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3DPIMMS – HIGH DETAIL EFFECTIVENESS CALCULATION FROM COLLECTED THREE-DIMENSIONAL FRAGMENT DISPERSION DATA

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ABSTRACT

Current accredited assessment techniques for incapacitation of soldiers from missile or warhead test consist primarily of two-dimensional statistical approaches. However, new test techniques have captured the three dimensional locations of fragment impact in structures of interest. This data along with blast, and temperature data in the past could not be utilized to support the system effectiveness of the proposed munition. This paper will cover the creation of a high resolution 3D many-on-many simulation methodology which allows new high detail test data to enter the system effectiveness calculations. The Verification and Validation of this methodology will be covered along with extensions utilizing new personnel injury codes being introduced by the JTCG/ME. The migration of this code to the Windows/Intel computing environment to support performance simulation studies will also be discussed. This methodology allows missile system developers to be credited with all of the effects from their warhead subsystem. Effectiveness simulations that limit the data collection to only primary lethal mechanisms shortchange innovative and low cost approaches to meet technical system performance specifications. In today's cost driven environment, the yardsticks of performance evaluation must not limit innovative approaches.

INTRODUCTION

The current accredited methodologies being utilized for evaluation of the performance of soldier fired munitions against masonry structures, concrete structures or earth and timber bunkers, utilize data that disregards the true spatial aspect of fragment dispersion. Instead the code, PIMMS (Probability of Incapacitation Methodology for Masonry Structures) utilizes a fragment per steradian input that is calculated for 5 degree zones drawn around the munition burst point. Input requirements are structural geometry and fragmentation density data that characterize munition fragmentation and structural debris patterns. The program outputs are probabilities of incapacitation for a random man location, a two man firing position and designated sniper positions in the structure.

The PIMMS methodology assumes the room is filled with 100 possible men locations for each attack scenario. A cylinder of a specified diameter and height provide a vertical cross-sectional area which is used to represent each man. A set of burst points at designated intervals along the entry wall are evaluated to represent a wall attack using an impact fuzed munition. A matrix of burst points covering the entire room at specified intervals is used to evaluate a delay fuzed munition. This model assumes that the delay fuzed munitions fragments could emanate from any given location in the room. Fragment data referenced to the burst point are input in 5 degree zones relative to the attack direction. For each munition burst point an incapacitation calculation is made for each possible man location within the room. A man is considered incapacitated when struck by one or more lethal fragments. Figure 1 shows the 5 degree zones for an impact fuzed case.

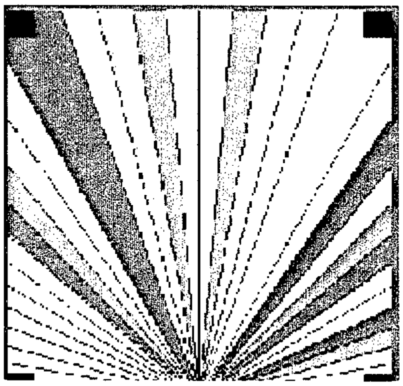


Figure 1 – Zones for Impact munition

Any man locations that are not struck are considered undamaged by the munition. The number of incapacitated men and corresponding room locations are averaged for all possible burst points to give an average Probability of Incapacitation (Pi/h) value for each set of test data.

EARLY METHODS

Original methods of inputting data required the user to make tedious zone calculations and estimates from photographs as to which fragments belonged in which zones. All of this was done from test photographs where the witness panels were gridded with one foot by one foot markings. The user examined the photographs and made a best guess as to where within the 5 degree zones each fragment was located. The zone locations were determined by the aimpoint angle and the burst point location. An input file was created for each set of test data using the sixteen witness panels. This method of data entry was time consuming and prone to errors. Figure 2 illustrates an early panel and the fragments that have perforated marked for the analyst.

The University of Alabama in Huntsville (UAH) supporting AMCOM developed a graphical user interface that allowed the user to bring up each panel on the computer screen one at a time. Then using the test photographs and your mouse the user would simply point and click at each fragment location. The program takes the fragment locations off of the screen and saves them to a file with the .gin extension that records the panel numbers and the x and y locations. This software provided the user with a tool to enter the fragment locations quickly and accurately.

The next step to further automate this process was suggested by Redstone Technical Test Center. They designed a light table apparatus that would allow the test engineer to generate a set of x and y locations for each fragment by laying the damaged witness panel on a light table. The apparatus scans the panel and determines locations of the panel perforations. Note that a fragment is only considered to be an incapacitating fragment if it completely penetrates the witness panel. Imbedded fragments are only considered to be nuisance fragments and are not given any credit in this analysis. Figure 3 shows a sample light table scan. The data from the test area includes an image file and a text file of panel fragment locations.

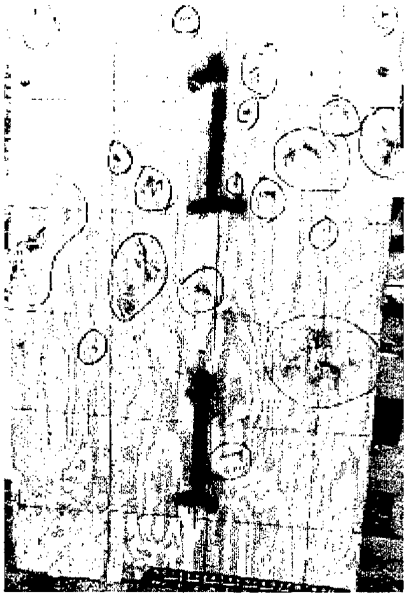


Figure 2 – Fragment recovery panel

The input process was greatly improved; however, the evaluation tool lacked the ability to utilize all of the collected data. The PIMMS code could not, for example, utilize fragment data collected from the floor of the room. After a few crude visualizations of the new light table data, a plan for a new model using full three-dimensional input data was devised.

Figure 3 - Light Table image showing fragments

High Resolution Methodology

The genesis for this new high-detail approach to calculation of Probability of Incapacitation can be found in BRL Technical paper BRL-MR-3969. This document details the modifications made to the ComputerMan program to allow for multiple wounding. This document shows that a Pi value can be computed in high resolution given a specific wound path or paths and a fragment's main characteristics. ComputerMan is a model designed to simulate wounding, the resulting performance degradation and the threat to life to personnel who sustain penetrating injuries. One or more fragments may cause the injuries.

In order to create a new methodology that utilized the test data specified as input to the Pimms code, several software approaches and geometry inputs were created. The first necessary item to accurately tie the methodologies together was a three dimensional geometric model. BRL-CAD was selected because of the robust shotline library RTLIB. Also, a BRL-CAD model of the ComputerMan geometry had already been created at ARL, but was later found to be unavailable for this effort. After this fact surfaced, several attempts were made to create a small useful BRL-CAD representation that would allow for the exact entry and exit coordinates to be recorded. This fact is very important to the working of this model. After several attempts to utilize the skin only elements and create a BRL-CAD geometry suitable for this purpose, it was determined that the resultant model was too large to be used for this application. However, after a review of the ComputerMan code, it was obvious that a model composed of only the Bounding Boxes of the dataset could be created and transformed into the crouching position. This Bounding Box man can be seen in Figure 4.

Three separate models of this type have been created. The first model has a standing man representation of the Bounding boxes. This model was used to check the entry and exit calculations by the Raytracing section of the methodology. This model was then rotated to match the needed crouching man geometry. This model matches the endpoint locations that are found in the ComputerMan model when the crouching man is selected.

The Raytracing module utilizes standard RTLIB calls. This allows a mathematical ray to be created from the Burst point location along a specified direction vector. These direction vectors

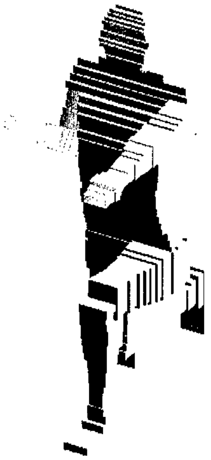


Figure 4 - A crouching Bbman image

are calculated by utilizing the specified original height and depth into the room as the original burst point location. Each fragment is read from the 2d .gin file or the 3d .3dp file and a direction vector is calculated from the original Burst point location to the impact point on the wall of the test structure. This set of direction vectors remains fixed during the calculation of the Pi number for both delay fuzed and impact fuzed tests. This portion of the code calculates the entry and exit points and number of impacts on any man in a room location. This information is then used in the call to the pmssub subroutine. The call to pmssub takes this form

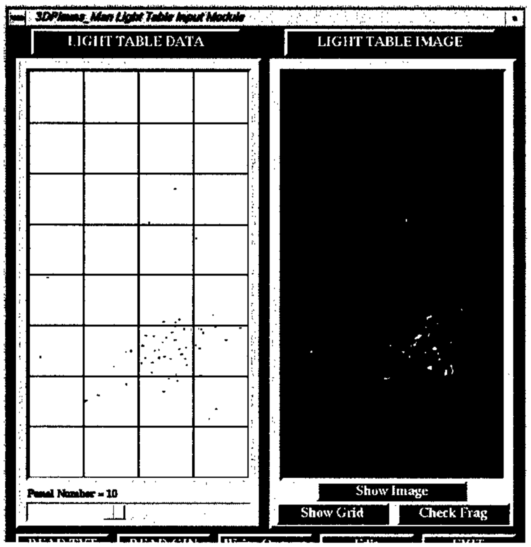
pmssub(fragment array, hitpoint array, numhits,)

PMSSUB

This subroutine is written in C++. It is essentially the Batch.C code from the ComputerMan distribution. However, there have been several modifications that allow the code to match this specific application. The Batch.C code has only two run types, single and grid. The need for multiple impacts in this methodology required that either the live-fire module or the point burst module be considered. The point burst module was utilized as the prototype and modified to return only the incapacitation number. Also, the inputs were modified to allow the entry and exit positions to designate the shotline path through the ComputerMan model.

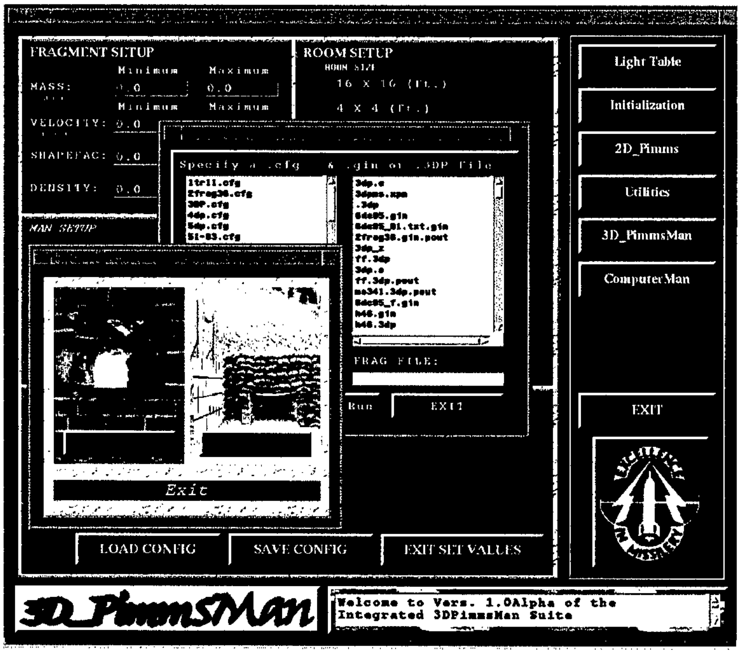
USER INTERFACE

Figure 5 illustrates several of the sub windows that can be accessed from the graphical user interface. This interface provides access to the early methodologies in the point and click form. However, the high resolution 3Dpimms code can be started after creating a fragment file and a configuration file. Figure 6 is the light table tool that allows review of the data read from the test area input data.



Panel Number = 10

Figure 6 – The Light Table Editor



MASS: Minimum 0.0 Maximum 0.0

VELOCITY: Minimum 0.0 Maximum

SHAPEFAC: 0.0

DENSITY: 0.0

ROOM SIZE 16 X 16 (Ft.)

4 X 4 (Ft.)

Specify a .cfg & .gin or .3DP File

1trll.cfg
2frag38.cfg
38P.cfg
4dp.cfg
5dp.cfg
51-83.cfg

3dp.c
3dpms.xpm
.3dp
6dc85.gin
6dc85_81.txt.gin
2frag38.gin.pout
3dp_z
ff.3dp
3dp.c
ff.3dp.pout
me341.3dp.pout
6dc85_f.gin
h46.gin
h46.3dp

FRAG FILE:

Welcome to Vers. 1.0Alpha of the Integrated 3DPimmsMan Suite

Figure 5 – The 3Dpimms User Environment

ADDITIONAL INSULTS

The high resolution many-on-many code described above utilizes only fragment incapacitation. There has been considerable interest in other damage mechanisms that include, blast, heat or thermal effects. The primary limiting factor has been that there are no accepted one-on-one models, physics or medical based, to detail the insult or injury that leads to incapacitation. Early attempts are based upon limited test data and extrapolation outside the test data is inherently risky. The Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) has been funding the development of ORCA, Operational Requirements-based Casualty Assessments, code which assesses Operational Casualties due to multiple insults for people performing various mission related tasks.

The full working of the ORCA code is beyond the scope of this paper; however, it takes the capabilities of ComputerMan to a natural next step. 3Dpimms as currently configured utilizes only limb dysfunction due to fragment penetration to determine Probability of Incapacitation. However, ORCA, utilizes an engineering capability vector to separate tasks into discrete necessary functions which a human is required to have to accomplish the specified operational duty. This generic approach allows injuries of other types to be combined with the injury that results from penetration / fragment type injuries. The full 3Dpimms tool being developed during this year will utilize ORCA object modules to input penetration, blast, and thermal insults for each of the man locations. A summary of the engineering capability vector will be used to assign an Operational Probability of Incapacitation.

ORCA Background

The ORCA code models injuries to personnel from various insults such as blast, penetration, burns, toxic gases and blunt trauma. It currently is a Graphical User Interface, GUI, driven toolkit. It allows the user to input various system parameters for each type of insult and results in evaluation of elemental capabilities such as cognitive mental processing, visual mental processing, auditory mental processing, acuity and color discrimination, visual field of view, torso support, limb strength, endurance, etc. Inputs for the blast evaluation include a Pressure vs. time history and position of the person to the blast. Input for the thermal effects are skin area exposed and time of exposure. All of these elements are evaluated from full to minimum performance requirements. The final analysis results from the reduction in the level of the soldier's performance due to the total insult. Figure 7 shows the ORCA taxonomy adapted to the 3Dpimms environment.

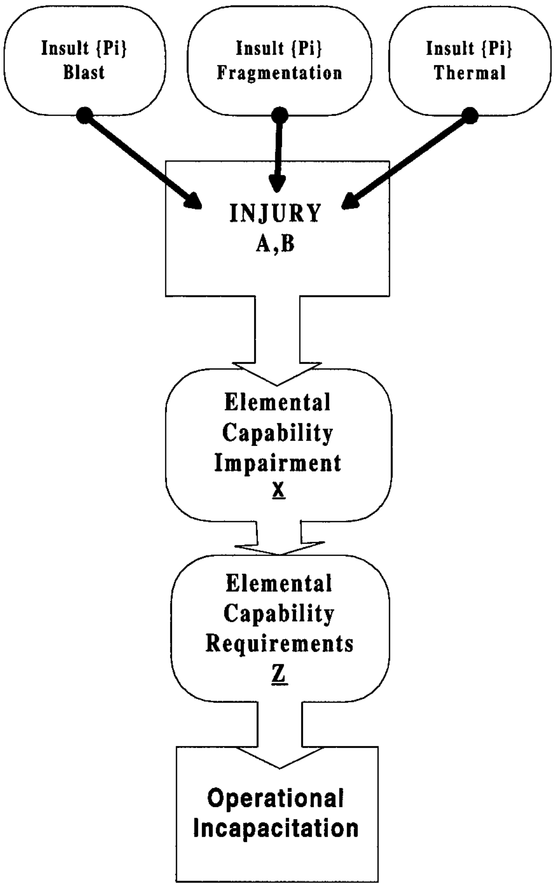


Figure 7 – ORCA taxonomy adapted to 3DPimms

Visualization & Verification/Validation

Several tools have been created to visualize the steps involved in the high resolution 3Dpimms evaluation methodology. These were designed to assist in the development of the code but also to allow an easy method for Verification and

Validation studies. The Verification steps break neatly into three distinct areas. The first area is to verify that the mathematical relationships between the collected fragment patterns and the positions represented on the room walls created an accurate model of the test data. This step is validated with both calculations and visualization of the individual panel data shown in the previous figure.

The second area is the tracing of the fragment directions into the representation of the crouching men. This task is accomplished by Army standard methods. These methods utilize BRL-CAD geometries and Raytracing library files. The methods utilized can output a large amount of detail beyond the data used to record entry and exit point of the wound path on the crouching men in each room location. Figure 8 shows the environment that visually checks the raytrace calculations and prints a plethora of other useful diagnostic information.

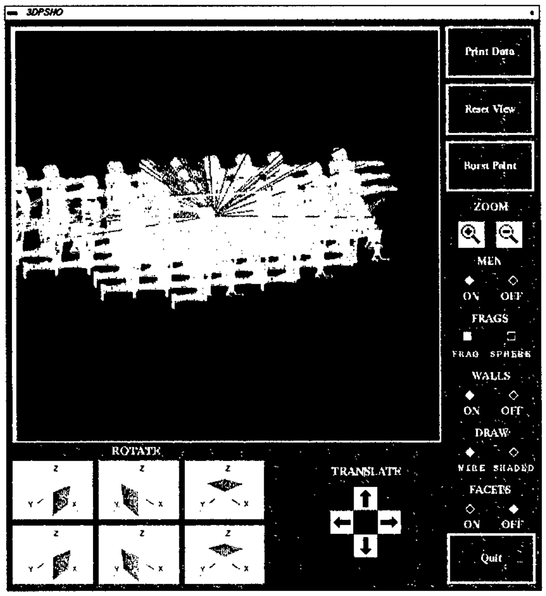


Figure 8 – 3DPShow Visualization Environment

The third area is the verification/validation of the bookeeping after the Pi value is determined by PMSSUB for each possible man position and for each possible burst point location. Each wound path entry and exit points are fed into the PMSSUB code to calculate the injury caused by a single fragment. The bookeeping must not only keep track of the cumulative injuries received by multiple wounds penetrating each man position and report the highest level of damage per man position but also tally these results for each possible burst point location

Virtual Environment

A virtual environment has been created to texture map the light table image data onto a virtual representation of the test room or bunker. This environment will allow an analyst to immerse into a virtual recreation of the test event. This can be compared to video or other photographic representations of the test event. The analyst can select the man position and view the fragment which hit that man location. This can be of tremendous help when attempting to interpret the final output. Also, it is an aid in the Validation step and it Verifies that the code subroutines do indeed reflect the math model that has been modeled.

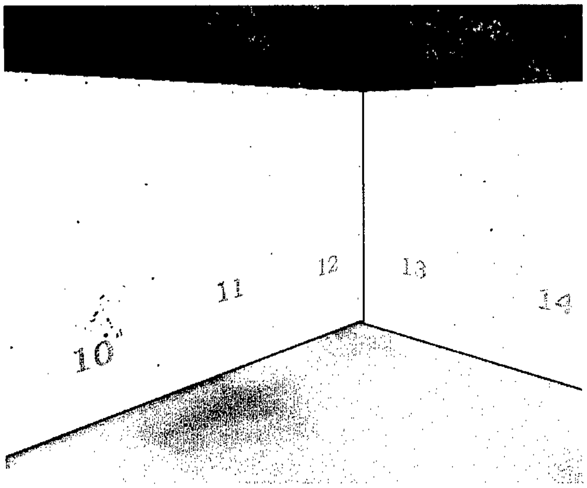


Figure 9 – Virtual Test Room Visualization

SIMULATION HOOKS

The main functions of 3Dpimms have been ported to the Windows/Intel operating environment. This is to allow Probability of Incapacitation to be computed at the end of the current six degree of freedom simulation. This module will accept detonation point and produce a Pi for that specific detonation point. Table lookup for grenade insertion probability will be required but his approach will link a stand alone analysis capability with fly-out simulation. Results can be tabulated at the end of a Monte-Carlo set and analyzed. Figure 10 illustrates one of the ported codes in a WindowsNT implementation.

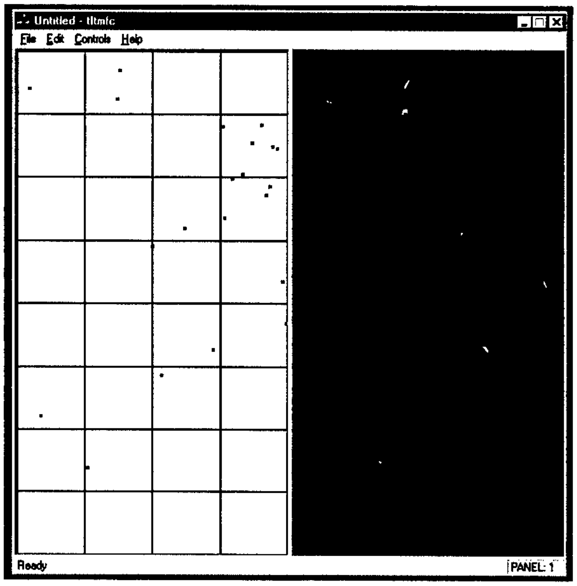


Figure 10 – Fragment input tool ported to Win95/NT

CONCLUSIONS

This paper documents the creation of a new weapon system evaluation tool from early statistical models to a robust multiple injury many-on-many code capable of linking to six degree-of freedom simulations. Tools have been developed to assist in the Verification and Validation steps required to gain accreditation for this tool.

Test data flows quickly and easily into useful evaluation tools that can be run between tests in the design phases of a program or can be used in conjunction with simulation for milestone decision analysis.

Also, secondary effects that can be important to a weapon or warhead concept have been targeted for inclusion in the evaluation tools. This will drive test requirements, however, a more robust evaluation of system effects will be available.

REFERENCES

Browning, David R., "Automated Debris Data Collection and Reduction for Input to Lethality Model Assessment Programs", ITEA Testing in the Global Village Symposium, Baltimore, MD, October 1994.

Saucier, R., and B. Ward. "ComputerMan Study of Multiple Wounding", BRL-MR-3969, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, June 1992.

Saucier, Richard and H.M. Kash III. "ComputerMan Model Description", ARL-TR-500, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, August 1994.

Romanczuk, Glenn E. , "MPIM 3D_PimmsMan Methodology Study", TR #5-33863, The University of Alabama in Huntsville, Huntsville, AL, 1997.

Nail, C.L. "Probability of Incapacitation Methodology for Masonry Structures (PIMMS), CSC TR-81-5692, Computer Sciences Corporation, Huntsville, AL.

BIOGRAPHY

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Mr. Romanczuk is a charter staff member at the UAH Visualization & Simulation Laboratory. His primary area of expertise is Vulnerability / Lethality approximation methods and penetration mechanics. Several unique methodologies have been created for use in design level studies. These include the 3DPimmsMan suite for Probability of Incapacitation for personnel in bunkers or rooms, the Dangerous Shotline methodology, and numerous other interactive methods.

Edith W. Crow

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Mrs. Crow has worked in the area of Simulation for the last 18 years. She is employed as an Aerospace Engineer by The U.S. Army Aviation & Missile Command. Her area of specialization include RCS prediction, Simulation Methodologies, Personnel Lethality, and Force-on-Force models.

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Mr. Pitts is a Research Associate in the UAH Research Institute. His research interests include volume visualization, polygonal decimation techniques, solid geometry to boundary representation tessellation techniques.

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