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A CONGERIES OF NUMERICAL MODELS USED AT THE BRL

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (clt)

This report consists of a directory of over 100 numerical models or computer codes used by the BRL scientific and technical community in mid-1979. The specific information within the directory provides a brief description of each model, of its strengths and of its limitations, as well as a point of contact for more detailed information. To provide rapid access to information within this directory, cross indexing has been arranged by task area, by code name, by point of contact and by word-concept

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I. INTRODUCTION

Ballistic Research Laboratory personnel who use numerical simulation techniques in the performance of their tasks are faced with such mundane but practical questions as: what codes are suitable to adapt or adopt? And, who knows anything about it? It is the purpose of this congeries to provide the beginnings of answers to these questions.

The next section, *The Congeries of Models,* which comprises the bulk of this report, consists of a collection of responses to the questionnaire listed in Table I. Over 100 models are discussed. The responses are those of people working in their fields, edited for grammar and the like but not for content. The questionnaires were completed by the end of August 1979 and reflect activities within the BRL at that time. Response was voluntary and so no claim to completeness is made. The exact number of codes available and used within the BRL is unknown, but this author hazards that there may be two to three times as many as reported here. These responses update and supplement earlier compilations[1,2].

Should this report be updated, say, biennially? The answer depends on how directly and indirectly useful this report is within the BRL community. A simple qualitative criterion is suggested. The amount of time cumulatively saved by BRL personnel must be greater than the time spent assembling this report for this report to be judged useful and hence to be followed up. We leave to others the quantification of this criterion.

The unique feature of this report lies in its indicies and their method of compilation. The four indicies are: 1) specific task area/discipline, 2) code name, 3) point of contact, and 4) word concepts: all arranged alphabetically. The second index contains code names as received and so may be either an acronym or a description.

This type of report with its indicies represents a pioneering first at the BRL since it was assembled by using the editing features of the UNIX Operating System of the BMD PDP11/70 computing system.

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1. Candland, C., Kuehl, G., and Cummings, B. E., "A Survey of Models Used Within the Vulnerability Laboratory - CIRCA 1973," BRL-M-2434, Jan 1975. (AD#B002042L)
2. Hirschberg, M. A., Lacetera, J., and Schmitt, J. A., "Storage and Retrieval of Information on Systems of Partial Differential Equations and Their Solutions: Createbase and the Continuum Mechanics Center Data Base of Hydrocodes," BRL-R-2015, Sep 1977. (AD#A050307)

MODELING QUESTIONNAIRE
(one sheet per model, type or print)

1. TASK AREA/DISCIPLINE: Fill in general ballistic area; i.e., interior, exterior, terminal, or vulnerability.

2. MODEL NAME:

REFERENCE(S): Please list citable reference(s). If no references state "NONE."

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Answer the question why or for what purpose is this model used. Not interested in *how* the model operates.

4. STRENGTH(S) OF MODEL: What are the specific advantages of this model? Possible areas of strength include but are not limited to: speed of computation, ease of input data handling, general type of code, easily adapted to wide variety of conditions.

5. LIMITATION(S) OF MODEL: What are the specific disadvantages of this model? Possible areas of limitations include but are not limited to: excessive run time, insufficient or inadequate input data, model complexity.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *(Your name)*

PHONE NUMBER:

TABLE 1. The Modeling Questionnaire and the Instruction for Filling It Out.

II. THE CONGERIES OF MODELS

This Section is grouped by divisions within the BRL (Ballistic Modeling, Interior Ballistics, Launch and Flight, Terminal Ballistics and Vulnerability/Lethality) and alphabetically by Code Name within the division, one questionnaire response per page.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: ABA (Airborne Ballistic Algorithm).

REFERENCE(S):

Benokiaitis, Vitalius and Mann, Thomas L., "Ballistic Algorithm for 30mm XM788 Target Practice Projectile," BRL IMR 651, June 1979.

Benokiaitis, Vitalius and Mann, Thomas L., "Ballistic Algorithm for 2.75" FFAR with MK40 Motor, M151 Warhead, M423 Fuze, BRL IMR 657, August 1979.

Mann, Thomas L., "Computer Program Implementation of Ballistic Algorithms for 30mm XM788 Projectile and 2.75 "FFAR," BRL IMR (to be published).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: The purpose of this model is to determine the airborne gun/rocket-pointing direction in order to hit a target whose location is given.

4. STRENGTH(S) OF MODEL: Speed of computation - 200 launcher pointing directions/sec. Accuracy - <2 mils for useful ranges. Calculation of Siacci functions in closed form. Easily adaptable to wide variety of conditions.

5. LIMITATION(S) OF MODEL: Moderate storage requirements.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Vitalius Benokiaitis*

PHONE NUMBER: BMD, extension 4196.

1. TASK AREA/DISCIPLINE: Artillery

2. MODEL NAME: AFACE (Austere Field Artillery Concepts Effectiveness)

REFERENCE(S):

ARBRL-TR-02040 (Feb 1978) (AD#C013398L)
ARBRL-MR-02865 (Oct 1978) (AD#C015816L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Depicts a US mechanized division defending against an armored assault. Stresses system interactions in pitting artillery, TOW, Dragon, AAH, close air support, and tanks against artillery, tanks, APC's, ZSU 23's, and HIND. The interactions and system numbers and characteristics are easy to change. The model is used in concept studies.

4. STRENGTH(S) OF MODEL: Two-sided.

Probabilistic.
Short running time.
Easily changed in some areas.
Extra options - firefinder, SMOKE.

5. LIMITATION(S) OF MODEL: Interactions not well known - no empirical evidence. Inadequate suppression submodel. Single scenario.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Alan R. Downs*

PHONE NUMBER: BMD, extension 3467

1. TASK AREA/DISCIPLINE: Interior ballistics.

2. MODEL NAME: ALPHA.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes the gas and particle flow in a closed breech weapon. Cylindrical symmetry is assumed. Chemical reactions in the gas are not considered.

4. STRENGTH(S) OF MODEL: 2-D, 2-phase modeling. Ability to compute the complete firing cycle, including ignition. Adaptive computing grid.

5. LIMITATION(S) OF MODEL: Uncertain experimental correlations. Long computing times Basic limitation of two-phase flow theory.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *A. Celmins*

PHONE NUMBER: BMD, extension 3688.

1. TASK AREA/DISCIPLINE: Interior, exterior, and terminal ballistics.

2. MODEL NAME: Ballistic Artillery Model, BAM

REFERENCE(S):

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: "Flies" a projectile by calculating interior ballistic performance, passing muzzle velocity data to an exterior ballistics routine and passing end-of-flight conditions to a terminal ballistics routine.

4. STRENGTH(S) OF MODEL:

Short run time.
Simple input data requirements.
Convenient for quick gun-to-target effects calculations in one program.

5. LIMITATION(S) OF MODEL: Interior ballistics calculations are not truly predictive. Terminal ballistics routine limited to direct fire against armor.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Kenneth Joel*

PHONE NUMBER: BMD, extension 3467

1. TASK AREA/DISCIPLINE: Exterior, terminal, and interior ballistics

2. MODEL NAME: Ballistic Utility Model (BUM).

REFERENCE(S):

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Provides several models for calculating tradeoffs in the performance of a KE penetrator.

4. STRENGTH(S) OF MODEL: Allows user to select his choice of model or insert his own.

5. LIMITATION(S) OF MODEL: Does not provide a pressure sensitive sabot model.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *C. M. Frank*

PHONE NUMBER: BMD, extension 2030/3346.

1. TASK AREA/DISCIPLINE: Terminal ballistics/vulnerability

2. MODEL NAME: Blast Field.

   REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model determines the blast field from large explosions using selected pressure measurements.

4. STRENGTH(S) OF MODEL: Low sensitivity to observational errors.

5. LIMITATION(S) OF MODEL: Symmetry of blast field assumed.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *A. Celmins*

   PHONE NUMBER: BMD, extension 3688.

1. TASK AREA/DISCIPLINE: General Ballistics

2. MODEL NAME: BRLGRAY

REFERENCE(S): BRLGRAY: The Ballistics Research Laboratory Version of the GRAY Equation of State... BRL Draft Report (Joseph Lacetera). Also BRL IMR-655.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Multi-phase EOS for metals and metal alloys. Accurate description of phase changes. A good physics code but physics of alloy unknown.

4. STRENGTH(S) OF MODEL: Accurate physical model from ambient to vapor state.

5. LIMITATION(S) OF MODEL: More core storage required than for a simple model.

FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Joseph Lacetera*

PHONE NUMBER: BMD, extension 4386.

1. TASK AREA/DISCIPLINE: Terminal ballistics

2. MODEL NAME: BRL HELP

REFERENCE(S): BRLHELP: The BRL 7600 version of the HELP code. BRL Draft Report (Joseph Lacetera, Janet Lacetera, Jim Schmidt)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: 2D Eulerian Hydrodynamics code used in terminal ballistics calculations.

4. STRENGTH(S) OF MODEL: Accurate treatment of jet formation in shaped-charge calculations.

5. LIMITATION(S) OF MODEL: Long running time; mixed-cell treatment of interfaces.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Joseph Lacetera*

PHONE NUMBER: BMD, extension 4386

1. TASK AREA/DISCIPLINE: Vulnerability-Laser Technology & Application-Propagation

2. MODEL NAME: BRLPRO

REFERENCE(S): BRL TR ARBRL-TR-02039, Jan 1978, BRL IMR Report Number 600, May 1978, BRL Report Number 572, Aug 1977, Soc. Photo-Optical Ins Eng Paper 195-22, (to be published). Comment cards in card deck serve as user's manual. (ARBRL-TR-02039, AD#B024978L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model is used in conjunction with laser effects models to assess the effects of a high energy laser on military targets. Model is based on a scenario of a ground based laser engaging a moving or stationary target. Target path is specified by a generic trajectory. Additional inputs consist of laser and environmental parameters such as beam power, wave length, beam shape, wave form (CW or Pulse), jitter, wind, turbulence, absorption, scattering, etc.

4. STRENGTH(S) OF MODEL: Simplicity, accuracy, computational speed, and ease of incorporation into or with other models due to modular subroutine structure.

5. LIMITATION(S) OF MODEL: Does not include the effects of smoke or contaminants except through a "global" representation of absorption and scattering coefficients which vary with altitude. Has only a simple form of adaptive optics. Needs correlations for additional beam shapes and more careful treatment for optical beam quality.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Harold J. Breaux*

PHONE NUMBER: BMD, extension 3688

1. TASK AREA/DISCIPLINE: Fire Control.

2. MODEL NAME: Cobra.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: This model helps us evaluate various firing strategies for rapidly firing tanks engaging maneuvering targets.

4. STRENGTH(S) OF MODEL:

5. LIMITATION(S) OF MODEL:

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Fred Bunn*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: System modeling.

2. MODEL NAME: Combat availability.

REFERENCE(S): "Mobility and Armor Protection Trade Off," ARBRL-MR-02933, by C. Masaitis, G. Francis and V. Woodward, Jul 1979. (AD#C019138L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes expected time of survival by a combat vehicle in a combat specified by fire intensity, mobility level, and percentage of time on the move and in a stationery position.

4. STRENGTH(S) OF MODEL: Expected time to survive is computed directly from the inputs, not as an estimate by simulation. Any threat and any size of the force can be considered.

5. LIMITATION(S) OF MODEL: The threat must be expressed in terms of fire rate per unit time per fighting vehicle and in terms of probability of kill give a shot. The model assumes that during selected short time intervals a vehicles remains stationary or mobile and that all possible sequences of alternating states of mobility are equally likely.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *C. Masaitis*

PHONE NUMBER: BMD, extension 3605.

1. TASK AREA/DISCIPLINE: Exterior ballistics, guidance & control of missiles/projectiles.

2. MODEL NAME: Computer Model for Laser Semi-active Terminal Homing.

REFERENCE(S): BRL MR 2419, Computer Model for Laser Semi-active Terminal Homing, Kenneth E. Joel and Lawrence J. Vande Kieft, Nov 1974. (AD#B000896L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Simulates the laser semi-active terminal homing situation using simplified constructs to represent the elements of the actual physical situation. Pulses of laser energy are propagated along a range which includes the laser, atmosphere, aerosol, fore-ground, target and background. The energy scattered from each of the elements is calculated and used to provide intensity data for a detector at a given location and angular orientation. Calculations can be repeated to provide information for a succession of detector positions, e.g., Corresponding to a missile trajectory.

4. STRENGTH(S) OF MODEL: Short running time. Easily adapted to accept flight simulation inputs. Contains all the basic elements pertinent to the problem.

5. LIMITATION(S) OF MODEL: Sub-models relatively unsophisticated. Not presently set up to "fly" a missile. Does not represent "real" seeker characteristics.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Kenneth E. Joel* or *Lawrence J. Vande Kieft*

PHONE NUMBER: BMD, extension 3467.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: CSQII - An exterior Finite Difference Program for Two-Dimensional Material Response.

REFERENCE(S): SAND77-1339, Sandia Laboratories Report, S. L. Thompson, Jan 1979.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: CSQII is a flexible code with broad applicability for computation of material motion in two spatial dimensions. The finite difference analogs of the Lagrangian equations of motion with material strength are employed with continuous rezoning to construct an Eulerian program. The code has been used for characterization of explosive/propellant-driven impulse generators for precise homing guidance control of high-spin guided projectiles/missiles.

4. STRENGTH(S) OF MODEL: A fast running code; can treat up to 10 materials; input instructions well documented and easy to handle; also being used in variety of kinetic energy penetrator problems; can handle interior cracks and spall; an excellent plot software for color graphics for adaptation to any graphic hardware.

5. LIMITATION(S) OF MODEL: No built-in fracture model; equation of state formulations too complicated and difficult to find necessary input data for materials; no provisions for EOS for propellants.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Yong Sook Park*

PHONE NUMBER: BMD, extension 3688

1. TASK AREA/DISCIPLINE: Fire Control

2. MODEL NAME: CURTAIN

REFERENCE(S): None

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model determines probabilities of hit and kill for a burst-fire tank gun utilizing the Curtain or Ambush firing technique.

4. STRENGTH(S) OF MODEL: Ease of input, quick computation.

5. LIMITATION(S) OF MODEL: None.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Denice M. Petro*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Smoke and Aerosol Obscuration

2. MODEL NAME: CYL

REFERENCE(S): None

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates absorption and scattering cross-sections of EM radiation from small particles being used for broad band absorption.

4. STRENGTH(S) OF MODEL: Ease of use. No "fudge" factors. Sound scientific development.

5. LIMITATION(S) OF MODEL: Model does not work for length/wave length ratios between 1.5-10.0 at present time. Model of shape may not be accurate enough for future work.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Gaelen R. Daum*

PHONE NUMBER: BMD, extension 4509

1. TASK AREA/DISCIPLINE: Integration of interior, exterior, terminal ballistics and vulnerability.

2. MODEL NAME: Duel3.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: This model simulates combat between 2 combatants.

4. STRENGTH(S) OF MODEL: Easy to use (conversational), very fast, deterministic, simulates burst fire.

5. LIMITATION(S) OF MODEL: The following are treated as constants:

a. Time between rounds and bursts.
b. Detection time.
c. Reaction time.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Fred Bunn*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Effectiveness Analysis

2. MODEL NAME: EFFMEASHEL

REFERENCE(S): None

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model analyzes the effectiveness of new air defense projectiles as compared to standard air defense projectiles against rotary-wing aircraft.

4. STRENGTH(S) OF MODEL: Ease of input.

5. LIMITATION(S) OF MODEL: None.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Denice M. Petro*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Effectiveness Analysis.

2. MODEL NAME: EFFMEASURE

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model analyzes the effectiveness of new air defense projectiles as compared to standard air defense projectiles against fixed-wing aircraft.

4. STRENGTH(S) OF MODEL: Ease of input.

5. LIMITATION(S) OF MODEL: None.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Denice M. Petro*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Field Artillery Fire Control

2. MODEL NAME: The Field Artillery Battalion Performance Model

   REFERENCE(S): "Proceedings of WAG-4 Symposium on Surface-to-Surface Tube Artillery," The Technical Cooperation Program, Sub-Group W (Conventional Weapons Technology), Action Group 4 (Surface-to-Surface Tube Artillery), DREV Memo 2443/77, Dec 77.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates time and accuracy for adjust-fire missions, using statistical representation for system elements. Used to determine performance of current, developmental or conceptual artillery.

4. STRENGTH(S) OF MODEL: Short running time. Easily adapted to various systems.

5. LIMITATION(S) OF MODEL: Inadequate input data. Runs at battery level; not completed at battalion level.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Kenneth Joel*

   PHONE NUMBER: BMD, extension 3467

1. TASK AREA/DISCIPLINE: Modeling - Projectile, Tube Interaction

2. MODEL NAME: Finite Element Gun Tube Simulation

   REFERENCE(S):

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   The model considers a gun tube in terms of a series of mass points and springs. The deals with:

   1. Projectile tube interaction including gyroscopic effects.
   2. Gas pressure effects on the tube and projectile.
   3. A projectile with three principal moments of inertia.
   4. Initial barrel bends and dynamic response due to projectile.
   5. Mount motions - due to recoil.
   6. Projectile exit effects and projectile launch direction.

4. STRENGTH(S) OF MODEL:

   a. Simple to use.
   b. Runs in several seconds on CDC 7600
   c. Very small memory requirements.
   d. Reasonably accurate.

5. LIMITATION(S) OF MODEL:

   a. Poor documentation.
   b. Barrel twisting not modeled.
   c. No graphics.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Mark D. Kregel*

   PHONE NUMBER: BMD, extension 4447

1. TASK AREA/DISCIPLINE: Vulnerability

2. MODEL NAME: FLYBY

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Simulates the response of a sensor, flying in an arbitrary trajectory, to the perturbation of the geomagnetic field by a tank, approximated as a prolate spheroid. Both the static field and its time derivative are computed set points along the trajectory.

4. STRENGTH(S) OF MODEL:

a. High speed.
b. Fair agreement with experiment, but not fully evaluated.

5. LIMITATION(S) OF MODEL:

a. Does not account for gun tube.
b. Does not include any permanent magnitization of the tank.
c. Further testing may reveal additional limitations.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Robert C. Tompkins*

PHONE NUMBER: BMD, extension 3598.

1. TASK AREA/DISCIPLINE: Exterior.

2. MODEL NAME: FLYOUT

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model determines the times of flight to various ranges for air defense projectiles.

4. STRENGTH(S) OF MODEL: Ease of input, quick computation time.

5. LIMITATION(S) OF MODEL: None.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Denice M. Petro*

PHONE NUMBER: BMD, extension 2030

1. TASK AREA/DISCIPLINE: System Performance.

2. MODEL NAME: Footprint Parametric Program.

REFERENCE(S): IMR to be published.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: It models the location of smart munition search areas and kill probabilities with respect to an armored company of tanks. Target location error, footprint radius, P_K, and number of rounds are all joined parametrically.

4. STRENGTH(S) OF MODEL: Fast running time allows for hundreds of parametric variations including various levels of false targets.

5. LIMITATION(S) OF MODEL: It has a static, non-reacting target. The impact patterns are hypothetical rather than realistic.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Bob Gschwind*

PHONE NUMBER: BMD, extension 4452. : loop awk -f pfile $1 shift goto loop

1. TASK AREA/DISCIPLINE: Terminal ballistics

2. MODEL NAME: Lethal Area Model

   REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates lethal area for fragmenting munitions against personnel standing, prone and in fox holes.

4. STRENGTH(S) OF MODEL: Speed of computation.

5. LIMITATION(S) OF MODEL: Obtaining *good* input data.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Kenneth Joel*

   PHONE NUMBER: BMD, extension 3467.

1. TASK AREA/DISCIPLINE: Maneuvering Target Fire Control.

2. MODEL NAME: "Maneuvering Target Generator."

   REFERENCE(S): AMSAA TR, "A Model for Maneuvering Targets," (in publication).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Stochastic model of planar vehicle motion between two points. Motion composed of circular arcs of random radii smoothly joined by random length line segments so that radial and tangential accelerations are continuous functions. Scalar speeds may differ on each arc/segment.

4. STRENGTH(S) OF MODEL: Cheap and fast. In gross detail, mimics closely the measured apparent behavior of actual combat vehicles on real terrain. Intuitive.

5. LIMITATION(S) OF MODEL: Statistically unvalidated. Planar motion only.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *S. S. Wolff*

   PHONE NUMBER: BMD, extension 4672.

1. TASK AREA/DISCIPLINE: Interior.

2. MODEL NAME: Mayer-Hart.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Finds the muzzle velocity for a round.

4. STRENGTH(S) OF MODEL: Very easy to use.

5. LIMITATION(S) OF MODEL:

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Fred Bunn*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Integration of interior, exterior, terminal ballistics and vulnerability.

2. MODEL NAME: M-dart.

   REFERENCE(S):

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Evaluates the performance of multi-dart penetrators versus single dart penetrators.

4. STRENGTH(S) OF MODEL: Fast and accurate.

5. LIMITATION(S) OF MODEL:

   a. Input data on exterior ballistics.
   b. Projectile design.
   c. Dart penetration capabilities.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Fred Bunn*

   PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: **AH 80-I: Weapon Systems Analysis & Modeling.**

2. MODEL NAME: Modern Gun Effectiveness Model

   REFERENCE(S):

   AMSAA TR No 180 (Oct 1976)
   AMSAA TR No 149 (Apr 1977)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Description of engagement between one gun and one aircraft (aircraft does not shoot back).

   Available outputs:
   Engagement Hit Probability (P_H) & P Kill Probability (P_K)
   (aircraft out of manned controlled within 30 seconds (K-Kill,
   idem within 5 minutes
   (A-Kill) forced landing)
   Burst P_H & P_K as function of range
   Single-Shot P_H & P_K as function of range
   Miss distance as function of range

4. STRENGTH(S) OF MODEL: Top-down structured, modular; realistic aircraft trajectories; modern fire control techniques; good treatment of projectile exterior ballistics.

5. LIMITATION(S) OF MODEL:

   Point-detonating (PD) rounds only
   Benign environment only
   Attrition kills only

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *J. K. Temperley*

   PHONE NUMBER: BMD, extension 5294

1. TASK AREA/DISCIPLINE: Sensor Technology (MM Wave)

2. MODEL NAME: None

REFERENCE(S):

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: This model would be able to exercise the parameters associated with sensor - target, sensor-background and sensor-CM/CCM interactions and to serve as a sub-model module for weapons systems simulations.

4. STRENGTH(S) OF MODEL: Allow realistic and validated sensor characteristics to be a part of system simulations.

5. LIMITATION(S) OF MODEL: Probably could not stray far from the validation data base limits. The basic limit will be the definition of exogenous variables (background, weather, and CM).

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *R. McGee*

PHONE NUMBER: BMD, extension 4289

1. TASK AREA/DISCIPLINE: Simulation of the Precision Aim Technique

2. MODEL NAME: PAT Simulation

   REFERENCE(S): None yet

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Simulates a gun environment and models gun responses to it. As the gun tube "bends" the PAT prediction scheme attempts to predict where the barrel will be pointing at future times. Comparisons are made between the PAT predictor and detailed model result.

4. STRENGTH(S) OF MODEL:

   a. Simple to use.

   b. Runs fast

5. LIMITATION(S) OF MODEL:

   a. No graphics

   b. Documentation lacking

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Mark D. Kregel*

   PHONE NUMBER: BMD, extension 4447

1. TASK AREA/DISCIPLINE: Terminal Ballistics

2. MODEL NAME: Projectile HE Model, PROHEM

REFERENCE(S):

BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates weight of explosive fill in a projectile of given extrnal configuration and weight.

4. STRENGTH(S) OF MODEL: Fast. Simple input data requirements. Projectile weight and caliber treated as parameters.

5. LIMITATION(S) OF MODEL: Assumes all metal parts of projectile (except fuze) have same density; likewise for fill.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Kenneth Joel*

PHONE NUMBER: BMD, extension 3467 configuration and weight.

1. TASK AREA/DISCIPLINE: Fire Control

2. MODEL NAME: ROFQUES

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model determines miss distance from the aim point of a burst-fire tank gun firing against a maneuvering target using various prediction algorithms..

4. STRENGTH(S) OF MODEL: Ease of input, quick computation.

5. LIMITATION(S) OF MODEL: Simple maneuver.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Denice M. Petro*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Interior.

2. MODEL NAME: Sabot.

   REFERENCE(S): none.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Finds the optimum combination of sabot, charge and penetration weights.

4. STRENGTH(S) OF MODEL: Very easy to use.

5. LIMITATION(S) OF MODEL:

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Fred Bunn*

   PHONE NUMBER: BMD, extension 2030.

1. **TASK AREA/DISCIPLINE: System Performance**

2. MODEL NAME: SADARM System Performance.

   REFERENCE(S): BRL MR 02856, Sep 78. (AD#C015654)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Models the SADARM descent geometry, target detection performance and accuracy, and the warhead lethality. It gives the system P_K.

4. STRENGTH(S) OF MODEL: It is a detailed simulation of the descent, detection, and warhead effects.

5. LIMITATION(S) OF MODEL: It is for a specific type of detector. It does not include artillery delivery errors or the distribution of tactical targets.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Bob Gschwind*

   PHONE NUMBER: BMD, extension 4452.

1. TASK AREA/DISCIPLINE: Statistics

2. MODEL NAME: SAMPLEGEN

   REFERENCE(S): None

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Code gives up to a 50 pair random sample exhibiting predetermined means and variances.

4. STRENGTH(S) OF MODEL: Ease of input, quick computation.

5. LIMITATION(S) OF MODEL: None.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Denice M. Petro*

   PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Solving Ordinary Differential Equations

2. MODEL NAME: SRK

REFERENCE(S):

M. D. Kregel and E. L. Lortie, "Description and Comparison of the K-Method for Performing Numerical Integration of Stiff Ordinary Differential Equations, BRL Report No. 1733, July 1974. (ADA #A0003855).

M. D. Kregel and J. M. Heimerl, "Comments on the Solutions of Coupled Stiff Differential Equations," BRL Memo Report No. 2769, July 1977; or Proceedings of the 1977 Army Numerical Analysis and Computers Conference, ARO Report 77-3, Nov 1977, p. 553-563. (AD #A043122).

T. P. Coffee, J. M. Heimerl and M. D. Kregel, "A Numerical Method for Large Stiff Systems of Ordinary Equations," Transactions of the 24th Conference of Army Mathematicians, ARO Report 79-1, Jan 1977, p. 249-257.

T. P. Coffee, J. M. Heimerl and M. D. Kregel, "A Numerical Method of Integrate Stiff Systems of Ordinary Differential Equations," ARBRL-TR-02206, January 1980. (AD#A080998)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

Solves coupled sets of numerically stiff, non-linear, coupled, first order differential equations.

4. STRENGTH(S) OF MODEL: State-of-the-art stiff ODE solver. Complementary approach to Gear.

5. LIMITATION(S) OF MODEL: See report.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Mark D. Kregel*

PHONE NUMBER: BMD, extension 4447

1. TASK AREA/DISCIPLINE: System Performance.

2. MODEL NAME: STAFF System Performance.

REFERENCE(S):

MR 02842, Jun 78 (AD#C014722L)
MR 02822, May 78 (AD#C014208L)
MR 02870, Oct 78 (AD#C016455L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Models the STAFF delivery accuracy, target detection performance and accuracy, and the warhead lethality. It gives the overall system P_K.

4. STRENGTH(S) OF MODEL: It is a very detailed analysis of the system. The delivery accuracy can be separated or input easily.

5. LIMITATION(S) OF MODEL: The delivery accuracy must be built up with all inputs therefore the differential effects are difficult to extract. The detector simulation is for a specific detector type.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Bob Gschwind*

PHONE NUMBER: BMD, extension 4452.

1. TASK AREA/DISCIPLINE: System modeling

2. MODEL NAME: Stochastic combat model

REFERENCE(S): Army Science Conference Proceedings 22-25 June 1976 Vol IV.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes probability of winning a tank duel and probability of surviving a closing-on maneuver, both as functions of the number of shots fired. Also computes expected duration of a duel, expected number of shots fired and expected distance traveled.

4. STRENGTH(S) OF MODEL: Computes complete set of probabilities of all duel events consisting of shots fired, distance covered, and the state of duelistics.

5. LIMITATION(S) OF MODEL: No simultaneous firing of the duelist is allowed. Distribution of time between shots is independent of the previous sequence of shots. A duelists can be in only two states -- fighting or defeated.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *C. Masaitis*

PHONE NUMBER: BMD, extension 3605.

1. TASK AREA/DISCIPLINE: Terminal ballistics/vulnerability.

2. MODEL NAME: Strong Blast Model.

REFERENCE(S): BRL CR 30, Jan 1971. (AD#722777)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes strong blast field according to Taylor/Sedov/Laparte/Chang formulai.

4. STRENGTH(S) OF MODEL: Simplicity of use. Input consists of simple engineering data.

5. LIMITATION(S) OF MODEL: Limited to strong blast (negligible ambient pressure).

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *A. Celmins*

PHONE NUMBER: BMD, extension 3688.

1. TASK AREA/DISCIPLINE: Integration of interior, exterior, terminal ballistics and vulnerability.

2. MODEL NAME: Tank.wars.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: MONTE-CARLO model simulating combat between m-blue tanks and n-red tanks.

4. STRENGTH(S) OF MODEL:

a. Very understandable cause-event histories can be traced.

b. Realistically plays interactions between all combatants.

5. LIMITATION(S) OF MODEL: Terrain effects on vulnerability are played but terrain effects on sensing may not be completely satisfactory.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Fred Bunn*

PHONE NUMBER: BMD, extension 2030.

1. TASK AREA/DISCIPLINE: Interior

2. MODEL NAME: Turbulence model for two phase flow in a gun tube.

   REFERENCE(S): none.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: A model is under development to describe the turbulence in a two phase, two dimensional, time dependent flow in a gun tube.

4. STRENGTH(S) OF MODEL: Incorporates the state of the technology.

5. LIMITATION(S) OF MODEL: Model will have to be expanded to higher Re numbers and a reactive environment.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *C. K. Zoltani*

   PHONE NUMBER: BMD, extension 3705

1. TASK AREA/DISCIPLINE: Stress Analysis

2. MODEL NAME: ADINA

REFERENCE(S): ADINA, K.-J. Bathe, MIT Report 82448-1, Sep 1975 (Revised May 1977).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Elastic-Plastic and Creep, 1, 2, and 3-D Stress Analysis of Static and Dynamic Solids.

4. STRENGTH(S) OF MODEL: General and Powerful Code.

5. LIMITATION(S) OF MODEL: Difficult input.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. Drysdale*

PHONE NUMBER: IBD, extension 2238.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: BRLTC (1-D Traveling Charge Gun Code).

   REFERENCE(S): I. W. May, A. F. Baran, P. G. Baer, P. G. Gough, "The Traveling Charge Effect," Proceedings of 15th JANNAF Combustion Meeting, Newport, R.I., 11-15 Sep 1978.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

The model is used to simulate the interior ballistic performance of a traveling charge gun in which an ultra-high burning rate propellant is attached to the projectile. Predictions are made by the model to evaluate the effect experimental ultra-high burning rate propellants will have on the performance of a traveling charge gun. Thus the model is used to guide the ultra-high burning rate propellant program leading to the development of a high velocity traveling charge gun.

4. STRENGTH(S) OF MODEL:

   a. For a 1-D code, the model runs rapidly, about 5 - 10 sec per case on CYBER 76.

   b. Code will either compute the propellant burning rates necessary to meet prespecified conditions such as constant pressure, acceleration, stress, or use experimentally measured propellant burning rates.

5. LIMITATION(S) OF MODEL: Model does not have the following:

   a. Friction between propellant - projectile and the bore surface.
   b. Heat loss from propellant gases to bore surface.
   c. Realistic mechanical stress-strain theory for the propellant.
   d. Capability of modeling flow of gasses from barrel after projectile has been ejected.
   e. Capability of modeling gun with nozzle in breech section.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Paul Baer*

   PHONE NUMBER: IBD, extension 3574.

1. TASK AREA/DISCIPLINE: Aerodynamic Static Properties ------ D-3.

2. MODEL NAME: $C_{N\alpha}$, $C_{M\alpha}$ for Finned Projectiles.

REFERENCE(S): ARBRL-MR-xxxx (manuscript in review).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: With reference to AMCP 706-280, "Design of Aerodynamically Stabilized Free Rockets," 1968, this series of programs linearizes the aerodynamics of finned projectiles in restricted Mach ranges and calculates the static moment and normal force. In combination with D-1 and D-2, it then calculates the lift coefficient and the yaw sensitivity.

4. STRENGTH(S) OF MODEL: The fact that it is done is the only strength of the model. Attempts to find an existing procedure failed - resulting in this HP-97 operation.

5. LIMITATION(S) OF MODEL: The model is limited to Mach numbers between 2 and 5. Simplified geometry has to be assumed and the input must include separately determined drag and physicals.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. Donovan*

PHONE NUMBER: IBD, extension 2411.

1. TASK AREA/DISCIPLINE: Aerodynamic Retardation ------- D-2.

2. MODEL NAME: Drag of a Finned Projectile.

REFERENCE(S): ARBRL-MR, March 1978, (Drag only).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Program accepts the geometric description and the physical properties as input and computes the drag coefficient and retardation. It then plots both quantities against Mach number.

4. STRENGTH(S) OF MODEL: This is the only known available program for finned projectiles. It is immediate and it is easy to use. The vehicle is the HP-9820-A with 9862-A plotter. Also programmed for HP-97.

5. LIMITATION(S) OF MODEL: The model is limited to flat fire trajectories at Mach number from 2 to 5.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. Donovan*

PHONE NUMBER: IBD, extension 2411.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Flame CODE.

REFERENCE(S):

a. "A Method for Computing the Flame speed for a laminar, premixed, one dimensional Flame," BRL-MR (to be published).

b. "The Detailed Modeling of Premixed, Laminar, Steady State FlameS to Obtain Validated Reaction Networks. I. Ozone," to be published, Combustion & Flame.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

Solves partial differential equations associated with 1-D, premixed, laminar flame. Computes flame speed and spatial profiles of species and of temperature - output to be used in an iterative sense to provide direction to experiments.

4. STRENGTH(S) OF MODEL:

Easily runs different flames and starting conditions (a subsidiary LOADER code arranges input for FLAME Code).

5. LIMITATION(S) OF MODEL:

a. Large run times for complicated Flames.

b. Kinetic and transport coefficients poorly known.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *T. P. Coffee or J. M. Heimerl*

PHONE NUMBER: IBD, extension 4322.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Eccentric Stress in an Elastic Thick Walled Cylinder

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculate stresses due to rotating projectile with eccentric center of gravity, assuming quasi-static loading.

4. STRENGTH(S) OF MODEL: Exact formulation provided load varies as a sine or cosine of the polar angle.

5. LIMITATION(S) OF MODEL: Programming not complete.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Alexander S. Elder*

PHONE NUMBER: IBD, extension 3083.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Elastic Plastic Stresses in a Thick Walled Cylinder.

   REFERENCE(S): ARO Report 76-1, 1976. Generalized Plane Strain in an Elastic, Perfectly Plastic Cylinder with Reference to the Hydraulic Autofrettage Process by A. S. Elder, R. C. Tomkins, and T. L. Mann.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates elastic, plastic, and residual stresses in an elastic, perfectly plastic cylinder under conditions of generalized plane strain. Both open and closed end conditions are considered.

4. STRENGTH(S) OF MODEL: The open end solution gives realistic axial stresses away from the ends which are known to exist experimentally but do not occur in the usual plane stress solution, which has been in use at the Benet Laboratories. The Prager-Hodge plane strain solution gives excessive axial stresses. The solution we obtained gives uniform axial strains and end conditions compatable with the autofrettage process.

5. LIMITATION(S) OF MODEL: Model designed for uniform wall ratios.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Alexander S. Elder*

   PHONE NUMBER: IBD, extension 3083.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: IBHVG (BRL), SBB (LCWSL)

REFERENCE(S): BRL Report No. 1183, (1962)(AD#299980)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: This is BRL's thermodynamic or "lumped parameter" interior ballistic model. Given input data describing a gun system, projectile, and propelling charge, the model computes detailed interior ballistic performance. Predicted performance includes chamber, mean, and projectile-base pressure, projectile acceleration, velocity, and travel, fractions of propellants burned, and gas temperatures, all as functions of time. A variety of output options are available, including plots on certain computers. The model is useful for charge, gun, and projectile design, systems studies, formulation of interface specifications, and malfunction analysis.

4. STRENGTH(S) OF MODEL:

a. Speed of computation: approximately 1 sec per run on BRL's CDC.
b. Simplicity: set of ordinary differential equations.
c. Accuracy: proven track record of good predictions given good input data.

5. LIMITATION(S) OF MODEL:

a. No post-shot-ejection or blowdown phase-incomplete pressure histories.
b. Semi-empirical heat loss term, assumes heat loss proportional to kinetic energy.
c. Simplified hydrodynamics-assumes unburnt propellant uniformly distributed with gas.
d. No detailed description of ignition.
e. Simplified burning rate: $\frac{dr}{dt} = BP^n$.
f. Nobel-Abel equation of state.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Robert W. Deas*

PHONE NUMBER: IBD, extension 3180.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Interior Ballistics of Recoilless Rifle

   REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   Computes chamber pressure, projectile velocity, recoil impulse, and other variable of interest, for a number of propellant grain geometries, as a function of time.

4. STRENGTH(S) OF MODEL: General type of code

5. LIMITATION(S) OF MODEL: Batch operation. Not yet available on CDC.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Robert W. Geene*

   PHONE NUMBER: IBD, extension 3180.

1. TASK AREA/DISCIPLINE: Everyday Geometry —— D-4.

2. MODEL NAME: Intersections.

   REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Several programs that determine the (D-5) intersections of radii with corresponding lines for use in the weight and center of gravity programs.

4. STRENGTH(S) OF MODEL: None - except that they are available and necessary.

5. LIMITATION(S) OF MODEL: Each model is a separate problem.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *W. Donovan*

   PHONE NUMBER: IBD, extension 2411.

1. TASK AREA/DISCIPLINE: Mechanical Properties of Solids —— D-1.

2. MODEL NAME: Mechanical properties of a Simple Flat Plate

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: These programs simulate the geometry of a flat plate of any material for integration into a complete fin assembly. The information is used in fixing the dynamic properties of complete projectile assemblies.

4. STRENGTH(S) OF MODEL: The only strength of the model is that it is immediately available on the HP-97. A more comprehensive program that does the complete job on the CDC is called "Moments II."

5. LIMITATION(S) OF MODEL: The program is limited by the capacity of the HP-97.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. Donovan* and *L. Kokanakis*

PHONE NUMBER: IBD, extension 2411 and 2238, respectively.

1. **TASK AREA/DISCIPLINE: Interior Ballistics**

2. MODEL NAME: NOVA Code

   REFERENCE(S):

   P. S. Gough and F. J. Zwarts, "Modeling Heterogeneous Two-Phase Reacting Flow," AIAA Journal, Vol 17 No. 1, Jan 79, pp 17-25.

   P. S. Gough, "Numerical Analysis of a Two-Phase Flow with Explicit Internal Boundaries," IHCR 77-5, Naval Ordnance Station, Indian Head, MD, Apr 77.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   The NOVA Code provides a two-phase flow description of the interior ballistic cycle under the assumption of quasi-one dimensionality (1-D with area change). Specifically, the code treats venting of the ignition system into the propellant bed/gun chamber, penetration of the gases through the bed and local heating of propellant to ignition, combustion of the main propellant charge, concomittant gas and solid-phase motion, and travel of the projectile down the bore. Various options allow treatment of such processes as transient burning and heat loss to the wall.

4. STRENGTH(S) OF MODEL:

   For many (approximately 1-D) configurations, the NOVA code simulates flame spread and pressure-wave development quite well. Treats wide range of "1-D" configurations, including multiple-increment, multiple-granulation charges and those with inert, rigid or compactible filler elements. Convenient tabular and graphical outputs.

5. LIMITATION(S) OF MODEL:

   a. One-dimensional representation does not allow proper treatment of bagged charges with annular ullage or of cased ammunition with bayonet primers providing radially-directed output.

   b. Serious deficiency of required input data, both classical (e.g., burning rates, barrel resistance) and non-classical (e.g., interphase drag, propellant bed rheology) limits all interior ballistics models.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Albert W. Horst*

   PHONE NUMBER: IBD, extension 4649.

1. TASK AREA/DISCIPLINE: Dynamics of Symmetric Projectiles ---- D-5.

2. MODEL NAME: None.

REFERENCE(S): BRL-MR-2215, (1972). (AD#904378L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model calculates weight, center of gravity, and three mass moments of inertia, for any symmetrical body of any material.

4. STRENGTH(S) OF MODEL: Fast and cheap on the CDC.

5. LIMITATION(S) OF MODEL: Limited to axial symmetry. No plot of the resulting outline is obtained.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. Donovan*

PHONE NUMBER: IBD, extension 2411.

1. TASK AREA/DISCIPLINE: Interior ballistics

2. MODEL NAME: RAP.

   REFERENCE(S): BRL MR 2591, Feb 1976. (AD#B009775L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   Calculates interior ballistics of spinning solid propellant rocket motor.

4. STRENGTH(S) OF MODEL: Simple.

5. LIMITATION(S) OF MODEL: Simple.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *C. Nelson*

   PHONE NUMBER: IBD, extension 3082.

1. TASK AREA/DISCIPLINE: Stress Analysis.

2. MODEL NAME: SAAS II

   REFERENCE(S): BRL-R-1539, S. G. Sawyer, Mar 1971. (AD#727702)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: 2-D BiLinear Elastic Stress Analysis of Static Solids.

4. STRENGTH(S) OF MODEL: Ease of use. Well adapted to our needs.

5. LIMITATION(S) OF MODEL: Not general.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *W. Drysdale*

   PHONE NUMBER: IBD, extension 2238.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: SAIB (Small Arms Interior Ballistics)

   REFERENCE(S): BRL-R-1624, Thomas R. Trafton "An Improved Interior Ballistic Model for Small Arms Using Deterred Propellants," Nov 1972. (AD#907962L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   Computes interior ballistic behavior in guns using deterred propellants. Calculates space mean temperatures and pressures, breech and base pressures, projectile displacements, velocities and accelerations, instantaneous propellant burning rates as functions of time, prints output and summary, plots pressures vs. time; pressures vs. travel; velocity, acceleration, travel vs. time.

4. STRENGTH(S) OF MODEL:

   Coded in standard FORTRAN for rapid computation of interior ballistic trajectories. Input data reflecting variations in weapon, projectile, and deterred propellants are easily handled.

5. LIMITATION(S) OF MODEL:

   a. Was developed prior to requirement for SI units. Input, output, plot and program operation are in English units.

   b. Does not consider gas ejection from barrel after projectile exit.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Tom Trafton*

   PHONE NUMBER: IBD, extension 5558

1. **TASK AREA/DISCIPLINE: Interior Ballistics**

2. MODEL NAME: Stresses due to Moving Loads in a Thick Walled Cylinder (Planned).

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates stresses due to a moving projectile including pressure pulses traveling with uniform velocity.

4. STRENGTH(S) OF MODEL: Exact elastic formulation using Pochammer-chree theory and following suggestions of Professor I. Snedden.

5. LIMITATION(S) OF MODEL: Not entirely accurate for tapered cylinders as in a real gun tube.

8. IF MORE INFORMATION NEEDED REGARDING THIS MODEL:

POINT OF CONTACT: *Alexander S. Elder*

PHONE NUMBER: IBD, extension 3083.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Stresses in a Hollow Elastic Cone

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model calculates elastic stresses due to internal pressure. Model is used to represent the gauge section of minihat gauge, and in connection with photoelastic studies at the Naval Research Laboratory.

4. STRENGTH(S) OF MODEL: This model represents the exact elastic solution, derived in terms of Legendre functions according to Neubers theory for axially symmetric solids.

5. LIMITATION(S) OF MODEL: Model does not account for bending due to constraints or body stresses due to acceleration.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Alexander S. Elder*

PHONE NUMBER: IBD, extension 3083

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Stresses, Strains, and Displacements in a Slightly Curved and Twisted Gun Tube.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates strain energy in terms of inertial coordinates fixed with respect to ground. Calculates strain energy in terms of intrinsic coordinates, curvature and twist, as defined in differential geometry. Intended to determine extent of coupling among various modes of motion where linear theory would predict uncoupled motion.

4. STRENGTH(S) OF MODEL: Should provide fundamental formulation with equal weight to inertial and geometric considerations. In essence, provides forcing functions for structural analysis of thin curved and twisted tubes.

5. LIMITATION(S) OF MODEL: Does not include effects of internal pressures on displacements. Theory of thin curved tubes requires extension.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Alexander S. Elder*

PHONE NUMBER: IBD, extension 3083

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Symmetric Stresses in an Elastic Thick Walled Cylinder.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculate stresses and strain in cylindrical portion of gun tube due to combined loading of propellant and rotating band. Accounts for both normal and shear stresses.

4. STRENGTH(S) OF MODEL: Exact elastic solution has been obtained more accurately and for a greater range of wall ratios (1.01 through 5.0) than in any other investigations. Methods of calculation especially effective at some distance from discontinuity of loading.

5. LIMITATION(S) OF MODEL: Stresses near a discontinuity of loading are not sufficiently accurate due to slow convergence of series. Alternate methods of computation are being investigated.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Alexander S. Elder*

PHONE NUMBER: IBD, extension 3083.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: TIMBR5

   REFERENCE(S): Kooker, D. E., *Seventeenth Symposium (International) on Combustion* Combustion Institute 1979.

   Kooker, D. E., AIAA Reprint Paper 79-0292, New Orleans, 1979.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   Computes (1-D) *transient* laminar flame propagation (and ignition) in *confined* mixtures of ozone and oxygen. Accounts for multispecies diffusion, finite-rate chemical reactions, variable transport properties, interaction of deflagration wave with pressure disturbances reflected from boundary walls.

4. STRENGTH(S) OF MODEL:

   Solves (1-D) compressible Navier-Stokes Equations for multispecies reacting fow in a closed chamber. Numerical solution technique is based on delta-linearized block implicit method with "stiff" chemical rate equations solved by EPISODE. The "stiff" integrator package.

5. LIMITATION(S) OF MODEL:

   Cell Reynold's number limit of 2 forces small chamber sizes. Chemistry sequence is coded only for ozone and oxygen.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Douglas E. Kooker*

   PHONE NUMBER: IBD, extension 3200.

1. TASK AREA/DISCIPLINE: Interior ballistics

2. MODEL NAME: TRANSBURN

   REFERENCE(S): BRL-R-1953, Jan 1977. (AD#A035250)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

   Calculates transient regression rate of solid propellant in changing pressure field.

4. STRENGTH(S) OF MODEL:

   General heat transfer capability for unsteady conduction.

5. LIMITATION(S) OF MODEL: None

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *C. Nelson*

   PHONE NUMBER: IBD, extension 3082.

1. TASK AREA/DISCIPLINE: Interior Ballistics

2. MODEL NAME: Unified Elastic Plastic Constitutive Equations.

   REFERENCE(S): ARBRL-CR-00389, "Examples of Rate-Theory Constitutive Equations Which Unify Elasticity and Plasticity," Barry Bernstein, Jan 1979. (AD#A068467)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Provides a single set of constitutive equations for both elastic and plastic zones. Stress strain curve features a continuously turning target at the onset of plasticity.

4. STRENGTH(S) OF MODEL: Most realistic stress strain curve among current models as in the autofrettage process involving swaging. Conventional elastic - perfectly plastic model difficult to apply to the unloading condition.

5. LIMITATION(S) OF MODEL: The model has not optimized choice of functions to represent stress - strain curve. Present function, chosen while Prof. Bernstein was at BRL one summer, was a matter of convenience, to utilize special function work then in progress. Should prove model satisfies constraints from thermodynamics and rational mechanics.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Alexander S. Elder*

   PHONE NUMBER: IBD, extension 3083.

1. TASK AREA/DISCIPLINE: Exterior ballistics (transitional).

2. MODEL NAME: AERO-SABOT.

REFERENCE(S): BRL Contract Report 181, AVIR Associates, Baltimore, MD. (AD#A000899)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: The aerodynamics of a generic sabot piece is treated using the Newtonian approximation. The sabot piece is compose of an inner and outer cylindrical surface, conical surfaces on either end, and longitudinal slices parallel to the axis. When assembled, an integral number of such similar pieces form an annular cylinder. A computer program gives the Newtonian lift, drag, and moment coefficients of the piece in terms of the front and rear cone angles, length, ratio of inner to outer radii, and number of pieces. Only pitching motion is treated, and no aerodynamic interference between sabot pieces or projectile is considered. Sabot discard is also considered.

4. STRENGTH(S) OF MODEL: Simple to use for predicting design trends for discard.

5. LIMITATION(S) OF MODEL:

a. Only pitching motion considered; no roll.

b. No aerodynamic interaction modeled; experiment shows this is most important.

c. Shape considered does not represent current practical concepts.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *G. D. Kahl*

PHONE NUMBER: LFD, extension 3081.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: ANGLES

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Performs a non-linear, least squares, weighted fit of differential equations of motion to flight data from ranges or yawsondes. Provides values of aerodynamic coefficients as functions of machine number and angle of attack.

4. STRENGTH(S) OF MODEL: Always converges. Provides results for differential equations which have no closed form solutions. Removes quasi-linear assumptions. Fast run time. Performs some smoothing.

5. LIMITATION(S) OF MODEL: Cannot distinguish between various side moments such as damping and magnus.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. H. Mermagen*

PHONE NUMBER: LFD, extension 3405.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: BALD APES (Ballistic Data Acquisition and Processing System).

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Acquires muzzle-blast pressure data, projectile velocity data, temperature and humidity data by graphical calculator in the in-door aerodynamics range. Computer sets delays to obtain correct exposure for film shadow graphs. Computer processes muzzle blast pressure data, displays pressure-time curves and stores data on tape for further processing by the CYBER system.

4. STRENGTH(S) OF MODEL: On-site processing of data. Number of errors can be reduced by use of automatic test equipment. Productivity of aerodynamics range can be increased.

5. LIMITATION(S) OF MODEL: Operator judgment must be used to set delays.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. K. Fansler*

PHONE NUMBER: LFD, extension 3786.

1. TASK AREA/DISCIPLINE: Vulnerability/Statistics.

2. MODEL NAME: Carbon Fibers Filter Transmission Factors.

REFERENCE(S): "A Mathematical Model for Carbon Fiber Transmission through Filters," by B. H. Rodin, ARBRL-MR-xxxxx (manuscript in preparation).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates the transmission factors of carbon fibers through different types of filters as a function of air speed and fiber length. The transmission factor is the ratio of the number of fibers passing through the filter to the number of fibers impinging on the filter.

4. STRENGTH(S) OF MODEL: Based on actual test data.

5. LIMITATION(S) OF MODEL: Limited to the types of filters tested.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Barry H. Rodin*

PHONE NUMBER: LFD, extension 5414

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: CONING.

   REFERENCE(S): NASA TR R-421, Jan 1974.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes side force due to coning motions which relates to pitch damping.

4. STRENGTH(S) OF MODEL: Short run time.

5. LIMITATION(S) OF MODEL: Supersonic flow, inviscid, sharp tip.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *W. B. Sturek*

   PHONE NUMBER: LFD, extension 4773.

1. TASK AREA/DISCIPLINE: Transitional ballistics.

2. MODEL NAME: DAWNA.

REFERENCE(S): "Muzzle Blast Flow Field Calculations," J. Ranlet and J. Erdos, BRL Contract Report No. 297, Apr 1976. (AD#B011967L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates gasdynamic properties of muzzle blast along boreline of gun. Calculates position of blast wave front, contact surface and recompression shock. Inputs are the pressure ratio, temperature ratio, jet plume Mach number distribution, propellant-gas gamma, gun bore diameter and jet exit Mach number as a function of time.

4. STRENGTH(S) OF MODEL: Calculates baseline properties quickly.

5. LIMITATION(S) OF MODEL: Does not take precursion blast wave into account. Needs muzzle-exit conditions and jet core conditions from other models. No graphics.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. K. Fansler*

PHONE NUMBER: LFD, extension 3786.

1. TASK AREA/DISCIPLINE: Exterior ballistics (Transitional).

2. MODEL NAME: DISPERS.

REFERENCE(S): "The Influence of Muzzle Gasdynamics Upon the Trajectory of Fin-Stabilized Projectiles," Kevin S. Fansler and Edward M. Schmidt, BRL Report No 1793, Jun 1975. (AD#B005379L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Predicts angular deviation of projectile caused by muzzle blast. Also predicts upper bound for transverse momentum given to projectiles.

4. STRENGTH(S) OF MODEL: Has been adapted to consider both spinning and nonspinning projectiles.

5. LIMITATION(S) OF MODEL: Muzzle exit conditions are needed and must be obtained from other models.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. K. Fansler*

PHONE NUMBER: LFD, extension 3786.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: EBAP

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Performs non-linear, least squares, weighted fit of the drag equation to time-velocity data from doppler radars. Output is axial force coefficient versus time or machine number.

4. STRENGTH(S) OF MODEL: Fast run time. Provides results for an equation which has variable coefficients and, hence, no closed-form solution. Performs some smoothing.

5. LIMITATION(S) OF MODEL: Does not account for drag due to yaw.

8. IF MORE INFORMATION NEEDED REGARDING THIS MODEL:

POINT OF CONTACT: *W. H. Mermagen*

PHONE NUMBER: LFD, extension 3405.

1. TASK AREA/DISCIPLINE: Computational Aerodynamics/Exterior ballistics.

2. MODEL NAME: Generalized Axisymmetric Navier Stokes Solver

   REFERENCE(S): Nietubicz, Pulliam, Steger, "Numerical Solution of the Azimuthial-Invariant Thin-Layer Navier Stokes Equations," AIAA Paper No. 79-0010, Jan 1979. [ARBRL-TR-xxxxx (manuscript in preparation) and submitted to AIAA for publication].

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model is capable of computing the flow field about axisymmetric shapes including the effects of spin. The code can also be used for computing internal swirl flow.

4. STRENGTH(S) OF MODEL:

   General geometry.
   Relatively short run time compared to full 3-D.
   Easy implementation of boundary conditions.

5. LIMITATION(S) OF MODEL: Axisymmetric flow fields.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Charles Nietubicz*

   PHONE NUMBER: LFD, extension 3691.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: HEEVE.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Performs non-linear, least squares, weighted fit of differential equations of motion to flight position data from ranges or radar. Provides values of aerodynamic coefficients as functions of Mach number.

4. STRENGTH(S) OF MODEL: Always converges. Provides results for differential equations which have no closed form solutions. Removes quasi-linear assumptions. Fast run time. Smoothing.

5. LIMITATION(S) OF MODEL: Is not a predictor-corrector and cannot be used in real time.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. H. Mermagen*

PHONE NUMBER: LFD, extension 3405.

1. TASK AREA/DISCIPLINE: Transitional ballistics.

2. MODEL NAME: JETCORE

REFERENCE(S): "Experimental and Theoretical Studies of Axisymmetric Free Jets," E. S. Love *et al.* NASA TR-R-6, Langley Research Center, Langley Field, VA, 1959.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: The code predicts the dynamic characteristics for the jet core of axisymmetric steady jets using a method of characteristics calculation. The parameters are the exit pressure - ambient pressure ratio and the specific heats ratio.

4. STRENGTH(S) OF MODEL: Reliable and fast running. Has been adapted to an interactive graphics model.

5. LIMITATION(S) OF MODEL: Cannot describe the field beyond the recompression shocks.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *K. S. Fansler*

PHONE NUMBER: LFD, extension 3786.

1. TASK AREA/DISCIPLINE: Optical Miss Distance Sensor/Exterior Ballistics.

2. MODEL NAME: Light Ray Tracing Along a Projectile Wake.

REFERENCE(S): ARBRL-TR-02119, Sedney, Gerber, and Bartos (Nov 1978).
(AD#A064099)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model traces light rays from a point source located behind a flying projectile and to the side of its trajectory. The study of the upstream traveling light rays produces a calculated shadow of the projectile on a screen ahead of the projectile and deviations of light rays for application to miss distance sensors and beam riding projectiles.

4. STRENGTH(S) OF MODEL:

a. Fully three-dimensional trajectories of light rays are treated, with no required assumptions of small deflections.

b. The gas flow model of the wake is applicable to a wide variety of sizes, shapes, and speeds of projectiles.

5. LIMITATION(S) OF MODEL:

a. As is, model does not compute the complete trajectory of light ray for a miss distance sensor; small modifications are needed.

b. Wake air flow model (though reasonably good) could be improved.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Nathan Gerber*

PHONE NUMBER: LFD, extension 4591.

1. TASK AREA/DISCIPLINE: Vulnerability/statistics.

2. MODEL NAME: Minefield Effectiveness Model.

   REFERENCE(S): BRL Report No. 1839, Oct 1975, "Methodology for Evaluating Minefield Effectiveness," by Barry H. Rodin. (AD#B007932L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates the probability of personnel and/or tanks getting through a minefield. Inputs include the number and distribution of the mines, the probability that a mine is a dud and the probability that a target is killed when it detonates a mine.

4. STRENGTH(S) OF MODEL: The advantage of this closed form methodology as compared to a MONTE-CARLO approach is the reduced computer running time.

5. LIMITATION(S) OF MODEL: The breach attempt is continued without regard to the number of casualties taken; the targets cannot change tactics.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Barry H. Rodin*

   PHONE NUMBER: LFD, extension 5414.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: Modified three degree of freedom trajectory model

REFERENCE(S): BRL Report 1314, Mar 1966. (AD#485869)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Simulates the flight of a projectile fired from a stationary weapon with an initial velocity through an atmosphere on a spinning, spherical earth with variable gravity. (Includes rocket assisted projectiles).

4. STRENGTH(S) OF MODEL: Its chief advantages are speed of computation and that it requires appreciably less input than the six degree model. It is adaptable to dynamically stable projectiles and widely varying atmospheric conditions.

5. LIMITATION(S) OF MODEL: The model will not simulate high angles of yaw. There is no provision for a rocket launch or a moving firing platform.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Robert F. Lieske* or *Joseph A. Hurff*

PHONE NUMBER: LFD, extensions 3880 and 3661.

1. TASK AREA/DISCIPLINE: Aerodynamics/Exterior ballistics.

2. MODEL NAME: MOGIVE.

   REFERENCE(S): AIAA Paper No. 79-0130, J. Steger and L. Schiff, Jan 1979 (manuscript in preparation).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: 3-dimensional inviscid and viscous flow over general Bodies of Revolution. Uses thin layer concept of Parabolized Navier Stokes Equation.

4. STRENGTH(S) OF MODEL: Computes viscous and inviscid flow simultaneously, short run time (<30 min), EDDY Viscosity Turbulence Model.

5. LIMITATION(S) OF MODEL: Supersonic Flow, not thoroughly checked out.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *W. B. Sturek*

   PHONE NUMBER: LFD, extension 4773.

1. TASK AREA/DISCIPLINE: Exterior Ballistics.

2. MODEL NAME: Moving Wall Integral Boundary Layer Description.

REFERENCE(S): "Boundary-Layer Development on Moving Walls Using an Integral Theory," K. S. Fansler and J. E. Dunberg, AIAA Journal, Vol 14, No 8, Aug 1976, pp 1137-1139.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Describes boundary layer and separation points on rotating cylinder in crossflow. Iterates between potential flow calculation and boundary layer calculation until convergence is achieved.

4. STRENGTH(S) OF MODEL: Rapid compared to finite-difference method.

5. LIMITATION(S) OF MODEL: Setup presently to only consider rotating cylinders in subsonic flow. Potential flow description needs improvement.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. K. Fansler*

PHONE NUMBER: LFD, extension 3786.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: Multibody collisions (Dynamite).

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes velocities and center of gravity motions of many bodies colliding with each other and under internal and external forces.

4. STRENGTH(S) OF MODEL: Can handle up to 150 bodies. Runs interactively.

5. LIMITATION(S) OF MODEL: Complicated inputs. Long run times for other than simple cases.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. H. Mermagen*

PHONE NUMBER: LFD, extension 3405.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: Murphy's Algorithm.

REFERENCE(S): BRL MR 2581 (1976) ARBRL MR 02918 (1979) (AD#B009421L) (AD#B039048L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Accounts for variations in roll and yaw during a measurement cycle for yawsonde data. Provides options for linear or quadratic variation of either or both variables.

4. STRENGTH(S) OF MODEL: Fast run time. Rectifies data ambiguities. Works at resonance. Provides smoothing.

5. LIMITATION(S) OF MODEL: Doesn't always converge.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. H. Mermagen*

PHONE NUMBER: LFD, extension 3405.

1. TASK AREA/DISCIPLINE: Hypersonic Flow Research/Exterior Ballistic.

2. MODEL NAME: Operation Cycle of Expansion Tube with Nozzle Plate.

REFERENCE(S):

BRL MR 1998, Gerber and Bartos (Jun 1969) (AD#857512)
BRL R 1741, Oertel, Gerber, and Bartos (Sep 1974) (AD#A001551)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model enables experimenter to predetermine the initial conditions (pressures, temperatures of gases in driver, driven sections) required to produce a desired gas flow in the working section of an expansion tube with nozzle plate, which is an experimental test facility.

4. STRENGTH(S) OF MODEL: Obviates the need of determining initial conditions by trial and error.

5. LIMITATION(S) OF MODEL: For *real* gas, the model is not automated for computer.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Nathan Gerber*

PHONE NUMBER: LFD, extension 4591.

1. TASK AREA/DISCIPLINE: Transitional ballistics.

2. MODEL NAME: PLUME.

REFERENCE(S): "Shock-Fitting Method for Complicated Two-Dimensional Supersonic Flows," M. D. Salas, AIAA Journal, Vol 14, No 5, pp 583-588, May 1976.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Describes the gas dynamic properties of 2-D and axisymmetric steady jet plumes. Inputs where the jet exit Mach number, pressure ratio, temperature ratio and gammas for the jet and free stream. It is a finite-difference code using a floating shock-fitting technique.

4. STRENGTH(S) OF MODEL: Can describe the whole field for a steady jet.

5. LIMITATION(S) OF MODEL: Is presently restricted to low pressure ratios. Cannot presently be used for realistic muzzle exit pressures.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. K. Fansler*

PHONE NUMBER: LFD, extension 3786.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: SBASE.

REFERENCE(S): Mueller, T. J., "Determination of Turbulent Base Pressure in Supersonic Axisymmetric Flow." J. of Spacecraft & Rockets, Vol 5, No 1, pp 101-107, Jan 1968.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computes base pressure for axisymmetric bodies in supersonic flow at zero angle of attack.

4. STRENGTH(S) OF MODEL: Base pressure can be determined for turbulent shear flow over conical shape afterbodies including both flares and boattails. The computations are economical.

5. LIMITATION(S) OF MODEL: Base pressures can be computed only for supersonic, axisymmetric shapes at zero yaw and for high Reynolds number turbulent flow.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *L. Kayser* or *W. B. Sturek*

PHONE NUMBER: LFD, extensions 3701 and 4773.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: Six degree of freedom trajectory model.

REFERENCE(S): BRL Report 1244, Mar 1964. (AD#441598)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Simulates the flight of a projectile fired or a rocket launched from a stationary or moving platform through an atmosphere on or above a spinning, spherical earth with variable gravity.

4. STRENGTH(S) OF MODEL: Will accurately simulate the flight of any projectile or rocket.

5. LIMITATION(S) OF MODEL: Its chief disadvantages are long computation time and a large input requirement.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Robert F. Lieske* or *Joseph A. Hurff*

PHONE NUMBER: LFD, extensions 3880 and 3661.

1. TASK AREA/DISCIPLINE: Aerodynamics/Exterior ballistics.

2. MODEL NAME: SPROJ.

REFERENCE(S):

BRL Report No. 1985, May 1977 (AD#A041338)
BRL CR 292, Mar 1976 (AD#A022670)
BRL CR 248, Jul 1975 (AD#A013518)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: 3-dimensional inviscid and viscous flow over spinning Body of Revolution.

4. STRENGTH(S) OF MODEL: Short run time, 3-D flow, laminar or turbulent boundary layer.

5. LIMITATION(S) OF MODEL: Marginal accuracy for Magnus prediction for boat-tailed shapes, sharp nose, smooth body, supersonic flow.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. B. Sturek*

PHONE NUMBER: LFD, extension 4773.

1. TASK AREA/DISCIPLINE: Exterior ballistics.

2. MODEL NAME: TRAJ.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Does a six-degree-of-freedom computation on the flight of a projectile. Provides motion of center of gravity and motion about center of gravity

4. STRENGTH(S) OF MODEL: Extremely flexible, wide variety of flight parameters accounted for.

5. LIMITATION(S) OF MODEL: Very slow. Inputs are very complex and tedious.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. H. Mermagen*

PHONE NUMBER: LFD, extension 3405.

1. TASK AREA/DISCIPLINE: Aerodynamics/Exterior ballistics.

2. MODEL NAME: TRANS.

REFERENCE(S): ARBRL-TR-02139, Feb 1979. (AD#A069106)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: 3-D transonic inviscid and viscous flow over Body of Revolution. Uses linearized potential for inviscid flow, implicit finite difference for viscous boundary layer.

4. STRENGTH(S) OF MODEL: Short run time (<10 min).

5. LIMITATION(S) OF MODEL: Shock-Boundary layer interaction, cannot compute Magnus.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *W. B. Sturek*

PHONE NUMBER: LFD, extension 4773.

1. TASK AREA/DISCIPLINE: Computational Aerodynamics/Exterior ballistics.

2. MODEL NAME: Unsteady 3-Dimensional Transonic Navier Stokes Solver.

   REFERENCE(S): Pulliam, T. H., and Steger, J. L., "On Implicit Finite-Difference Simulations of Three-Dimensional Flow," AIAA Paper No. 78-10, Jan 78.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model is capable of computing unsteady three-dimensional flow about arbitrary body shapes for subsonic, transonic and supersonic flow. It is presently being utilized for transonic computations about projectiles shapes.

4. STRENGTH(S) OF MODEL:

   Arbitrary geometry
   Implicit scheme and so is stable
   Easy implementation of boundary conditions

5. LIMITATION(S) OF MODEL:

   Large computer storage requirement
   Large computer run times

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Charles Nietubicz*

   PHONE NUMBER: LFD, extension 3691.

1. TASK AREA/DISCIPLINE: Vulnerability/Meteorology.

2. MODEL NAME: VMATE CAP - Vulnerability Assessment of Materiel Targets Exposed to Clouds of Airborne Particle.

REFERENCE(S):

BRL Report 1981 - Oct 77 (NOT AVAILABLE)
BRL Report 2027 - Oct 77 (AD#C015839L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Predicts cloud transport and atmospheric diffusion of particles from munition release to arrival at target. Generates dosage/deposition as a function of downwind distance and time. Considers delivery errors. Assesses expected effects on targets.

4. STRENGTH(S) OF MODEL: Accurate simulation of the process. Applies frost wind profile.

5. LIMITATION(S) OF MODEL: Assumes normal distribution of material across wind.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dale Sloop* (RE: Chuck Crawford or Matt Hutton)

PHONE NUMBER: LFD, AV 343-7277 (7-3570).

1. TASK AREA/DISCIPLINE: Terminal Ballistics.

2. MODEL NAME: ADINA.

REFERENCE(S): "ADINA - A Finite Element Program for Automatic Dynamic Incremental Nonlinear Analysis," by Klaus-Juergen Bathe, MIT 82448-1, Rev. Dec 1978. Also, MIT 82448-2 Theo. Man.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Non-linear material and geometric structural response of problems involving large displacement, plasticity, transients, impact, metal forming, fluid-structure interactions, geologic materials, etc.

4. STRENGTH(S) OF MODEL: It is the most advanced generalized non-linear dynamic structures code in terms of its element library and its numerical solution techniques.

5. LIMITATION(S) OF MODEL:

a. It requires extensive investment of manpower and experience to make effective use of the code.

b. Materials models for various elements are not as general as desired at BRL.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *F. H. Gregory*

PHONE NUMBER: TBD, extension 5574.

1. TASK AREA/DISCIPLINE: Nuclear Weapons Effects - Blast.

2. MODEL NAME: BLOM - Blast Overturning Model.

REFERENCE(S): BRL Report No. 1889 - "Blast Overturning Model for Ground Targets," N. Ethridge, Jun 1976. (AD#B012102L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model calculates overturning of targets, such a vehicle, struck side-on by a long duration blast wave such as that produced by a nuclear explosion.

4. STRENGTH(S) OF MODEL: Simplicity of model, characterizes target as a rigid body rotating about a fixed axis. Permits easy variation of parameters for sensitivity studies.

5. LIMITATION(S) OF MODEL: Simplistic representation not realistic for some targets. Does not consider sliding response. Experimental data for verification are limited and difficult and expensive to obtain. Contains outdated blast wave forms.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *N. Ethridge*

PHONE NUMBER: TBD, extension 3097.

1. TASK AREA/DISCIPLINE: Terminal ballistics.

2. MODEL NAME: EPIC-2

REFERENCE(S):

ARBRL-CR-00373, ADA058786

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: A two-dimensional (plus spin) computer program for modeling impact and explosive detonation problems.

4. STRENGTH(S) OF MODEL: Modified numerical technique based on Lagrangian finite element formulation with quick computation time.

5. LIMITATION(S) OF MODEL: Inputing of data is time consuming, no automatic rezoning capability, difficulty in handling slidelines.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. J. Zukas*, and *J. Misey*

PHONE NUMBER: TBD, extension 5520.

1. TASK AREA/DISCIPLINE: Terminal ballistics.

2. MODEL NAME: EPIC-3.

REFERENCE(S): "Further Development of the EPIC-3 Computer Program for Three Dimensional Analysis of Intense Impulsive Loading," AFATL-TR-78-81.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: It is primarily intended for analysis of three-dimensional wave propagation and penetration problems resulting from high velocity impact. It is based on an explicit Lagrangian finite element formulation where the equations of motion are integrated directly rather than through the traditional stiffness matrix approach.

4. STRENGTH(S) OF MODEL: The code has material descriptions which include strain hardening, strain rate effects, thermal softening and fracture. It has automatic geometry generators, sliding surfaces and plot routines. It operates with little human intervention and uses moderate running time.

5. LIMITATION(S) OF MODEL: Because of the triangular elements the model exhibits some stiffness. Unless one goes to extremely fine elements, EPIC-3 also has simplified failure models.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. J. Zukas, G. H. Jonas, Dr. Gordon Johnson*

PHONE NUMBER: TBD, extensions 5520, 5520, and 612-931-6863, respectively.

1. TASK AREA/DISCIPLINE: Penetration mechanics/terminal ballistics.

2. MODEL NAME: Eroding Rod.

REFERENCE(S): A. Tate, J. Mech. Phys. Solids, Vol 15, p. 387-399, 1967 and Vol 17, p. 141-150, 1969.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: 1-D model, purely mechanical, uses three simultaneous ordinary differential equations for balance of mass, momentum, and Bernoulli equation with strength. Predicts depth of penetration in semi-infinite target, residual length of rod, and instantaneous speed during penetration.

4. STRENGTH(S) OF MODEL: Simplicity, qualitative results seem suitable for parametric variations, can be used quantitatively if calibrated.

5. LIMITATION(S) OF MODEL: Material model is too simple, not now well suited for finite target.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *T. W. Wright*

PHONE NUMBER: TBD, extension 2972.

1. TASK AREA/DISCIPLINE: Terminal ballistics/vulnerability.

2. MODEL NAME: Fuel Fire.

   REFERENCE(S): J. Dehn, "A Fuel Fire Model for Combat Vehicles," ARBRL-MR-02892, Apr 1979.(AD#A067520)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates the probability of a sustained diesel fuel fire in a combat vehicle when it is attacked by a particular threat.

4. STRENGTH(S) OF MODEL: Simple, mathematically sound.

5. LIMITATION(S) OF MODEL: Purely empirical.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Dr. James Dehn*

   PHONE NUMBER: TBD, extension 4976.

1. TASK AREA/DISCIPLINE: Terminal ballistics.

2. MODEL NAME: HULL (A Hydrodynamic Computer Code).

REFERENCE(S): The HULL Hydrodynamics Computer Code, AFWL-TR-76-183, Air Force Weapons Laboratory, Sep 1976.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES:

- 2-D and 3-D free field airblast using invisid Euler equations.

- Equations of state for many materials, including air, detonation products for several explosives, metals, and various soils and rocks.

- Shock diffraction and drag phase loading on non-responding surfaces and structures.

- Self-contained grid generation and plotting capability.

- Capable of computing explosive detonation.

- Nuclear blast simulation.

4. STRENGTH(S) OF MODEL: Applicable to a wide range of problems, both 2-D cylindrical and cartesian, and 3-D cartesian over a wide range of pressure. The code uses a relatively stable difference technique and is fast-running. Data manipulation and storage is very well done.

5. LIMITATION(S) OF MODEL: Does not compute viscous effects. Flow field cells are limited to being rectangles (in cross section) in 2-D, and rectangular parallepipeds in 3-D, so complex targets are difficult to model. Numerical algorithm is somewhat diffusive.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Richard E. Lottero*

PHONE NUMBER: TBD, extension 3097.

1. TASK AREA/DISCIPLINE: Terminal ballistics/dynamics fracture.

2. MODEL NAME: NAG/FRAG/SNAG.

REFERENCE(S): BRL-CR-222, Apr 1975 (AD#B004672L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Models dynamic fracture by voids on shear bands. Represents damage as proceeding by nucleation, growth, and coallecence of damage centers. Rate of damage accumulation is a function of applied stress levels and current damage so model is of the internal variable type.

4. STRENGTH(S) OF MODEL: Represents proper phenomenology.

5. LIMITATION(S) OF MODEL: Complex, introduces many new material constants that are difficult and expensive to obtain.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *G. Moss*

PHONE NUMBER: TBD, extension 5670.

1. TASK AREA/DISCIPLINE: Terminal ballistics.

2. MODEL NAME: PDP

REFERENCE(S): "The Particle Dynamics of Penetration," ARBRL-TR-02188, Sep 1979, by J. Dehn. (AD#A077114)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates residual masses, speeds and exit angles(if appropriate) for any projectile, striking speed and obliquity against any target array leading to perforation, ricochet or embedment with or without projectile erosion and/or breakup.

4. STRENGTH(S) OF MODEL: Simple yet rational. Exact solutions of differential equations and statistical distributions. Semi-empirical.

5. LIMITATION(S) OF MODEL: Does not describe projectile deformation or target spall and debris.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. James Dehn*

PHONE NUMBER: TBD, extension 4976.

1. TASK AREA/DISCIPLINE: Terminal Ballistics.

2. MODEL NAME: PETROS 3.5.

REFERENCE(S):

"Finite-Difference Analysis for Predicting Large Elastic-Plastic Transient Deformations....," S. D. Pirotin, L. Morino, E. A. Witmer, J. W. Leech, BRL CR 315, Sep 76. (AD#B013924L)

"PETROS 3.5: New Developments and Program Manual for the Finite-Difference Calculations of Large Elastic-Plastic Transient Deformation...," S. D. Pirotin, B. A. Berg, E. A. Witmer, BRL CR 211, Feb 75. (AD#A007215)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Large non-linear transient response of thin, variable thickness, multi-material layer shell with elastic-plastic material behavior subjected to pressure and impulsive loading.

4. STRENGTH(S) OF MODEL:

a. Sophisticated kinematic hardening plasticity model.
b. Treats arbitrary topological four/three sided shells.
c. Accepts arbitrary pressure/impulse distribution.
d. Prescribed tractions; prescribed displacements; free, clamped, hinged boundary conditions and combinations of these; and polar boundaries.
e. Treats multi-material layers, variable thickness
f. Thermal stresses.

5. LIMITATION(S) OF MODEL:

a. Finite difference formulation not compact and not entirely consistent with boundary formulation.
b. Will occasionally develop numerical instabilities on long runs.
c. Moderately difficult to learn to use (learning time about 2-3 months.)

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *J. M. Santiago*

PHONE NUMBER: TBD, extension 2022.

1. TASK AREA/DISCIPLINE: Terminal ballistics

2. MODEL NAME: PETROS 4.

   REFERENCE(S): "Finite-Difference Analysis for Predicting Large Elastic-Plastic Transient Deformations....," S. D. Pirotin, L. Morino, E. A. Witmer, J. W. Leech, BRL CR 315, Sep 76. (AD#B013924L)

   "PETROS 4: New Developments and Program Manual for the Finite-Difference Calculations of Large Elastic-Plastic, and/or Viscoelastic Transient Deformation..." S. D. Pirotin, B. A. Berg, E. A. Witmer, BRL CR 316, Sep 76.(AD#B014253L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Large non-linear transient response of shear deformable, multi-material layer, sandwich shell with elastic-plastic, viscoelastic material behavior subjected to arbitrary pressure and impulsive loading.

4. STRENGTH(S) OF MODEL:

   a. Sophisticated kinematic hardening plasticity model. b. Treats arbitrary topological four/three sided shells. c. Treats multi-layered, variable thickness shell in which each layer is independently shear deformable (includes sandwich plates). d. Prescribed tractions; prescribed displacements; free, clamped, hinged boundary conditions, combinations of these; and polar boundaries. e. Arbitrary pressure/impulse distribution. f. Thermal stresses.

5. LIMITATION(S) OF MODEL:

   a. Finite difference formulation not compact and not entirely consistent in order of approximation with boundary formulation. b. Difficult to learn to use (learning time about 6 months) and difficult to interpret results. c. Long run times

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *J. M. Santiago*

   PHONE NUMBER: TBD, extension 2022

1. TASK AREA/DISCIPLINE: Terminal ballistics/vulnerability.

2. MODEL NAME: PKMAX.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Optimizes the design of a fragmentation warhead in order to maximize the kill probability of the target.

4. STRENGTH(S) OF MODEL: A mathematical design tool based on variation of warhead parameters, given target vulnerability area and encounter condition information.

5. LIMITATION(S) OF MODEL: Mostly the accuracy of vulnerable area information.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. James Dehn*

PHONE NUMBER: TBD, extension 4976.

1. TASK AREA/DISCIPLINE: Terminal Ballistics

2. MODEL NAME: REPSIL.

REFERENCE(S):

"Formulation of the Large Deflection Shell Equations for Use in Finite Difference Structural Response Computer Codes," J. M. Santiago, BRL R 1571, Feb 72. (AD#740742)

"A User's Manual for the REPSIL Code," J. M. Santiago, H. L. Wisniewski, N. J. Huffington, BRL R 1744, Oct 74. (AD#A003176)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Large non-linear transient response of general thin shell with elastic-plastic material properties subjected to pressure and impulsive loading.

4. STRENGTH(S) OF MODEL:

a. Sophisticated kinematic hardening plasticity mode.
b. Compact, efficient finite difference formulation.
c. Treats arbitrary topological four sided shells.
d. Accepts arbitrary pressure/impulse distributions.
e. Fast in-core solver implies short run times.
f. Easy to learn to use.

5. LIMITATION(S) OF MODEL:

a. Treats only one material.
b. Treats only shell of constant thickness.
c. Limited boundary conditions (only treats clamped, hinged, and symmetry boundar

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *J. M. Santiago*

PHONE NUMBER: TBD, extension 2022.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: CINDA (SINDA).

REFERENCE(S): Chrysler Improved Numerical Differencing Analyzer for 3rd Generation Computers, TN-AP-67-287, Oct 20, 1967.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Solves the 1-, 2-, and 3-dimensional steady-state or transient heat conduction equations. Includes both linear and nonlinear boundary conditions.

4. STRENGTH(S) OF MODEL: Offer user a variety of methods for solution of heat conduction equations. Program contains numerous subroutines for solving complex heat transfer problems.

5. LIMITATION(S) OF MODEL: Limited to 4000 model points in describing problem.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. F. F. Quigley*

PHONE NUMBER: VLD, extension 7-3721.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: Compartment Vulnerability Model.

REFERENCE(S): BRL IMR 238, June 1974 and BRL-IMR 239, June 1974.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: It estimates the vulnerability of armored vehicles to attacks by conventional munitions.

4. STRENGTH(S) OF MODEL: Very short running time once all input is available.

5. LIMITATION(S) OF MODEL: This model utilizes correlation functions of empirical data, and data for the correlation functions is limited to a small class of vehicles.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Joe Ploskonka*

PHONE NUMBER: VMT, extension 5432.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: Computation of Vulnerable Area and Repair Time (COVART) Program.

REFERENCE(S): Draft report in progress.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model is used to: (a) compute vulnerable areas for aircraft damaged by Kinetic Energy penetrators (KE), and (b) compute combat damage repair times for aircraft.

4. STRENGTH(S) OF MODEL:

Advantages:

(a) Handles a variety of threats: Armor Piercing Incindiary (API) projectiles and fragments, and impact speeds,
(b) can be adapted to a variety of conditions for vulnerability analyses, and
(c) general code adapted to CDC, IBM and UNIVAC systems.

5. LIMITATION(S) OF MODEL:

Disadvantages:

(a) insufficient and inadequate input data,
(b) handles only single penetrators, and
(c) does not handle all fragments if impacting projectile shatters.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Bedford T. Bentley*

PHONE NUMBER: VLD, extension 4224.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. **MODEL NAME: DELFIC.**

REFERENCE(S): BRL R 1783, "Department of Defense Land Fallout Prediction System - An Updated User-Oriented Documentation for DELFIC MARK V." DASA 1800 Vol I-VII, "Department of Defense Land Fallout Prediction System." (AD#B004148L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: For a surface or low air burst nuclear detonation, the code models the initial conditions, cloud rise, cloud rise-transport interface, transport, and fallout definition by application of first principles whenever possible or practical. Produces 18 predictions of fallout phenomena.

4. STRENGTH(S) OF MODEL: Best in DOD or DOE for accuracy and variety of predictions.

5. LIMITATION(S) OF MODEL: Applies to surface and above surface detonation predictions only.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Joseph C. Maloney*

PHONE NUMBER: VLD, extension 7-3027.

1. TASK AREA/DISCIPLINE: Data Fitting, general.

2. MODEL NAME: GENFIT.

REFERENCE(S): ARBRL-MR-02832, April 1978. (AD#A054642)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Fits the parameters of an arbitrary (user supplied) function to multi-independent variable data.

4. STRENGTH(S) OF MODEL: Does not require input of function derivatives - contains numerous search controls to handle wild or pathological functions.

5. LIMITATION(S) OF MODEL: Requires some familiarity with the model to result in facile use. Only implemented on the U-1108 at present. Somewhat slow.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *J. Terrence Klopcic*

PHONE NUMBER: VLD, extension 7-3551.

1. TASK AREA/DISCIPLINE: Vulnerability-Target Modeling.

2. MODEL NAME: GIFT Code.

REFERENCE(S): BRL Report 1802, dated Jul 1975. (AD#B006037L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: The Model simulates the geometry of a three-dimensional vehicle for use in vulnerability studies. It provides line-of-sight distances, normal thicknesses and angles of obliquity of a ray traveling through the various components of the vehicle. The data generated; therefore, describes the path or paths of a destructive device.

4. STRENGTH(S) OF MODEL: The model contains numerous tests to check the correctness of the data. The geometry can be described to a high degree of precision and accuracy.

5. LIMITATION(S) OF MODEL: The model requires large amounts of man hours to generate the geometry data for a target such as a tank or helicopter.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Gary G. Kuehl*

PHONE NUMBER: VLD, extension 4951.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: GIFT.

REFERENCE(S):

L. W. Bain, Jr. and M. J. Reisinger, "GIFT Code User Manual, Vol 1, Introduction and Input Requirements," BRL Report 1802, July 1975. (AD#B006037L)

G. E. Kuehl, L. W. Bain, Jr. and M. J. Reisinger, "GIFT Code User Manual, Vol II, Output Options," ARBRL-TR-02189, Sep 1979. (AD#A078364)

"GIFT Code User Manual, Vol III, Analyst Manual," (in preparation).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Combinatorial - geometric description tool which ultimately yields grid shotline data for input into vulnerability area programs.

4. STRENGTH(S) OF MODEL: The availability of many geometric shapes enables the describer to achieve an excellent target simulation.

5. LIMITATION(S) OF MODEL: It can be a very cumbersome task - requires much skill with 3-D imagery and set theory. If a high level of detail is required, the number of manmonths effort is prohibitive.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Ronald L. Henry*

PHONE NUMBER: VLD, extension 2878.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: High Explosive Vulnerable Area and Repair Time Program.

REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model is under development to: (a) compute vulnerable areas for aircraft damaged by high explosive incendiary (HEI), (b) compute combat damage repair times for aircraft.

4. STRENGTH(S) OF MODEL:

Advantages:
(a) can assess damage to aircraft caused by HEI projectiles 23mm to 57mm,
(b) general code adapted to CDC, IBM and UNIVAC computer systems, and
(c) damage caused by fragments and blast are evaluated.

5. LIMITATION(S) OF MODEL:

Disadvantages:
(a) insufficient input data for the assessment of fragment and blast damage,
(b) run time is excessive, and
(c) has not been fully validated for all proposed uses.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Bedford T. Bentley*

PHONE NUMBER: VLD, extension 4224.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: KDFOC.

REFERENCE(S): BRL R 1768, Mar 1975, "User's Guide for Army Underground Fallout Prediction-Code AUGER," J. C. Maloney and C. Crisco, Jr. (AD#B003132L)

UCRL 51179, June 1972, "KDFOC: A computer Program to Calculate Fallout from Underground and Land Surface Nuclear Explosions," (U) J. B. Know, *et al* (S-RD-CNWDI).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: By algorithms, the fraction of activity versus scaled depth, cloud dimensions, activity division into base surge and main cloud, transport, and deposition are predicted. The BRL version has extended output options.

4. STRENGTH(S) OF MODEL: Has all known underground burst experimental data considered in the model.

5. LIMITATION(S) OF MODEL: Must be calibrated to soil conditions, otherwise gives poor results. Calibration conditions are sparce.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Joseph C. Maloney*

PHONE NUMBER: VLD, extension 7-3027.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: LV.

REFERENCE(S): BRL-R-1779, April 1975. (AD#B003513L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Model calculates the single-shot kill probability of a laser against a target.

4. STRENGTH(S) OF MODEL: Combines most parameters of interest, from both weapon and target, into single shot kill probability (SSKP) interpretation.

5. LIMITATION(S) OF MODEL: Requires computerized target descriptions, and penetration formula parameters which may not be available.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *J. Terrence Klopcic*

PHONE NUMBER: VLD, extension 7-3551.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: NASTRAN.

REFERENCE(S): NASTRAN Users Manual, NASA SP-222(03), Sep 1970.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: General purpose program which solves the following general classes of problems:

(1) static structural problems;
(2) elastic stability problems;
(3) dynamic structural problems; and
(4) general matrix problems.

4. STRENGTH(S) OF MODEL: General purpose.

5. LIMITATION(S) OF MODEL: Limited to linear elastic structural analysis.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Dr. E. F. Quigley*

PHONE NUMBER: VLD, extension 7-3721.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: OPTBAR

REFERENCE(S): "Computers and Structures," Volume 1, pp 265-309, Pergamen Press, 1971 by V. B. Venkayya, Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Given the geometry and material properties of an indeterminate (element cross-sectional areas are indeterminate) bar structure plus and combination of the following boundary conditions:

(a) multiple loading conditions,
(b) stress constraints,
(c) displacement constraints, and
(d) element size constraints, the program obtains a minimum weight structural design by an energy criterion and search procedure that varies the cross-sectional area of each element.

4. STRENGTH(S) OF MODEL: Truss optimization, FORTRAN code, quick run times.

5. LIMITATION(S) OF MODEL: Inflexible format, bar analysis only.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Tom Erline*

PHONE NUMBER: VLD, extension 4224.

1. TASK AREA/DISCIPLINE: Vulnerability Analysis.

2. MODEL NAME: PKHDOC

REFERENCE(S): "Documentation of $P_{K/H}$ Computer Program," developed by BRL, documented by Armament Systems, Inc., 1695 W. Crescent Ave., Anaheim, CA, Nov 1974.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: The code computes conditional kill probabilities for components impacted by fragments of known mass and velocity. Regression curve fits are performed for a set of fragment masses, velocities, and associated kill probabilities. Equation coefficients, or optionally, 2 or 4 step functions associating these parameters are provided for subsequent use in vulnerability analyses.

4. STRENGTH(S) OF MODEL: The code simplifies the conversion of kill criteria information to probability of kill data required by the VAST vulnerability analysis code.

5. LIMITATION(S) OF MODEL: The code, although not complex or difficult to use, contains certain methodology defects which include ways of adjusting kill areas to account for physical size of penetrators, randomness of attack, and curve fitting over data ranges involved.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *John C. Saccenti*

PHONE NUMBER: VLD, extension 3914.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: PKHDOC.

REFERENCE(S):

"An Analytical Method for Deriving Conditional Probabilities of Kill for Target Components," by L. Kruse and P. Brizzolara, BRL IMR 1563, Dec 1971.

"Documentation of $P_{K/H}$ Computer Program," developed by Ballistic Research Laboratories, documented by Armament Systems, Inc., 1695 W. Crescent Avenue, Anaheim, CA, Nov 1974.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Current BRL "point-burst" type methodology for analytically estimating the vulnerability of a target requires a method for predicting the probability of rendering the target's components nonfunctional given that they are struck by some damage mechanism. PKHDOC is the model that provides estimates of component vulnerability to fragment impact.

4. STRENGTH(S) OF MODEL: Only model currently available to analytically predict component vulnerability. Alternative is to experimentally provide component vulnerability information which is not possible because of expense, quantity of components, manpower, and time require. Analytical predictions of model correlate well with experimental results.

5. LIMITATION(S) OF MODEL: Model does not explicitly account for damage to components from blast, shock, heat, fire, etc. (it is based only on damage caused by fragment penetration). Model is not sensitive to attack direction. Model does not handle some mathematical manipulations well.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Gary Durfee* or *Richard Kinsler*

PHONE NUMBER: VMT, extensions 5534.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: PKHDOC.

   REFERENCE(S): "Documentation of PK/H Methodology and Computer Program," developed by BRL, documented by Armament Systems Inc. of Anaheim, CA, Nov 74, BRL Report 1563, 1971. (AD#891805L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Computer model designed for deriving conditional Probability of Kill (P_K) analytically.

4. STRENGTH(S) OF MODEL: Provides a standard method for Probability of Kill (P_K) derivation.

5. LIMITATION(S) OF MODEL: Extremely cumbersome to develop required inputs for studies that have hundreds of critical components.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Ronald L. Henry*

   PHONE NUMBER: VLD, extension 2878.

1. TASK AREA/DISCIPLINE: Vulnerability (Unit Level Combat Effectiveness).

2. MODEL NAME: RCC.

REFERENCE(S):

ARBRL-TR-02156, April 1979. (AD#B037451L)

ARBRL-TR-02196 (Addendum to ARBRL-TR-02156), Sep 1979. (AD#B042085L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: The model evaluates the residual capability of a unit as a function of resources, hardening, training, and combat scenario.

4. STRENGTH(S) OF MODEL: The model interprets a wide and varied range of militarily significant parameters as they impact on combat effectiveness. The code supporting the model is highly user-oriented, and has been easily learned. The code is also quite fast.

5. LIMITATION(S) OF MODEL: No outstanding disadvantage.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: J. Terrence Klopcic

PHONE NUMBER: VLD, extension 7-3551.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: RIP

REFERENCE(S):

"Documentation of the NEW RIP Routine of the GIFT Code," by L. Losie and T. Hafer, ARBRL-TR-xxxxx, (manuscript in review).

"An Improved Method for Calculating the Kill Probability of a Critical Component in a Military Vehicle by a Burst of Fragments," W. B. Beverly. Journal of Ballistics, Vol 3, No.3, pp.593-614, 1979

"The Forward and Adjoint Estimation of the Kill Probability of a Critical Component in a Military Vehicle by a Burst of Fragments," W. B. Beverly. ARBRL-TR-xxxxx (manuscript in preparation).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Picks sample fragments from a spall burst and transports these sample fragments to possible impacts with critical components. Calculates kill probability of impacts.

4. STRENGTH(S) OF MODEL: Picks only fragments which have a high probability of impacting the critical component.

5. LIMITATION(S) OF MODEL: Uses large amounts of computer time; additional approximations injected into calculations of sampling procedure currently used.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *William Beverly*

PHONE NUMBER: VLD, extension 2853.

1. TASK AREA/DISCIPLINE: Vulnerability

2. MODEL NAME: Simple Lethality and Vulnerability Estimation Model (SLAVE).

   REFERENCE(S): None.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: SLAVE is a simplified point burst model used to predict the vulnerability of armored vehicles when attacked by a variety of munitions.

4. STRENGTH(S) OF MODEL: Main strengths of the model are that it is quick and inexpensive to run, it is flexible enough to handle many types of armored vehicles and a wide range of munitions, minimal knowledge of target components is needed to run the program.

5. LIMITATION(S) OF MODEL: The limitation of the model are the same as all point burst models, an insufficient, inadequate, outdated data base.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *F. Tyler Brown*

   PHONE NUMBER: VMT, extension 5432.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: STRIPR.

REFERENCE(S): No final report. This is BRL version of VAERA developed by G. Halloway (AMSAA).

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Vulnerable area program which yields summary vulnerable area tables for a number of azimuths per elevation angle as a function of kill level.

4. STRENGTH(S) OF MODEL: Flexible in regards to individual required inputs better run times than others.

5. LIMITATION(S) OF MODEL: Not standard. Doesn't handle projectiles. Doesn't yield individual component data. No correlation with component presented area.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Ronald L. Henry*

PHONE NUMBER: VLD, extension 2878.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: VAREA.

REFERENCE(S):

Published by Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), "VAREA Computer Program, Vol I, User Manual."

Published by Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), "VAREA Computer Program, Vol II, Analyst's Manual," JTCG/ME-71-6-2; TN 4565-1-71.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Fore runner of STRIPR. STRIPR allows analyst to look at horizontal zones on the target.

4. STRENGTH(S) OF MODEL: Flexible in regards to individual required inputs better run time than others.

5. LIMITATION(S) OF MODEL: Only handles basic fragment vulnerable areas, not geared to handle spall fragmentation effects (see VAST).

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Ronald L. Henry*

PHONE NUMBER: VLD, extension 2878.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: VAST.

   REFERENCE(S): "Vulnerability Analysis for Surface Targets (VAST) A Internal Point Burst Vulnerability Model," T. F. Hafer and A. S. Hafer, ARBRL-TR-02154, April 1979. (AD#B038960L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Vulnerable area program for fragments. Allows shaped charge and spall considerations.

4. STRENGTH(S) OF MODEL: Flexible.

5. LIMITATION(S) OF MODEL: Standard high run time for some routines.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Ronald L. Henry*

   PHONE NUMBER: VLD, extension 2878.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: VAST.

REFERENCE(S): T. F. Hafer, A. S. Hafer, "Vulnerability Analysis for Surface Targets (VAST) An Internal Point-Burst Vulnerability Model," ARBRL-TR-02154, Apr 1979. (AD#B038960L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: There are two primary approaches to vulnerability analysis; these approaches are compartment kill and component kill. In a compartment kill model the level of damage to a target is determined by using empirical curve of damage as a function of the parameters of the threat. These curves exist for each compartment of the target (i.e., engine compartment, crew compartment) and for each type of damage (i.e., Mobility, Firepower, and Catastrophic Kills). On the other hand, a component kill model uses conditional probability of kill ($P_{K/H}$'s) to assess damage to each essential component within the target, as well as the target as a whole. VAST uses a component kill approach to compute target vulnerability areas and/or target probabilities of kill (P_K's) for shaped charge jets or fragment from artillery rounds versus surface targets (i.e., tanks, Armored Personnel Carriers (APC's), missile systems, howitzers, etc.).

4. STRENGTH(S) OF MODEL: VAST is used to evaluate those targets for which compartment kill curves do not exist (i.e., missile systems), to evaluate the lethality of threats (such as fragments from artillery rounds) which are not readily evaluated by compartment kill models, or to assess detailed component/system vulnerability reduction measures.

5. LIMITATION(S) OF MODEL: Since VAST currently evaluates only shaped charge jets or fragments, the evaluation of such threats as bullets, long rod penetrators, mines, self-forging fragments, and high explosive (HE) rounds cannot be driven by the inputs of VAST. In evaluating these types of munitions the present approach is to "hard-wire" the necessary changes to VAST. In many cases, the assumptions underlying the changes may be questionable or may conflict with the code and result in a trial-and-error approach to obtain vulnerability/lethality estimates. Another difficulty is with the spall data bases. VAST currently characterizes spall from one of two data bases for spall debris formed during the penetration process. One of the data bases is for spall debris formed from shaped charge jets against rolled-hard armor (RHA) while the other data base is from steel fragments against aluminum armor. In the evaluation of other types of threats the analyst/user must use the spall characterization from these data bases (which is a questionable practice) or use experimental data from an inadequate number of test shots.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Lawrence D. Losie* VLD, extension 5749.

1. TASK AREA/DISCIPLINE: Vulnerability.

2. MODEL NAME: VAST (Vulnerability Analysis for Surface Targets).

REFERENCE(S): ARBRL-TR-02154, Apr 1979. (AD#B038960L)

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Calculates values used as probabilities of kill (mobility, firepower, catastrophic, mobility and firepower) due to shaped charge or certain kinetic energy projectiles. Performs vulnerability analysis upon systems, usually armored vehicles.

4. STRENGTH(S) OF MODEL: Available.

5. LIMITATION(S) OF MODEL: Not stochastic, penetration is only damage mechanism specifically considered, no synergestic effects, many submodels inadequate, target description time consuming.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

POINT OF CONTACT: *Douglas Ringers*

PHONE NUMBER: VMT, extension 5432.

1. TASK AREA/DISCIPLINE: Nuclear weapon effects/radiation transport.

2. MODEL NAME: Vehicle Code System (VCS).

   REFERENCE(S): ORNL-TM-4664, Oct 1974.

3. BRIEF DESCRIPTION OF WHAT MODEL DOES: Transports initial radiation from nuclear weapon burst to crew members of military vehicles or personnel in other shielding structures.

4. STRENGTH(S) OF MODEL: State-of-the-art calculations using a set of widely disseminated and tested computer codes.

5. LIMITATION(S) OF MODEL: Difficult to use computer codes; requires a highly trained analyst. Realistic problems require expenditure of large amounts of computer time.

6. FOR MORE INFORMATION REGARDING THIS MODEL:

   POINT OF CONTACT: *Al Rainis*

   PHONE NUMBER: VLD, extension 7-3655.

IV. INDEX 2 - MODEL/CODE NAME

V. INDEX 3 - POINT OF CONTACT

VI. INDEX 4 - WORD CONCEPT(S)

ACKNOWLEDGEMENTS

It is obvious that such a report as this would not be possible without the responsiveness of the Points of Contact noted above. To all of them, a hearty thank you. A note of thanks is also extended to Drs. Norm Banks, Mark Kregel and Larry Vande Kieft. Myra Hartwig typed the contents and, together with Dr. Bruce Henriksen, put the UNIX ststem through its paces.

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