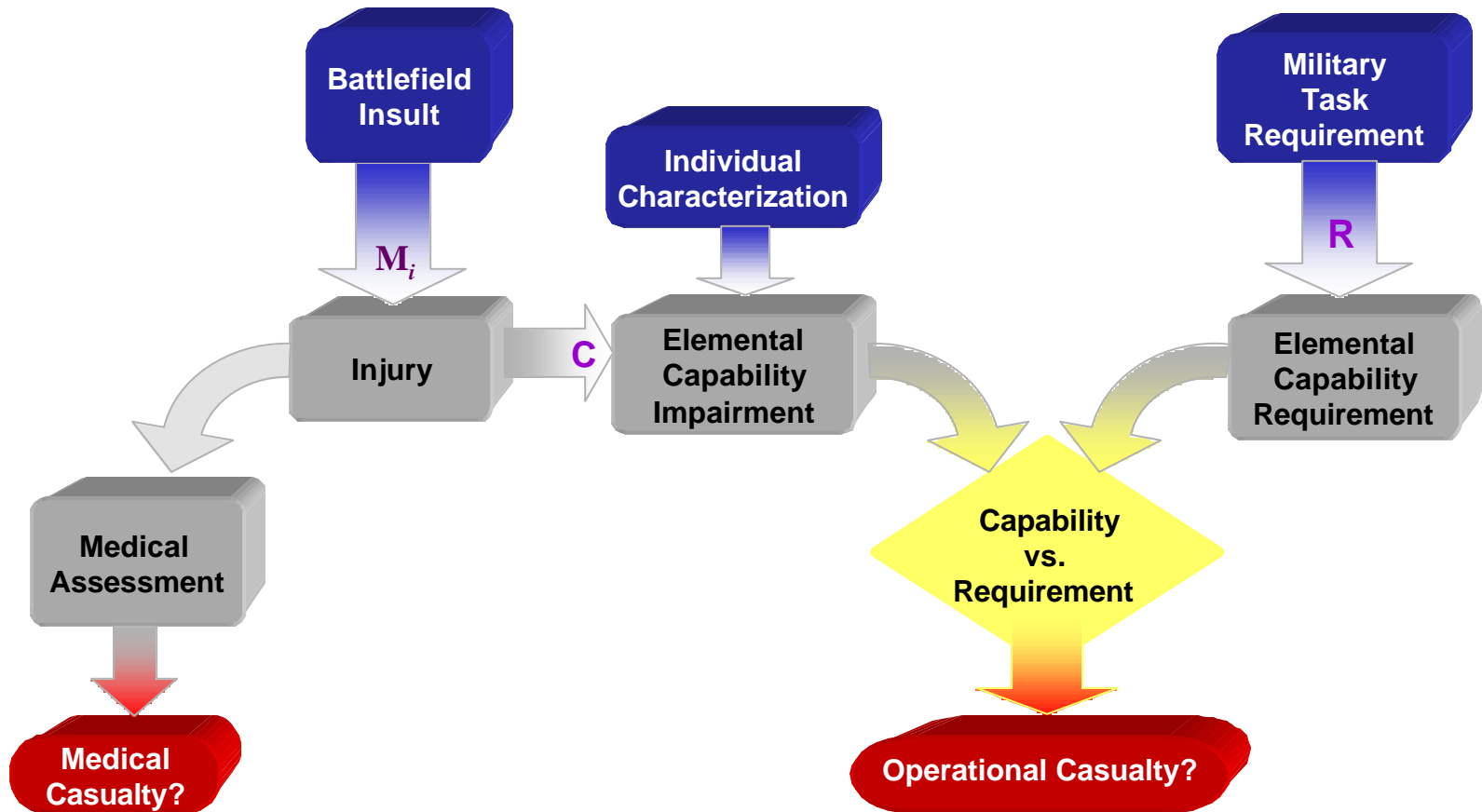


# Operational Requirement-based Casualty Assessment Model (ORCA)

- Numerous injuries (insults) addressed
- Strong reliance on adaptation of existing models
- Requires same inputs as ComputerMan
- Uses same anatomical geometry and shot-line convention as ComputerMan
- ORCA requires job definition of target (Infantry Rifleman)



# ORCA Casualty Assessment Methodology





# ORCA Screenshots

ORCA Version 2.34 Jan 09 1999

**CURRENT STATUS**  
 Insult: Penetration Operational Requirement: Infantry Rifleman  
 Injury: Computed Individual: Default

Insult Type Display Injury Individual Characteristics Operational Requirement Assess Casualty Control Help

Penetration Version 2.34 Jan 09 1999

Input ComputerMan Data BACK RIGHT FRONT

Projectile Properties  
 Mass: 15.0 grains  
 15.0  
 Velocity: User Def 1000  
 Density (gm/cc): 7.8  
 Shape Factor: 1.50  
 1.5

Soldier Properties  
 Position: Crouching

Processing Modes:  
 Single Shot Grid Run Point-Burst Shot

Process Single Shot

Close Help

Rotate X Rotate Y Rot

x = 9998 y = -721 z = 1046 section = -

**SINGLE SHOT**

Two Points  
 One Point and Angles

Entrance Point (mm): 360 160 727  
 Exit Point (mm): 346 10 676

Close Previous Coordinates

Assessment Summary Version 2.34 Jan 10 1999

Job : Infantry Rifleman

	Initial	Immed.	30 sec.	5 min.	1 hour	24 hours	72 hours
Job Performance	1.00	0.00	0.48	0.48	0.32	0.32	0.32
Weighted Task Average	1.00	0.52	0.97	0.93	0.87	0.87	0.87

Close Help

**RESULTS**

Elemental Capabilities	Requirement		Capabilities							
	Full Perf.	Min Perf.	Initial	Immed.	30 sec.	5 min.	1 hour	24 hours	72 hours	
Acuity and Color Discrimination	3.0	2.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Night Vision	3.0	2.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Visual Field of View	3.0	2.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Disorientation and Mobility	3.0	2.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Threshold: Low Frequency	4.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Threshold: High Frequency	4.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Blindness	5.0	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Scientific Smells	5.0	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Balistic	2.0	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Cognitive Mental Processing	7.0	5.2	7.0	6.5	6.5	6.5	5.8	5.8	5.8	
Visual Mental Processing	7.0	5.2	7.0	6.5	7.0	7.0	6.5	6.5	6.5	
Auditory Mental Processing	6.5	4.8	7.0	6.5	7.0	7.0	6.5	6.5	6.5	
Psychomotor Mental Processing	7.0	5.2	7.0	6.5	6.5	6.5	5.8	5.8	5.8	
Speech Intelligibility/Vocal Clarity	4.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Background Noise/Vocal Power	3.0	2.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Leg Strength	3.0 L	3.0 L	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Leg Strength	5.0 R	3.0 R	5.0	4.4	4.4	4.4	4.7	4.7	4.7	
Arm/Wrist Strength	5.0 L	3.0 L	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Arm/Wrist Strength	5.0 R	3.0 R	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Arm/Hand Dexterity	3.0 L	2.2 L	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Arm/Hand Dexterity	3.0 R	2.2 R	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Trunk Support	2.0	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Head/Neck Movement	5.0	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Endurance	5.0	3.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	

Color Code: ■ = capability below need ■ = capability below rat

3 = Strong W = Weak L = Left R = Right

Close View Summary View Tasks View Casualty Task Elements Restore Job Help



# Data Required for Models

- Fragment impact (strike) location on mannequin
- Shot-line Information
- Fragment mass





# Data Collection

- Fragment Impact Locator sheet
- Strike Logging
- Fragment Data Collection
- Shot-line Information
- Photographic Record
- Hierarchical bagging system

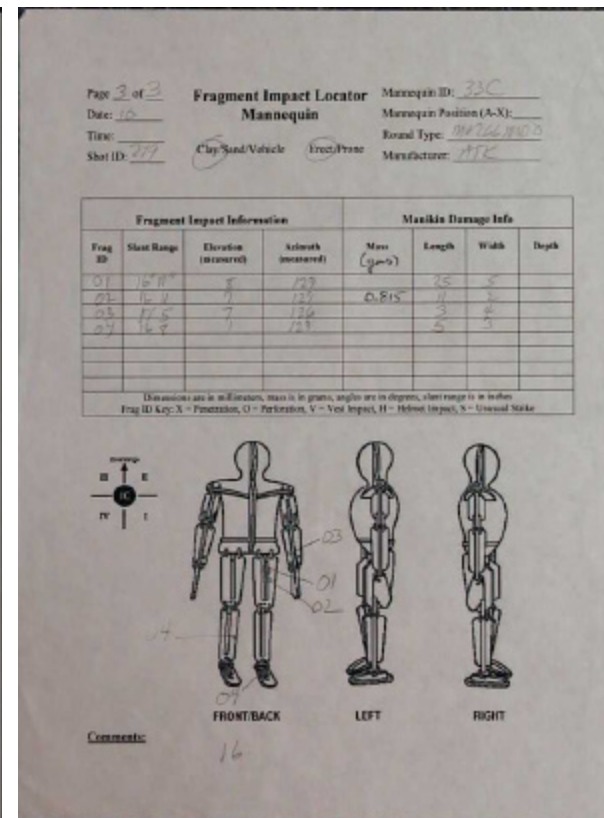
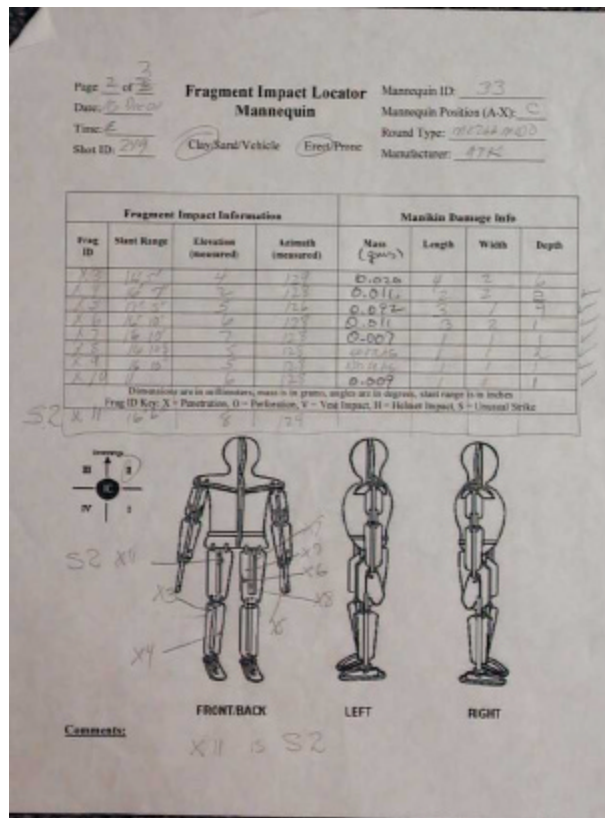
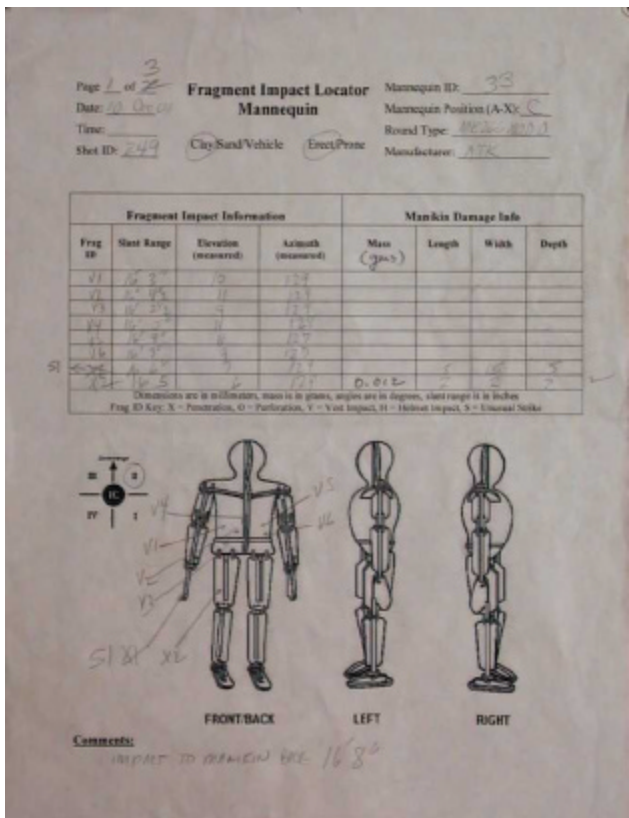


# Data Collection (cont.)





# Representative Model Results – Field Data



Shot 249, Position C, Mannequin 33



# Conversion from Field Data to Model Input

- Determine gross anatomical part affected (DumGen)
- Calculate striking velocity (DumGen)
- Calculate fragment mass if required (DumGen)
- Determine entrance point of fragment (ComputerMan and ORCA)
- Convert measured Azimuth and Elevation angles to model angle convention (ComputerMan and ORCA)



## Model Outputs and Filter Process

- Selected specific model outputs to incorporate in analysis
- Focus on 5 minute timeframe, Assault tactical role (ORCA: Infantry Rifleman job)
- JMEM result is in proper “format”
- ComputerMan results for 5 minute Assault role broken down into two probability values
- ORCA 5 minute Weighed Task Average inverted to a measure of “incapacity”



## Representative Model Results Shot 249, Position C, Mannequin 33

DUMGEN Preprocessor JMEM Results	
Assault 5 min E(I/H)	Supply 12 hour E(I/H)
<b>0.95</b>	<b>0.92</b>

ORCA RESULTS	Initial	Immediate	30 sec	5 min	1 hour	24 hours	72 hours
Job Performance	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Weighed Task Average	1.00	0.04	0.08	<b>0.06</b>	0.03	0.03	0.03



# Representative Model Results

## Shot 249, Position C, Mannequin 33 (cont.)

<b>ComputerMan Results</b>					
Post-Wounding Time	Probability of Incapacitation for Assault Role for given Performance Degradation				
Time	0%	25%	50%	75%	100%
-----	-----	-----	-----	-----	-----
30 sec	0.191	0.000	0.628	0.167	0.014
<b>5 min</b>	<b>0.111</b>	<b>0.000</b>	<b>0.303</b>	<b>0.272</b>	<b>0.314</b>
30 min	0.084	0.000	0.227	0.204	0.485
12 hrs	0.032	0.000	0.200	0.305	0.463
24 hrs	0.064	0.000	0.400	0.337	0.199
5 days	0.064	0.000	0.400	0.337	0.199



## Representative Model Results

### Shot 249, Position C, Mannequin 33 - Filtered

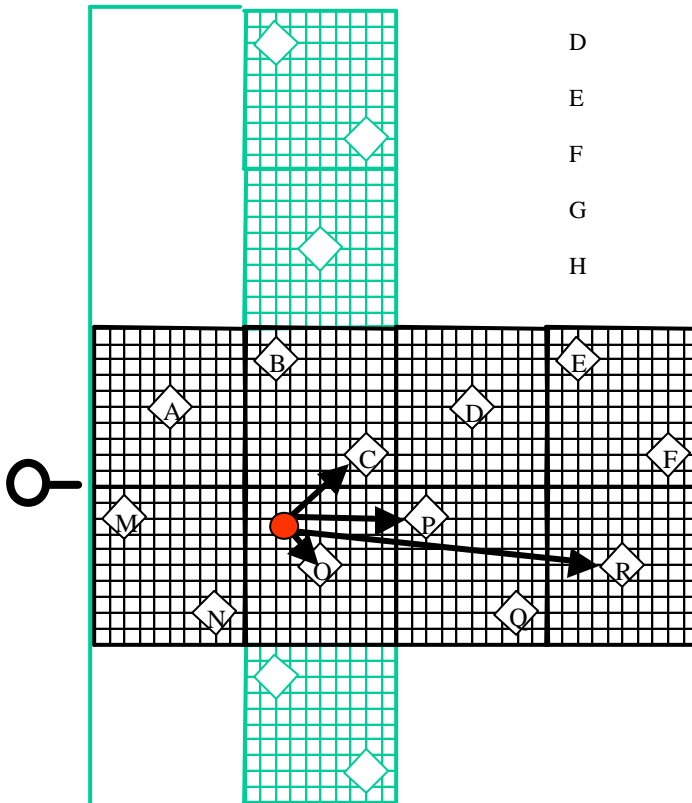
<b>JMEM Assault 5 min E(I/H)</b>	<b>ComputerMan Assault 5 min p(25%+)</b>	<b>ComputerMan Assault 5 min p(75%+)</b>	<b>ORCA 5 minute 1-WTA</b>
<b>0.95</b>	<b>0.889</b>	<b>0.586</b>	<b>0.94</b>





# Data Evaluation Examples

Round	ave per	JMEM	Cman.25+	Cman.75+	ORCA 1-WTA
A	2.3	0.495	0.454	0.353	0.508
B	1.66	0.547	0.442	0.339	0.434
C	2.6	0.485	0.439	0.365	0.365
D	1.9	0.353	0.320	0.201	0.256
E	1.75	0.456	0.434	0.277	0.343
F	1.5	0.492	0.433	0.400	0.183
G	1.92	0.463	0.435	0.301	0.349
H	1.71	0.461	0.434	0.295	0.320

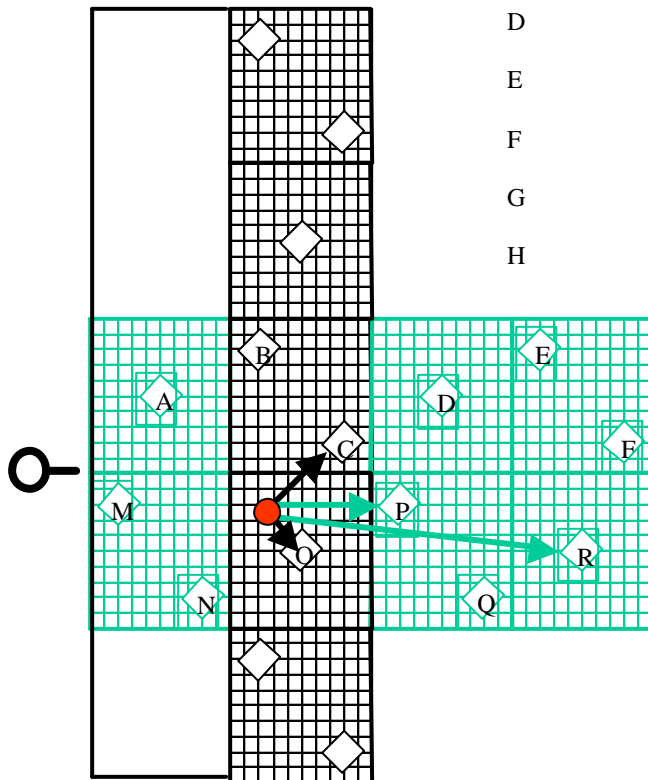


All mannequins hit, regardless of whether they would have been in the squad or not



# Data Evaluation Examples

Round	ave per	JMEM	Cman.25+	Cman.75+	ORCA 1-WTA
A	0.666	0.339	0.403	0.349	0.482
B	0.333	0.27	0.292	0.292	0.32
C	0.20	0.172	0.106	0.056	0.006
D	0.857	0.346	0.353	0.234	0.249
E	1	0.573	0.549	0.384	0.378
F	0.25	0.223	0.188	0.188	0.083
G	0.84	0.493	0.46	0.318	0.304
H	0.875	0.515	0.489	0.351	0.329

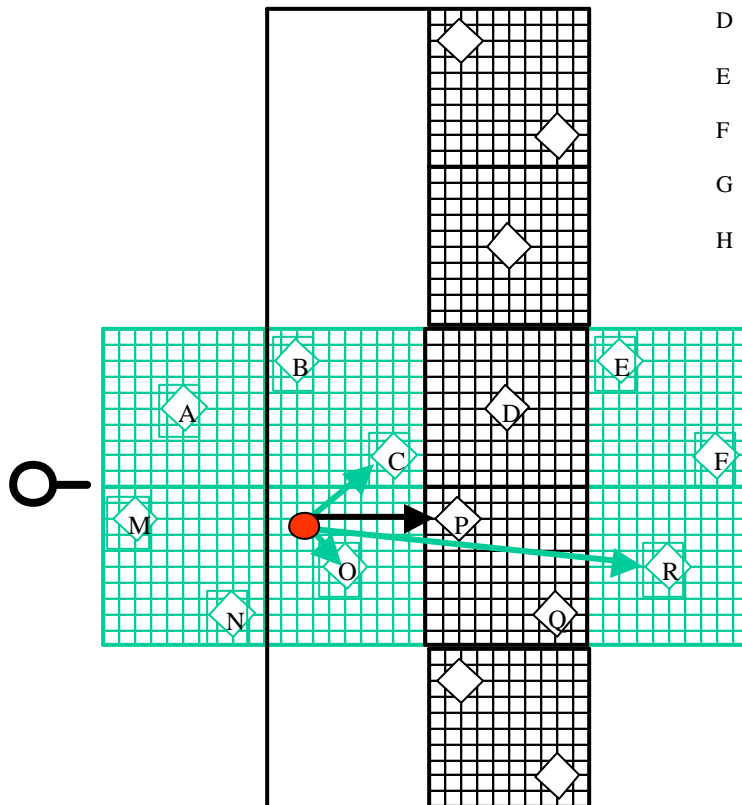


Only mannequins hit that would have been in squad area



# Data Evaluation Examples

Round	ave per	JMEM	Cman.25+	Cman.75+	ORCA 1-WTA
A	1.16	0.65	0.611	0.273	0.404
B	1.16	0.65	0.611	0.273	0.404
C	1.2	0.750	0.716	0.650	0.552
D	0.857	0.234	0.174	0.101	0.155
E	0.70	0.211	0.167	0.080	0.193
F	1	0.370	0.438	0.396	0.170
G	0.8	0.319	0.277	0.194	0.265
H	0.75	0.238	0.212	0.133	0.189



Only mannequins hit that would have been in squad area had the round impact in the 20 meters preceding the squad



# Ranking and Scoring Example

Round	ave per		JMEM		Cman.25+		Cman.75+		ORCA 1-WTA		Score/ Rank
A	2.3	2	0.495	2	0.454	1	0.353	3	0.508	1	1.8/ 1
B	1.66	7	0.547	1	0.442	2	0.339	4	0.434	2	3.2/ 3
C	2.6	1	0.485	4	0.439	3	0.365	2	0.365	3	2.6/ 2
D	1.9	4	0.353	8	0.320	7	0.201	8	0.256	7	6.8/ 7
E	1.75	5	0.456	7	0.434	5	0.277	7	0.343	5	5.8/ 6
F	1.5	8	0.492	3	0.433	6	0.400	1	0.183	8	5.2/ 5
G	1.92	3	0.463	5	0.435	4	0.301	5	0.349	4	4.2/ 4
H	1.71	6	0.461	6	0.434	5	0.295	6	0.320	6	5.8/ 6



# Data Evaluation Results

All evaluation categories

	SECT 1	SECT 2	SECT 3	SECT 4	SECT 5	SECT 6	SECT 7	SECT 8	SECT 9	SECT 10	SECT 11	SECT 12	SECT 13	SECT 14	SECT 15	1 TO 15	8 TO 10		
ROUND	ALL	A MANN	A LETH	B MANN	B LETH	A+B MA	A+B LE	A ADJ	B ADJ	A+B AD	P 90	P 70	D 90	D70	D AVE	AVE	B-P	AVE	I-K
A RANK	1	3	3	2	2	2	1	3	1	1	3	2	2	2	2	2	2	1.66	
A SCORE	1.8	3.6	3.6	2.4	2.2	2.6	1.6	3.2	1.2	1.4	2.25	2.5	3	2	2	2.36	1.93		
B RANK	3	1	6	2	2	3	2	5	1	2	2	1	3	4	4	2.73	2.66		
B SCORE	3.2	2.2	5.4	2.4	2.2	3	3.2	5.2	1.2	2.4	2	1.75	3.6	4.2	4	3.06	2.93		
C RANK	2	6	8	1	1	1	3	8	6	8	1	3	1	1	1	3.4	7.33		
C SCORE	2.6	5.8	8	1	1	1.8	3.4	8	5.4	8	1.75	4.25	1	1	1	3.6	7.13		
D RANK	7	7	5	6	6	8	7	4	4	5	7	7	4	5	5	5.8	4.33		
D SCORE	6.8	7	4.8	5.4	5.8	7	6.6	3.8	4.2	4.4	7.25	7.25	4.2	4.4	5	5.59	4.13		
E RANK	6	5	1	7	7	7	5	1	5	3	5	6	7	6	8	5.26	3		
E SCORE	5.8	5	1.2	5.6	6.4	6.2	4.6	1.2	5.2	3.4	5.5	5.25	6.4	6.4	8	5.08	3.26		
F RANK	5	2	7	4	3	5	7	7	2	6	6	3	5	6	3	4.73	5		
F SCORE	5.2	3.2	7	3.8	3.4	5	6.6	7	3	5.8	7	4.25	5.6	6.4	3	5.09	5.26		
G RANK	4	4	4	3	4	4	4	6	6	7	4	5	2	3	6	3.73	6.33		
G SCORE	4.2	4.8	3.8	3.2	4	4.4	4.2	5.4	5.4	6.6	4	5	3	3.6	6	4.5	5.8		
H RANK	6	3	2	5	5	6	6	2	3	4	5	4	6	6	7	4.66	3		
H SCORE	5.8	3.6	2.2	4.8	5.2	6	5.8	2.2	3.6	4	5.5	4.75	5.8	6.4	7	4.85	3.26		



# Data Evaluation Results

All evaluation categories by model

	B-O AVE	1 TO 14				I-K AVE	8 TO 10				
	JMEM	CM.25+	CM.75+	ORCA 1-WTA		JMEM	CM.25+	CM.75+	ORCA 1-WTA		
ROUND											ROUND
<b>A</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>		<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>		<b>A</b>
	2.643	2.5	2.786	1.357		2	2.333	2	1		
<b>B</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>2</b>		<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>		<b>B</b>
	2.5	2.786	3.214	2.571		3	2.666	2.666	2.333		
<b>C</b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>		<b>7</b>	<b>8</b>	<b>8</b>	<b>7</b>		<b>C</b>
	3.5	3.786	3.429	4.143		7.666	6.666	6.333	7.333		
<b>D</b>	<b>8</b>	<b>7</b>	<b>8</b>	<b>7</b>		<b>4</b>	<b>5</b>	<b>6</b>	<b>4</b>		<b>D</b>
	6.071	6.214	6.571	6.071		3.666	4.333	5.666	5		
<b>E</b>	<b>6</b>	<b>6</b>	<b>7</b>	<b>3</b>		<b>2</b>	<b>4</b>	<b>5</b>	<b>2</b>		<b>E</b>
	4.857	5.857	5.929	4.071		3	3.666	4.333	2.333		
<b>F</b>	<b>7</b>	<b>4</b>	<b>3</b>	<b>8</b>		<b>5</b>	<b>6</b>	<b>4</b>	<b>6</b>		<b>F</b>
	5.429	4.5	3.286	7.143		5.333	5	3.666	7		
<b>G</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>5</b>		<b>6</b>	<b>7</b>	<b>7</b>	<b>5</b>		<b>G</b>
	4.286	4.714	4.571	4.143		5.666	6	6	5.333		
<b>H</b>	<b>5</b>	<b>4</b>	<b>6</b>	<b>6</b>		<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>		<b>H</b>
	4.786	4.5	4.786	5.143		3.333	3	3.333	3.333		



# Summary

- Three models – three flavors of results
- Some conversion/translation required
- Focus on specific outputs
- Test objective met



# Questions?

