COVART 6.1: FASTGEN Legacy Mode

User's Manual

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14. ABSTRACT
The prediction of damage to a target caused by the ballistic impact of projectiles has long been a goal of military analysts. One of the more widely accepted approaches to this problem is the shotline method. This method involves projecting rays of a specified direction through a target and describing the interactions along each ray.

The Fast Shotline Generator (FASTGEN) is computer program that executes the shotline method. The user inputs a geometric description of the desired target and specifies a threat type (whether KE or HE). The code then uses this information to generate rays representing the threat and traces these rays through the target. The end result of this process is the generation of files containing shotlines, ordered lists of components intersected by each ray. This manual describes how to use the FASTGEN5 legacy mode of the COVART6 computer program.

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Abstract

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The Fast Shotline Generator (FASTGEN) is computer program that executes the shotline method. The user inputs a geometric description of the desired target and specifies a threat type (whether KE or HE). The code then uses this information to generate rays representing the threat and traces these rays through the target. The end result of this process is the generation of files containing shotlines, ordered lists of components intersected by each ray.

In COVART6, the ray-generation and tracing capabilities of FASTGEN have been directly integrated into the COVART vulnerability assessment process. Two of the operational modes of COVART6 heavily depend upon these integrated capabilities: COVART6 integrated mode and FASTGEN5 legacy mode. This manual details how to use the FASTGEN5 legacy mode of COVART6.

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1. General Description

1.1 Introduction

Prediction of damage to a target caused by the ballistic impact of projectiles has long been a goal of military analysts. One of the more widely accepted approaches to this problem is the shotline method. This method involves projecting rays through the target with a specified direction and describing the encounters along each ray.

The Fast Shotline Generator (FASTGEN) is computer program that executes the shotline method. The user inputs a geometric description of the desired target and specifies a threat type (whether KE or HE). The code then uses this information to generate rays representing the threat and traces these rays through the target. The end result of this process is the generation of files containing shotlines, ordered lists of components intersected by each ray.

In COVART6, the ray-generation and tracing capabilities of FASTGEN have been directly integrated into the COVART vulnerability assessment process. COVART6 has three distinct modes of operation as outlined below:

1. COVART6 Integrated Mode – This is the primary mode of COVART6 that utilizes the integrated ray-tracing capabilities of FASTGEN and BRL-CAD. In this mode, COVART generates rays representing the threat, traces these rays through the target, and calculates the vulnerability of the target to the threat.

2. COVART5 Legacy Mode – This is a secondary mode of the code that calculates vulnerability using the inputs and processes used by COVART5. This mode does not utilize the integrated ray-tracing engines, so shotline information needs to be entered via an input file.

3. FASTGEN5 Legacy Mode – This is a secondary mode of the code that performs ray-tracing in a manner similar to FASTGEN5. This mode utilizes the integrated FASTGEN ray-tracing library to generate and trace threat rays through FASTGEN targets. This mode creates shotline output files that can be used as inputs to the COVART5 legacy mode.

This manual details how the user sets up and utilizes COVART6 in FASTGEN5 legacy mode.

FASTGEN traces rays representing a projectile's trajectory through a target. For the intents and purposes of the code, a target is a database of geometric data detailing the shape and extent of an entity in three dimensions. The target is divided into smaller objects called components, and components are built using geometric primitives called elements. When tracing a ray through the target, the components intersected by the ray are arranged in the order of encounter. This sequenced list of components along a ray is called a shotline, and a file containing these lists is a shotline file. Shotline files contain specific data about each of the components intersected by the ray. Some of the data included in these files are the following:

1. Group and component identification number

2. Location (in three dimensions)

3. Thickness (line-of-sight and normal)

4. Shotline obliquity angle.

The purpose of executing FASTGEN is to develop shotline data for use in other software, such as the Computation of Vulnerable Area Tool (COVART).

A failure modes, effects, and criticality analysis (FMECA) must be accomplished prior to preparing a FASTGEN target description. A FMECA is a multidisciplinary (reliability, maintainability, safety, survivability, etc.) system design evaluation procedure. The FMECA in itself does not determine the vulnerability characteristics of a target (Reference 5). The FMECA should be used as source data to determine which components are included in a FASTGEN target description.

Given a list of components determined by the FMECA, the geometric shape of each component is digitized by developing a three-dimensional target database. The target database can be at any level of resolution consistent within FASTGEN constraints. Components of the target database need to be larger than several sub-grids, and elements of components need to be larger than the sub-grid. The target database includes all flight and mission critical components of the operationally configured target. It also includes all components which effectively degrade the ability of a threat to cause damage/failure, i.e., shielding components. All air vehicle surfaces (skin and transparencies) are also modeled in detail because they shield or mask other components to some degree (Reference 5).

A FASTGEN target database is based on the paradigm that target surfaces can be approximated by a series of adjacent lines, triangles, quadrilaterals, cones, cylinders, spheres, and hexahedrons. This database preparation process is intricate and must be accomplished according to inherent FASTGEN logical requirements and limitations.

The source data for the geometric database may be obtained in several forms: engineering drawings, CAD/CAM database, NASTRAN internal loads model for structural data, and other digitized data. Using digitized source data greatly reduces the database generation task, but does not reduce the time required for debugging and error correction. The use of non-FASTGEN based data increases the time required to finalize the target description.

FASTGEN features assist the analyst with database development, error checking, and correction activities as well as enhance the compatibility with visualization tools and CAD/CAM software.

As FASTGEN continues to evolve, it is natural that methodologies developed for previous versions will be phased out. In this manual, text highlighted in *italicized blue* indicates a keyword that users are discouraged from using, as it is likely that it will not be recognized in future versions of FASTGEN.

1.2 Historical Background

1.2.1 FASTGEN 4

FASTGEN-4 development was motivated by the need to improve the generation of FASTGEN target descriptions. The original software and documentation were accomplished on a part time basis by the Systems Survivability Branch (ENSSS) in the Systems Analysis Division (ENSS) of the Directorate of Systems Engineering (ENS). The following people supported the original FASTGEN-4 code and documentation development: Hugh Griffis, Bill Kralik, and Marty Lentz. Additional development of FASTGEN-4 was completed by Hugh Griffis, Analysis IPT (XRA) within DSC of Development Planning (XR) at Wright Patterson Air Force Base.

The Ketron Division of the Bionetics Corporation (Frank M. Wiygul and Joseph B. Burk) also performed work on FASTGEN-4. This work included numerous corrections to the interference and element subroutines. The basic structure and data management remained unchanged. This version represented the first technically robust version of FASTGEN-4. FASTGEN 4.7 was the last version of FASTGEN restricted to the use of parallel rays. The VIEW3 option in FASTGEN-4 permitted a limited diverging ray analysis, but execution time was poor.

1.2.2 FASTGEN 5

FASTGEN-5 development was motivated by the need for a diverging-ray generation tool that was compatible with FASTGEN-4 target descriptions. The HEVART and PGEN diverging ray generation tools both have issues. An update of these tools was not attempted because HEVART has fundamental flaws and the PGEN code lacks FASTGEN element types as well as efficient coding practices. An additional goal of the FASTGEN-5 development effort was decreasing run time for VIEW3 runs. FASTGEN-5 development required significant restructuring of FASTGEN-4 source code. Geometric input data requirements for FASTGEN-5 are unchanged from FASTGEN-4. FASTGEN-5 is designed to use burst point data from COVART 4.3.

1.2.2.1 FASTGEN 5.2

FASTGEN 5.2, with its direct and reflected divergent burst ray generation, was developed by the Advanced Engineering & Sciences Division of ITT Industries (Mr. Wallace Westlake) to augment FASTGEN with a blast ray modeling capability.

1.2.2.2 FASTGEN 5.3

FASTGEN 5.3 was developed by the Advanced Engineering & Sciences Division of ITT Corporation. The purpose of FASTGEN 5.3 was to update the methodologies of FASTGEN's diverging burst ray capability and its ability to communicate with COVART and its different modular parts. In addition, several SHAZAM-like capabilities based on the desire to improve the handling of dynamic encounters were implemented. Internal and external burst points are permitted. A direct hit capability is not present in the current release of FASTGEN. This set of features is commonly called the Advanced Diverging Ray Methodology (ADRaM).

FASTGEN 5.3.5 was also developed by the Advanced Engineering & Sciences Division of ITT Corporation. The purpose of FASTGEN 5.3.5 was to update the methodologies of FASTGEN to include uniform air blast, direct hit capability, and enhancements for large targets with very dense components. Precision improvements for specific calculations, dynamic memory allocation, and the dynamic use of system resources to improve performance were also included.

1.2.2.3 FASTGEN 5.4

As a result of increasing target file sizes and calculation precision issues, FASTGEN was migrated by ITT Corporation from FORTRAN 77 to FORTRAN 90. This allowed the use of dynamically-allocated arrays as well as a means to internally specify the precision. Internal precision specification not only affected the handling of physically-large targets, such as transports, but it also impacted the slight differences in results occurring across computing platforms, especially those differences occurring between the Linux and Windows operating systems.

FASTGEN 5.4.4 added a feature that allows the user a choice in the threat velocity to use when vectoring ADRaM rays. With this feature, a user can select a designate a fixed burst point velocity in the CONTROL file or use the burst velocity calculated by COVART during the burst point location run. Additional error reporting capabilities and minor but fixes were also included with this release.

An output file to support the JCAT Combat Assessment Tool was added, in addition to some minor bug fixes, with the release of FASTGEN 5.4.7

1.2.2.4 FASTGEN 5.5

The ITT Corporation incorporated a number of major improvements in this release to support multi-hit assessments and the expansion of features available for the Combat Assessment Tool (CAT).

The multi-hit capability allows users to assess bullet and fragment threats as groups of impacts. This feature was added to provide a means to model bursts of small arms fire. Like other shotline information, COVART uses this data to assess the vulnerability of the target to this kind of threat, taking into account multiply-vulnerable failures due to the multiple threat impacts. For more information on this capability, refer to "COVART 5.1 Users Manual" (JASP-M-07-03-003) and "Multiple Hit Methodology for KPPs" (M-07-07-001).

CAT support includes the ability to provide data to COVART for computation of penetration information. For more information refer to "COVART 5.1 Users Manual" (JASP-M-07-03-003) and "Combat Assessment Tool Users Manual" (JASP-M-07-05-001).

1.2.2.5 FASTGEN 6.0

FASTGEN 6.0 is not a standalone executable but another name for the FASTGEN5 legacy mode of the COVART6 computer program. As such, major modifications were made to FASTGEN in order to integrate it into COVART6. During this integration activity, several key FASTGEN processes were identified and separated into modules. This effort resulted in the creation of the following code entities:

1. Ray-tracing library

2. Ray-generation module

The FASTGEN ray-tracing library encapsulates the features that interact with the target file and traces rays through the target. This library introduces a new method of target-shredding (grouping elements to increase ray-tracing efficiency) called voxelization. This methodology replaces the subcomponent methodology found in previous versions of FASTGEN. For more information on voxelization, refer to the FASTGEN 6.0 Theory and Implementation manual (Reference 15).

The ray-generation module contains the FASTGEN functions necessary to translate the threat definition into a series of rays. In this module, a threat template is created based on the threat defined by the user, and rays are generated by applying this template to the conditions of the simulation.

Besides these modules, FASTGEN 6.0 also introduces a new VIEW/SHOT record combination, VIEW4/SHOT4. This combination allows the user to assign differing attack aspects to unique groups of aim points. This record combination represents an improvement over the capability currently provided by the VIEW3 record.

1.3 Coordinate System Definitions

This section defines and briefly describes the coordinate systems used by FASTGEN to execute the different shotline and diverging ray options available to the user via the CONTROL file. To provide accurate input to FASTGEN in the CBULK and CONTROL files, the user should be familiar with these coordinate systems and their limitations. In general, the function of a coordinate system transformation is to simplify a complex process.

The construction of the FASTGEN target model contained in the CBULK file, found in the Target Database Definition, occurs in the target coordinate system. When (AZ, EL) orientations are specified using a VIEW1/2/3/4 input record, this is telling FASTGEN the angles to use to transform the target to the shotline coordinate system. Although the target is only read once, a conventional vulnerability analysis that uses parallel ray tracing will rotate the target multiple times based on the number of different orientations the user specifies in the CONTROL file. Transforming the shotline/target interaction process into the shotline coordinate system greatly simplifies the process of computing LOS information.

The introduction of advanced ray tracing methodologies and new threat types increases the number of coordinate systems required by FASTGEN to efficiently implement these methodologies. In the context of diverging burst rays, the LOS process outlined above for shot lines was expanded, and applied to fragments that fly off the threat warhead when it explodes. Burst rays representing these fragments are projected from the burst point along linear trajectories in a variety of directions, each defined by an independent (AZ, EL) view orientation relative to the target. The fragment fly out process for a dynamic threat/target environment dictates the introduction of a coordinate system oriented with the fragment trajectory. This coordinate system is redefined for each burst ray that flies off the threat, with the burst ray's velocity vector aligned with its trajectory.

Traditional FASTGEN ray tracing is limited to static threats and a static target. Migration of dynamic encounter methodologies from the SHAZAM endgame analysis code to FASTGEN introduces additional coordinate systems associated with the threat velocity and target velocity. The orientation of these coordinate systems with respect to their static counter parts are achieved using yaw, pitch, and roll angle definitions. In addition, when each burst ray interacts with the moving target, a relative velocity coordinate transformation is utilized.

To summarize, for a fully dynamic threat/target environment, a total of six coordinate system definitions are used by FASTGEN: the target spatial coordinate system, the target velocity coordinate system, a view coordinate system representing the attack aspect of the threat velocity vector relative to the target velocity coordinate system, the fragment spatial coordinate system, the fragment velocity coordinate system, and the relative velocity coordinate system which is defined locally for each burst ray.

1.4 Input Files

1.4.1 MASTER Input File

Since FASTGEN legacy mode is a part of COVART6, the COVART6 simulation control file is required to access this capability. This file, called the MASTER file, must be directly piped to COVART6 for every execution of the code. However, only two records are required to be in the MASTER file to utilize FASTGEN5 legacy mode, one to specify the desired operational mode of COVART6 and another to denote the end of the file. A short description of these records can be found in Table 1-1. These records are defined in more detail in Section 3.

Table 1-1 MASTER File Records

MODE	-	Defines the operational mode of COVART6.
ENDDATA	-	Denotes the end of the MASTER file.

1.4.2 CONTROL Input File

The case control file contains available analysis solution options. The relatively small case control file is independent of the larger bulk data file. Therefore, the case control file may be altered without introducing errors into the bulk data file. (Note: All case control files created for use with FASTGEN5 legacy mode must have the file name CONTROL.)

FASTGEN has the capability to analyze parallel shotlines:

1. A Rayleigh, two dimensional normal, distribution of shotlines about an aim point (SHOT1)

2. Multiple shotlines over a two-dimensional grid (SHOT2)

3. A single shotline at an aim point (SHOT3)

4. Multiple shotlines at multiple aim points (SHOT3)

5. Multiple shotline locations and orientations (VIEW3, VIEW4/SHOT4).

6. A user-specified distribution of shotlines about an aim point (MULTIHT1)

FASTGEN has the capability to analyze diverging fragment rays:

1. Multiple burst points based on a SHOT2 run with omni-directional diverging rays (BURST2)

2. Multiple burst points based on a SHOT2 run with diverging rays that are threat definition specific (BURST1)

3. Multiple burst points based on user input locations with diverging rays that are threat definition specific (BURST4)

4. Single burst points based on a SHOT3 run with diverging rays that are threat definition specific (BURST5);

FASTGEN has the capability to analyze diverging air blast rays:

1. Multiple burst points with uniform rays diverging in all directions (BLAST1)

Table 1-2 Target Orientation Options

VIEW1	-	Defines the target description orientation for 1 view.
VIEW2	-	Defines the target description orientation for 3, 6, 13, and 26 views.
VIEW3	-	Defines the target description orientation for a specific aim point.
VIEW4	-	Defines the target description orientation for a series of aim points.

Table 1-3 Parallel Ray-Tracing Options

SHOT1	-	Defines the location of shotlines. Single shotline at an aim point or several shotlines distributed about an aim point by using a Rayleigh distribution.
SHOT2	-	Defines the location of shotlines. The shotlines are distributed over the target by using a uniform grid.
SHOT3	-	Defines the aim point location of one shotline
SHOT4	-	Defines the aim point location of one shotline associated with the target description orientation defined by a VIEW4 record.
MULTIHT1	-	Defines the offset from the aim point for a Multi-hit shotline

Table 1-4 Diverging Fragment Ray-Tracing Options

BURST1	-	Defines multiple burst points based on a SHOT2 run with diverging rays that are threat definition specific. Valid burst point sources are from the COVART format burst point location file.
BURST2	-	Defines multiple burst points based on a SHOT2 run with uniform rays diverging in all directions. Valid burst point sources are from the COVART format burst point location file. This is intended as a replacement for burst ray generation provided by the PGEN tool.
BURST4	-	Defines multiple burst points based on user input locations with diverging rays that are threat definition specific.
BURST5	-	Defines single burst points based on a SHOT3 run with diverging rays that are threat definition specific.

NOTE: Due to limitations of FASTGEN and COVART all BURST1 and BURST2 options based on FASTGEN SHOT2 runs MUST be in a single VIEW.

Table 1-5 Diverging Air Blast Ray-Tracing Option

BLAST1	-	Defines uniform air blast rays. These air blast rays are traced through the target along uniformly created rays. These rays provide information on all the components encountered along each ray. This information is passed out to COVART through the OFRAGA or OFRAGB files for post-processing and analysis.

Table 1-6 Output Options

OUTPUT1	-	Defines files that are created which contain the primary LOS output data.
OUTPUT2	-	Defines type of information output to the OERROR file. This information assists the analyst in target description debugging and error correction.
OUTPUT3	-	Defines files that are created which contain additional LOS data.

Table 1-7 Reduced Target Processing Options

ENV	-	Defines a subset of the target description to reduce the analysis set.
DEL	-	Defines components that are deleted from the analysis.
CRIT	-	Defines critical components. Shotlines that intersect critical components are used for LOS output.
LIMITS	-	Maximum and minimum density of rays, and maximum length of a ray.

Table 1-8 Miscellaneous Options

ANCHOR	-	Defines the target coordinates of the lower left hand corner of the beginning location of a gridded run.
BULK	-	Defines the end of the case control file.
CRANBACK	-	*Defines the random number seed used with backing components.*
$COMMENT	-	Defines user comments.
FOOTER1	-	Echo FASTGEN input to a COVART input file. Only used with VIEW3.
FOOTER2	-	Echo FASTGEN input to a COVART input file. Only used with VIEW3.
TRGTPAR	-	Defines target yaw, pitch, roll, and speed for dynamic fragment ray modes. This data is intended for use with BURST1, BURST4, and BURST5 only.
THRTPAR	-	Defines threat yaw, pitch, roll, and speed for dynamic fragment ray modes. This data is intended for use with BURST1, BURST4, and BURST5 only.
UNITS	-	Defines units of distance.

A detailed description of the CONTROL file is in Section 4 of this manual.

1.4.3 CBULK Input File

The CBULK input file defines a target that is composed of complex geometric shapes (objects). These objects are modeled by using a series of points and simple geometric primitives called elements. (Note: All target databases created for use with FASTGEN5 legacy mode must have the file name CBULK.) Locations in space are defined through the use of points. All points are defined in the Cartesian target spatial coordinate system.

Elements define the surfaces of an object. Elements are defined by connecting a series of points. Objects are defined within global regions called *groups* and local regions called *components*. Each component must be initialized with a SECTION record.

The FASTGEN database has hierarchical, relational, and object oriented features. Objects are classified by group, component, and element. A group identification number defines a general class of objects. A component identification number defines a specific object. An element identification number defines a portion of a specific object. An example of this classification system is an engine control unit panel. The engine is in the power plant group, the control unit is a component in the power plant group, and the panel is an element in the control unit component.

Components may be modeled in plate or volume mode. A plate mode component is assumed to be a thin plate that only has one surface modeled. The LOS for an element in a plate mode component is the element thickness divided by the cosine of the obliquity angle. A volume mode component is assumed to be a solid volume. The component LOS for a volume mode component is the distance from the volume entrance to the volume exit.

A component in volume mode must be totally enclosed. Gaps and openings are not permitted. Volume mode components are intended to represent solid items in the target and must be continuous. Certain modeling exceptions are recognized to exist with a user-defined interference. The term "interference" refers to anything that intersects a volume component. The user-defined interference is an intentional intersection of the volume mode component for modeling simplification. An example of a user-defined interference is a hydraulic line running through a fluid volume. FASTGEN identifies all interferences and includes these in the OERROR output file, unless the user provides a WALL record. The WALL record identifies to FASTGEN that the interference was intentional modeling by the user and will suppress reporting the interference. Volume subtraction is accomplished by defining a HOLE record associated with a volume component. All HOLE and WALL records must precede the first section record.

The surrounding component must be in the volume mode, and the interfering component may be in volume or plate mode. A typical example of a surrounding volume is a fuel tank. This tank could have bulkheads modeled as plates. The bulkhead component identification number would be identified on a WALL record. A large channel in this tank could be modeled with volume subtraction. The channel component identification number would be identified on a HOLE record.

In most cases, fuel tanks will be partially full at fuel loadings specified for vulnerability assessments. Therefore, a fuel tank will contain both fuel and ullage. To conveniently model the ullage in the tank, a feature exists (COMPSPLT record) to easily define the fuel/ullage boundary within the fuel tank. All COMPSPLT records must precede the first section record.

Older target descriptions will typically be of a lower fidelity than more recent targets. Updating these older descriptions may be necessary but the resources may not allow the user to explicitly model all *elements of the target. This would typically be true for the structural aspects of the model. Therefore, a feature is available (CBACKING record) that will allow the user to randomly insert thin components behind existing components to capture the effects of this new component without explicitly modeling it. The use of CBACKING is not a preferred modeling approach.*

The CHGCOMP feature will allow the user to alter the shotline trace histories (LOS file) without changing the target description. The CHGCOMP record identifies the component to be changed, the component that triggers the change and the new component number. If the component to be changed appears on the shotline after the trigger component, the change in component number will occur. This feature was developed to control the assigned P_K values for rocket motor propellant impacts, but could be used for other purposes if its use is deemed appropriate.

Internal documentation within the database is possible and strongly recommended. Each component should have one or more $COMMENT records to describe the component being modeled. Model developers should generate a set of keywords, i.e. LRU, electrical cable, etc., to be used on the $NAME record. These keywords are application and database dependent. $NAME records should contain a group and component identification number. A master list of keywords should appear within the database. This small task of documenting the database greatly improves the quality and maintainability of the database.

The name of the target description is defined with the VEHICLE record.

A short description of these records can be found in Table 1-9. A detailed description of the contents of the CBULK file is provided in Section 5 of this manual.

The user should refer to the FASTGEN6 Target Description document for changes to the CBULK description.

Table 1-9 CBULK File Records

GRID	-	Defines the location of a 3-D geometric point.
CLINE	-	Defines a line shaped element.
CTRI	-	Defines a triangular shaped element.
CQUAD	-	Defines a quadrilateral shaped element.
CSPHERE	-	Defines a sphere shaped element.
CCONE1	*-*	*Defines a thin wall cone/cylinder shaped element.*
CCONE2	-	Defines a thick wall cone/cylinder shaped element.
CCONE3	*-*	*Defines a compound thick wall cone/cylinder shaped element.*
CHEX1	-	Defines a thin wall hexahedron shaped element.
CHEX2	-	Defines a solid hexahedron shaped element.
CBAR	*-*	*Defines a reinforcing member typically associated with a structural component. Use of this element is not recommended.*
SECTION	-	Defines the beginning of a new component.
HOLE	-	Defines a hole within a surrounding volume. Subtracts a volume or a plate from the outer volume.
WALL	-	Defines the intersection of two or more components.
COMPSPLT	-	Define the fuel level within a fuel tank.
CBACKING	*-*	*Defines a thin component behind an existing component to capture the effects of this new component without explicitly modeling the component.*
CHGCOMP	-	Alter the trace history of a shotline without changing the target description.
$COMMENT	-	Defines user comments.
$NAME	-	Defines names of groups and components.
VEHICLE	-	Defines the vehicle code. (can only be used once)

1.4.4 CTHREAT Input File

The CTHREAT input file contains threat related information obtained by analysts from a wide range of sources. FASTGEN assumes that a threat may be represented by a cylindrical object that contains a warhead. The point in space where this warhead explodes is the burst point. The user, using information from the intelligence community or their own experience, specifies how the fragments fly off the warhead using the polar zone concept. To take advantage of this advanced diverging ray capability (ADRaM), the user must create a file called CTHREAT, and execute a FASTGEN simulation using the BURST1, BURST4, or BURST5 control parameters. A listing of the records found in the CTHREAT file is in Table 1-10. A detailed description of this file is in Section 6 of this manual.

Table 1-10 CTHREAT File Records

$COMMENT	-	Defines user comments.
FRAGDEF	-	Define individual fragment or fragment group characteristics within static polar zones.
HECHAR	-	Define threat related warhead distance and warhead length parameters.
POLARZON	-	Define threat related static polar zones and local burst ray generation parameters.
PROJDIAM	-	Define threat related diameter parameter.
PROJLEN	-	Define threat related length parameter.
THRTSTAT	-	Define threat low density zone characteristic parameters.
ENDDATA	-	Defines the end of the CTHREAT file.

1.4.5 CCOVBP Input File

The only additional input file that might be needed by FASTGEN is an output file from COVART. This file, CCOVBP, contains burst point location information and is usually generated by the burst point location feature (BPLOC) in COVART. This input file is only used by the BURST1, BURST2, and BURST5 control records. A detailed description of this file is in Section 7 of this manual.

1.5 Output Files

1.5.1 OPKSA Output File

This file is created by setting the PKSA flag in the OUTPUT1 record. This file contains packed line-of-sight output data in an ASCII format. A detailed description of this file is in Section 8 of this manual.

1.5.2 OPKSB Binary Output File

This file is created by setting the PKSB flag in the OUTPUT1 record. This file contains packed line-of-sight output data in a binary format. A detailed description of this file is in Section 9 of this manual.

1.5.3 OUNPKA Output File

This file is created by setting the UNPKA flag in the OUTPUT1 record. This file contains unpacked line-of-sight output data in an ASCII format. A detailed description of this file is in Section 10 of this manual.

1.5.4 OLOSV Output File

This file is created by setting the LOSV flag in the OUTPUT3 record. The file OLOSV is provided to enable display of the LOS data. A detailed description of this file is in Section 11 of this manual.

1.5.5 OCHEM Output File

This file is created by setting the CHEM flag in the OUTPUT3 record. The OCHEM file is provided to support the aircraft Residual Chemical Hazard Evaluation Model (RCHEM). The OCHEM data only *contains the first and last hits (essentially the outer mold line) of the shotline. A detailed description of this file is in Section 12 of this manual.*

1.5.6 *OCDF Output File*

This file is created by setting the CDF flag in the OUTPUT3 record. The OCDF file can be displayed with the VISAGE visualization program. A detailed description of this file is in Section 13 of this manual.

1.5.7 *OCOEFA Output File*

This file is created by setting the ICOA flag in the OUTPUT3 record. Some applications of the shotline method require a complete surface description for each intersection. Two sets of direction cosine data output (entrance and exit) are provided in an ASCII format. A detailed description of this file is in Section 14 of this manual.

1.5.8 *OCOEFB Binary Output File*

This file is created by setting the ICOB flag in the OUTPUT3 record. Some applications of the shotline method require a complete surface description for each intersection. Two sets of direction cosine data output (entrance and exit) are provided in a binary format. A detailed description of this file is in Section 15 of this manual.

1.5.9 OCOVART Binary Output File

This file is created by setting the COVBP flag in the OUTPUT1 record. OCOVART is a binary file containing PGEN replacement mode line-of-sight (threat shotlines and burst rays) data that can be used in COVART. This file is also used to support the Multi-Hit ray tracing capability. A detailed description of this file is in Section 16 of this manual.

1.5.10 OCOVARTA Output File

This file is created by setting the COVBPA flag in the OUTPUT1 record. OCOVARTA is a version of the OCOVART file in an ASCII format that is only available with the Multi-Hit capability. A detailed description of this file is in Section 17 of this manual.

1.5.11 *OBURST Output File*

This file is created by setting the BURST flag in the OUTPUT1 record. OBURST is the BRL-CAD burst point file format. A detailed description of this file is in Section 18 of this manual.

1.5.12 OFRAGB Output File

This file is created by setting the IFRGB flag in the OUTPUT1 record. This binary file is generated by FASTGEN when a BURST1 simulation is executed and the appropriate flag on the OUTPUT1 control record is activated. This file only contains information on burst rays that actually hit the target. This file is the primary mechanism for passing diverging burst ray information from FASTGEN to COVART. A detailed description of this file is in Section 19 of this manual.

1.5.13 OFRAGA Output File

This file is created by setting the IFRGA flag in the OUTPUT1 record. This ASCII file is generated by FASTGEN when a BURST1 run is made and the appropriate flag on the OUTPUT1 control record is activated. This file contains information on the burst rays emanating from the threat that impact the target. This file is a superset of the information that is passed to COVART via the OFRAGB file. For production runs, this file should not be generated due to its potentially large size. As multiple burst rays per real fragment can potentially occur, a polar zone/fragment number key combination is output in this file to allow external programs to efficiently access information in CTHREAT file. A detailed description of this file is in Section 20 of this manual.

1.5.14 ODISPLAY_THREAT Output File

This file is created by setting the ITHRT flag in the OUTPUT3 record. This ASCII file is generated by FASTGEN when a BURST1, BURST4, or BURST5 simulation is executed and the appropriate flag on the OUTPUT3 control record is activated. This file is a FASTGEN geometry file that contains CCONE2, CLINE, CSPHERE, and GRID records that aid the visualization of burst rays emanating from the threat burst point. CCONE2 elements are used to construct simplified representations of the threat, the warhead, and the polar zones associated with fragment fly out. This file is intended for use by any visualization package that can interact with the FASTGEN target elements. A detailed description of this file is in Section 21 of this manual.

1.5.15 OERROR Output File

This file is created by setting the ERR flag in the OUTPUT2 record. Errors encountered during the execution of FASTGEN are output in the ASCII file, OERROR. Error messages are the result of incorrect user inputs, target database errors, and exceeding software array bounds. Examining the contents of OERROR also allows the user to follow the progress of a FASTGEN simulation. By default, when FASTGEN identifies a problem with user input or a target modeling error, the error or warning message is output to the OERROR file, not to the user's terminal. **Important! The user should always check the contents of the OERROR file after every FASTGEN simulation.** A detailed description of this file is in Section 22 of this manual.

1.5.16 ODIAGMSGS Output File

This file is created by setting the DIAG flag in the OUTPUT2 record. Messages contained in this file are complimentary information contained in the OERROR file. Specific messages are provided for interferences, open volumes, degenerate elements, and improperly specified element modes. A count of each of these is kept and the percentage of shotlines encountering these errors is calculated. A detailed description of this file is in Section 22 of this manual.

1.5.17 ODIAGLIST Output File

This file is created by setting the DIAG flag in the OUTPUT2 record. This file contains a list of interferences occurring during the FASTGEN run. A detailed description of this file is in Section 22 of this manual.

1.5.18 RBURST Output File

This file is created by FASTGEN when a SHOT1, SHOT2, SHOT3, or BURST4 simulation is executed and the IRBURST flag on the OUTPUT3 record is activated. This is an optional output file that is used to support the Combat Assessment Tool (CAT). This ASCII file lists the target components intersected by the rays representing the threat. A detailed description of this file is in Section 23 of this manual.

1.6 Software Description

The arrays in FASTGEN are sized so that a target description with 149,850,000 (50 groups times 999 components times 3000 elements) elements and grid points can be processed. These sizes can be adjusted by altering the parameter statements defined in the FASTGEN source code. The predefined sizes should be large enough to support traditional FASTGEN target descriptions (Non-CAD targets) while not exceeding the user's computer system capacity. CAD-based FASTGEN target descriptions typically have large numbers of very small elements. This creates requirements for each target that are unique and may necessitate the modification of these FASTGEN parameter statements. The subroutines comprising FASTGEN5 legacy mode are written in ANSI Standard FORTRAN 90.

1.7 Modeling Limitations

1.7.1 Spatial overlap

FASTGEN components should not spatially overlap other components except where HOLE and WALL records are used. Spatial overlap of one element's thickness into another element's thickness is not permitted, and FASTGEN will take steps to remove the overlap or report it as an error. However, plate mode components that use CTRI, CQUAD, and CHEX1 elements will have spatial overlap. A spatial overlap occurs at each element's edge when two or more non-coplanar surfaces with thickness intersect. Restricting element thickness reduces the spatial overlap error. Although there are legitimate uses for elements in plate mode components, it is recommended that all future target modeling should use volume mode components.

1.7.2 Component and Element Size

FASTGEN processes elements and components using a mixture of double and single precision floating point calculations. This creates problems when the components are geometrically small, or contain geometrically small elements. Imprecision issues during the calculation of element area, obliquity angle, and intersection may occur when small elements and small components are used in the target model. The inclusion of small elements and components also significantly increases runtime without providing any improvement in the output results.

1.8 FASTGEN Utilization

FASTGEN can ray trace single rays, parallel rays, PGEN-style diverging rays, ADRaM-style diverging fragment rays, and uniform air blast rays through the defined target.

Table 1-11,

Table 1-12, and Table 1-13 briefly summarize some of the potential uses of FASTGEN. Detailed FASTGEN use is covered in Section 2 of this manual.

Table 1-11 FASTGEN Parallel Ray Modes

	VIEW1	VIEW2
SHOT1	Case 1: Allows runs of several shotlines from one aim point using a Rayleigh distribution.	Case 2: Allows runs of several shotlines from one aim point using a Rayleigh distribution in a predefined set of attack aspects.
SHOT2	Case 3: Allows runs of multiple parallel shotlines based on a grid.	Case 4: Allows runs of multiple parallel shotlines based on a grid in a predefined set of attack aspects.
SHOT3	Case 5: Allows runs of one or more shotlines at aim points provided on SHOT3 records.	Case 6: Allows runs of one or more shotlines at aim points provided on SHOT3 records in a predefined set of attack aspects.
MULTIHT1	Case 7: Allows runs of one or more shotlines distributed about an aim point provided by either a SHOT2 or SHOT3 record.	Case 8: Allows runs of one or more shotlines distributed about an aim point provided by either a SHOT2 or SHOT3 record in a predefined set of attack aspect.

Table 1-12 FASTGEN Diverging Ray Modes

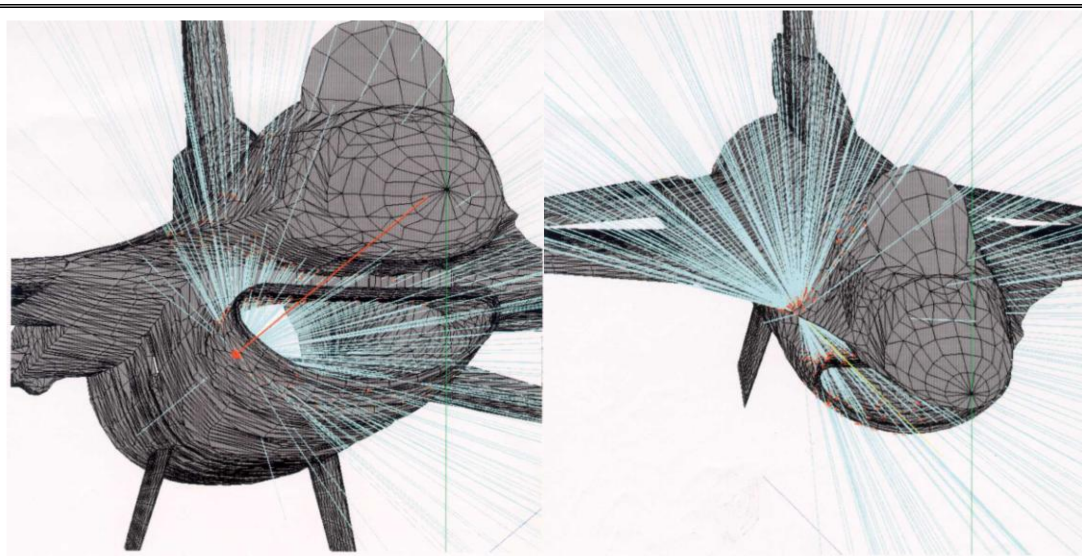
	Fragment Rays Only	Fragment Rays and Uniform Air Blast (BLAST1)
BURST1 (ADRaM Rays)	Case 9: Allows multiple burst point runs with burst coordinates input from the CCOVBP file	Case 10: Same as Case 9 with uniform air blast rays included in the OFRAGB file.
BURST4 (ADRaM Rays)	Case 11: Allows multiple burst point runs with coordinates specified by the user on the BURST4 record. Different threat orientations may be specified using multiple VIEW1 and BURST4 record pairs.	Case 12: Same as Case 12 with uniform air blast rays included in the OFRAGB file.
BURST5 (ADRaM Rays)	Case 13: Allows single burst point runs with burst coordinates input from the CCOVBP file	Case 14: Same as Case 15 with uniform air blast rays included in the OFRAGB file.
BURST2 (PGEN Rays)	Case 15: Allows runs of multiple burst points with burst coordinates input from the CCOVBP file. *	
* PGEN style rays are uniform rays drawn through the target. These rays are used for both fragment rays and uniform air blast rays. As a result, this mode does not use a BLAST1 style run.		

Table 1-13 External Ray Generation Mode

VIEW3	Case 20: Allows runs of one projectile in a unique direction. This has a view and an aim point associated
VIEW4/SHOT4	Case 21: Allows groups of projectiles to be run in a unique direction. VIEW4 records provide the attack aspect and can be associated with one or more aim points provided by SHOT4 records. When processed, the aim points associated with a given VIEW4 record are run as one group through FASTGEN. Multiple VIEW4/SHOT4 combinations can be handled by the code.

Results from a typical FASTGEN internal burst point simulation are visualized in Figure 1-1. In these pictures, a burst point was placed inside the F-16. Blue lines in this figure are rays emitted from the burst point. The red line is the shotline, and the red points indicate intersections with the target elements on the F-16 body.

Figure 1-1 F-16 Internal Burst Point Visualization



2. Using FASTGEN

The FASTGEN5 legacy mode of COVART6 can be used to generate shotline data for a variety of analyses. The inputs and outputs of FASTGEN were designed to be flexible enough to accommodate a wide variety of applications.

FASTGEN legacy mode requires specific inputs to run. These inputs are contained in files that have fixed formats and provide the data required to trace threat rays through a target. There are currently five input files required to run this mode of COVART6:

1. MASTER – Defines the operational mode of COVART6
2. CBULK – Contains the target model geometry
3. CONTROL – Contains the case control data
4. CTHREAT – Contains the threat definition information
5. CCOVBP – Contains burst point location information

The MASTER, CBULK, and CONTROL files are always required; the CCOVBP is required for impact-based HE threats, and the CTHREAT file is required for ADRaM HE threats.

The output files are selected through records contained in the CONTROL file. Many of the output files are associated with specific modes of FASTGEN operation. These files are further segregated into primary LOS files and additional information files.

FASTGEN is run in either a one-pass or two-pass process. The one-pass process is used for all shotline and proximity burst ray runs. The two-pass process is used for all impact-based diverging ray runs. In the two-pass process the first pass generates parallel ray shotlines. The output of this run is processed by COVART to create a COVBP file containing the detonation location for each shotline. The second pass through FASTGEN uses the COVBP file as an input to place the center point of the diverging rays along the shotline. FASTGEN then processes each diverging ray through the target.

An update to FASTGEN included a mode for processing multiple parallel shotlines as if they were rays to support a Multi-hit methodology. This capability is a one-pass process that requires the user to input information about the COVART threat into FASTGEN records. This information is passed to COVART to identify the correct threat and velocity that is associated with intersection data for a particular shotline. Although this is a parallel ray technique, the Multi-hit mode uses a diverging ray OCOVART output file.

2.1 Kinetic Energy (KE) Threat Type Modes

Kinetic energy (KE) types of threats include AP, API, and single fragment threats. These types of threats are generally analyzed by using a single FASTGEN pass to generate shotlines through a target. These shotlines may be a single shotline, a group of shotlines about an aim point, a collection of single shotlines, or multiple parallel shotlines associated with a uniform grid. The output of FASTGEN is fed into COVART for penetration, damage, and vulnerability calculations. This is the called single-pass process since FASTGEN is only run once for these types of threats.

2.1.1 KE Views

Each FASTGEN run will have at least one view. A view is defined as an attack aspect between the threat and the target. For KE threats, this attack aspect is provided by the user as an azimuth and elevation that is referenced between the threat and the target in the target spatial coordinate system. Vulnerability and survivability analyses currently use 26 principal views. A discussion of view can be found in Section

4.2.6. The VIEW1 record allows the user to input a single view that can be any azimuth and elevation desired. The VIEW2 record allows a selection of 4 different groups of the predefined principal views. If multiple VIEW1 records are included in the CONTROL file with the same azimuths and elevations as the selected VIEW2 record selection, the output data from both runs will be identical.

For the parallel shotline generation portion of FASTGEN, either a VIEW1, VIEW2, or VIEW4 record is acceptable, but there are specific requirements when FASTGEN is run in preparation for HE analysis, that will only allow the use of single VIEW1 records. This is due to limitations in FASTGEN and COVART when running High Energy (HE) threat types. This is mentioned here since often a parallel shotline run will be used as the basis for both KE and HE type threats. It is recommended that rather than use a single FASTGEN run to analyze multiple VIEW1 records, that this analysis be broken into multiple FASTGEN runs analyzing different individual VIEW1 records. This will always provide output from FASTGEN that can be used by COVART, and in turn fed back into FASTGEN for a second pass.

2.1.2 Output Data

FASTGEN has several output files, and each file provides specific information. Some of these selections are not valid with some control file record selections. Table 2-1 lists the output files that contain valid data for KE threat type FASTGEN runs. The OUTPUT1, OUTPUT2, and OUTPUT3 records hold options that allow the user to select the specific output files or content desired.

2.1.2.1 Error and Warning Output Files

2.1.2.1.1 OERROR File

The OERROR file contains the errors and warnings generated during a FASTGEN run. This file contains significant information about issues found by FASTGEN during the ray-tracing process. Modeling issues as well as problems completing a run are reported in this file. Options for the OERROR file are contained on the OUTPUT2 record.

2.1.2.1.2 ODIAGMSGS File

The ODIAGMSGS file contains details of the errors that occur during a FASTGEN run. Options for the ODIAGMSGS file are contained on the OUTPUT2 record.

2.1.2.1.3 ODIAGLIST File

The ODIAGLIST file contains details of the errors that are generated during a FASTGEN run. This file contains a list of the items that are included as a summary in the ODIAGMSGS file. Options for the ODIAGLIST file are contained on the OUTPUT2 record.

2.1.2.2 Primary Output Files

The primary output files for parallel ray runs are the OPKSA, OPKSB, and the OUNPKA output files. OPKSA and OUNPKA are ACSII files used by the analyst when a human readable version of the LOS data is needed. OPKSB is typically the binary file that is passed along to COVART. The OUTPUT1 record is used to select the primary files for a FASTGEN run.

2.1.2.3 Additional Output Files

There are additional output files for parallel ray runs: OCHEM, OLOSV, OCOEFA, and OCOEFB. These files are only used for specific unique purposes such as visualization of the shotlines or residual chemical analysis. The OUTPUT3 record is used to select any additional files for a FASTGEN run.

2.1.3 CONTROL Cases for KE Modes

The following sections describe various FASTGEN modes of operation, the CONTROL file inputs, and the available output files for the most commonly used KE FASTGEN functions. Figure 2-1 shows an example of a FASTGEN KE threat type CONTROL file.

Figure 2-1 Example FASTGEN KE Threat Type CONTROL File

```
$COMMENT This is a grid based parallel ray example
$COMMENT       2       3       4       5       6       7       8
$COMMENT12345678123456781234567812345678123456781234567812345
$COMMENT    pksb    pksa    upka
OUTPUT1        1       1       1
$COMMENT   --- OERROR FILE ------
$COMMENT     inf     err     wgt
OUTPUT2        1       1       1
$COMMENT      az      el
VIEW1       0.00    0.00
$COMMENT     gs1     gs2     thr     loc    seed
SHOT2      20.00    2.00     0.0       1    9999
BULK
```

2.1.3.1 Single Shotline Single View

This mode of FASTGEN generates a single shotline resulting from a threat impacting the target at one aim point from a single attack aspect. This is accomplished by selecting a VIEW1 record and a SHOT3 record. This will run a single shotline through the target at an angle specified on the VIEW1 record at an aim point specified by the SHOT3 record. This method is represented in Table 2-1 as case AP1.

2.1.3.2 Single Shotline Multiple Predetermined Views

This mode of FASTGEN generates a single shotline resulting from a threat impacting the target at one aim point but from multiple attack aspects. This is accomplished by selecting a VIEW2 record and a SHOT3 record. This will run a single shotline through the target at the predefined angles specified by the code provided on the VIEW2 record at an aim point specified by the SHOT3 record. This method is represented in Table 2-1 as case AP2.

2.1.3.3 Multiple Shotlines Single View

This mode of FASTGEN generates multiple shotlines resulting from a threat impacting the target at several aim points from a single attack aspect. This is accomplished by selecting a single VIEW1 record and multiple SHOT3 records. This will run shotlines, based on the number of SHOT3 records, through the target at an angle specified on the VIEW1 record at the aim points specified by each SHOT3 record. This method is represented in Table 2-1 case as AP3.

2.1.3.4 Multiple Shotline Predetermined Multiple Views

This mode of FASTGEN generates multiple shotlines resulting from a threat impacting the target at several aim points from multiple predefined attack aspects. This is accomplished by selecting a single VIEW2 record and multiple SHOT3 records. This will run shotlines, based on the number of SHOT3 records, through the target at the predefined angles specified by the code provided on the VIEW2 record at the aim points specified by each SHOT3 record. This method is represented in Table 2-1 as case AP4.

2.1.3.5 Multiple Shotline Multiple Views

This mode of FASTGEN generates multiple shotlines resulting from a threat impacting the target at several aim points from multiple attack aspects. This is accomplished by selecting multiple VIEW1 records and multiple SHOT3 records. This will run shotlines, based on the number of SHOT3 records, through the target at the angles specified by each VIEW1 record at the aim points specified by each SHOT3 record. Running FASTGEN in this manner ensures that all aim points specified by SHOT3 records are run in all attack aspects. This method is represented in Table 2-1 as case AP5.

2.1.3.6 Multiple Rayleigh Shotlines Single View

This mode of FASTGEN provides multiple threat shotlines, created using a Rayleigh distribution about an aim point, to be run through the target at a single attack aspect. This is accomplished by selecting a single VIEW1 record and a single SHOT1 record. This will run multiple shotlines, based on the parameter passed in the SHOT1 record, through the target at an angle specified on the VIEW1 record distributed around the aim point specified by the SHOT1 record. This method is represented in Table 2-1 as case AP6.

2.1.3.7 Multiple Rayleigh Shotlines Predetermined Multiple Views

This mode of FASTGEN provides multiple threat shotlines, created using a Rayleigh distribution about an aim point, to be run through the target at multiple attack aspects. This is accomplished by selecting a single VIEW2 record and a single SHOT1 record. This will run multiple shotlines, based on the parameter passed in the SHOT1 record, through the target at the predefined angles specified by the code provided on the VIEW2 record at an aim point specified by the SHOT1 record. This method is represented in Table 2-1 case as AP7.

2.1.3.8 Grid-based Multiple Shotlines Single View

This mode of FASTGEN generates multiple shotlines resulting from a uniform grid of threat impacts on the target from a single attack aspect. This is accomplished by selecting a VIEW1 record and a SHOT2 record. This will run multiple shotlines, either centered or arbitrarily placed, inside a grid specified by two parameters passed in the SHOT2 record. These shotlines are run through the target at the angle specified by the VIEW1 record. This method is represented in Table 2-1 as case AP8.

This mode is used for both KE and HE runs. The HE runs will use this mode to place the shotlines on the target. The output of this run will go to COVART to have penetration and burst point locations calculated. The COVART output is then fed back into FASTGEN for the diverging ray portion of the processing.

2.1.3.9 Grid-based Multiple Shotlines Predefined Multiple Views

This mode of FASTGEN generates multiple shotlines resulting from a uniform grid of threat impacts on the target from a set of predefined attack aspects. This is accomplished by selecting a VIEW2 record and a SHOT2 record. This will run multiple shotlines, either centered or arbitrarily placed, inside a grid specified by two parameters passed in the SHOT2 record. These shotlines are run through the target at the predefined angles specified by the code provided on the VIEW2 record. This method is represented in Table 2-1 as case AP9.

This mode is used only for KE runs and cannot be used to provide multiple views for HE runs. This is a limitation of FASTGEN and COVART due to the way the view information is handled.

Table 2-1 FASTGEN AP/API/FRAGMENT PARALLEL RAY MODES

<table>
<tr><th rowspan="2">CASE / MODE</th><th rowspan="2">CONTROL RECORDS</th><th rowspan="2">INPUT FILES</th><th>PRIMARY OUTPUT FILES</th><th rowspan="2">COMMENTS</th></tr>
<tr><th>OTHER OUTPUT FILES</th></tr>
<tr><td rowspan="2">Case: AP1

Single shotline; single view</td><td rowspan="2">VIEW1
SHOT3
OUTPUT1
OUTPUT2
OUTPUT3</td><td rowspan="2">CBULK
CONTROL</td><td>OPKSA
OPKSB
OUNPKA</td><td rowspan="2"></td></tr>
<tr><td>OERROR
OCHEM
OLOSV
OCOEFA
OCOEFB</td></tr>
<tr><td rowspan="2">Case: AP2

Single shotline; pre-determined multiple views</td><td rowspan="2">VIEW2
SHOT3
OUTPUT1
OUTPUT2
OUTPUT3</td><td rowspan="2">CBULK
CONTROL</td><td>OPKSA
OPKSB
OUNPKA</td><td rowspan="2"></td></tr>
<tr><td>OERROR
OCHEM
OLOSV
OCOEFA
OCOEFB</td></tr>
<tr><td rowspan="2">Case: AP3

Multiple shotlines; single view</td><td rowspan="2">VIEW1
SHOT3
SHOT3
SHOT3
OUTPUT1
OUTPUT2
OUTPUT3</td><td rowspan="2">CBULK
CONTROL</td><td>OPKSA
OPKSB
OUNPKA</td><td rowspan="2"></td></tr>
<tr><td>OERROR
OCHEM
OLOSV
OCOEFA
OCOEFB</td></tr>
<tr><td rowspan="2">Case: AP4

Multiple shotlines; pre-determined multiple views</td><td rowspan="2">VIEW2
SHOT3
SHOT3
SHOT3
OUTPUT1
OUTPUT2
OUTPUT3</td><td rowspan="2">CBULK
CONTROL</td><td>OPKSA
OPKSB
OUNPKA</td><td rowspan="2">This will run each SHOT3 through all views selected on the VIEW2 record.</td></tr>
<tr><td>OERROR
OCHEM
OLOSV
OCOEFA
OCOEFB</td></tr>
<tr><td>Case: AP5

Multiple</td><td>VIEW1
VIEW1
SHOT3</td><td>CBULK
CONTROL</td><td>OPKSA
OPKSB
OUNPKA</td><td>This will run each SHOT3 through each VIEW1, (i.e. 2 VIEW1</td></tr>
</table>

CASE / MODE	CONTROL RECORDS	INPUT FILES	PRIMARY OUTPUT FILES OTHER OUTPUT FILES	COMMENTS
shotlines; multiple views	SHOT3 OUTPUT1 OUTPUT2 OUTPUT3		OERROR OCHEM OLOSV OCOEFA OCOEFB	records and 2 SHOT3 records results in 4 shotlines).
Case: AP6 Multiple shotlines Rayleigh; single view	VIEW1 SHOT1 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL	OPKSA OPKSB OUNPKA OERROR OCHEM OLOSV OCOEFA OCOEFB	This is a special mode of FASTGEN that creates data which is not compatible with COVART.
Case: AP7 Multiple shotlines Rayleigh; pre-determined multiple views	VIEW2 SHOT1 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL	OPKSA OPKSB OUNPKA OERROR OCHEM OLOSV OCOEFA OCOEFB	This is a special mode of FASTGEN that creates data which is not compatible with COVART.
Case: AP8 Grid based multiple shotlines; single view	VIEW1 SHOT2 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL	OPKSA OPKSB OUNPKA OERROR OCHEM OLOSV OCOEFA OCOEFB	This is used for all impact HE/HEI threats. This is the suggested first pass method for all two pass runs.
Case: AP9 Grid based multiple shotlines; pre-determined multiple views	VIEW2 SHOT2 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL	OPKSA OPKSB OUNPKA OERROR OCHEM OLOSV OCOEFA OCOEFB	This cannot be used for any impact HE/HEI threats since COVART will not provide FASTGEN with view data in the CCOVBP input file.

2.2 High Explosive (HE) Threat Types

These types of threats include HE, HEI, and proximity-fused threats. These types of threats are generally analyzed by using a single FASTGEN pass to generate the shotlines for the unexploded threat, which are then passed to COVART. COVART performs penetration and fusing calculations to decide where to place the detonation point along the shotline. This information is then passed back to FASTGEN and diverging fragment ray processing based on the location of these burst points is performed. These fragment rays may be uniform fragment rays (PGEN replacement), or fragment rays based on specific threat definitions (ADRaM). Both uniform fragment rays, and threat definition based fragment rays for impact threats are associated with burst points that are defined by the output of COVART from the first pass through FASTGEN. The output of the second pass through FASTGEN is sent to COVART for penetration, damage, and probability calculations. This is often referred to as a two-pass process since FASTGEN is run twice in order to produce these diverging rays.

A single-pass process is used when analyzing single proximity fused threats. Since the detonation location of the threat is input by the user, the first pass to establish this location through COVART is not necessary.

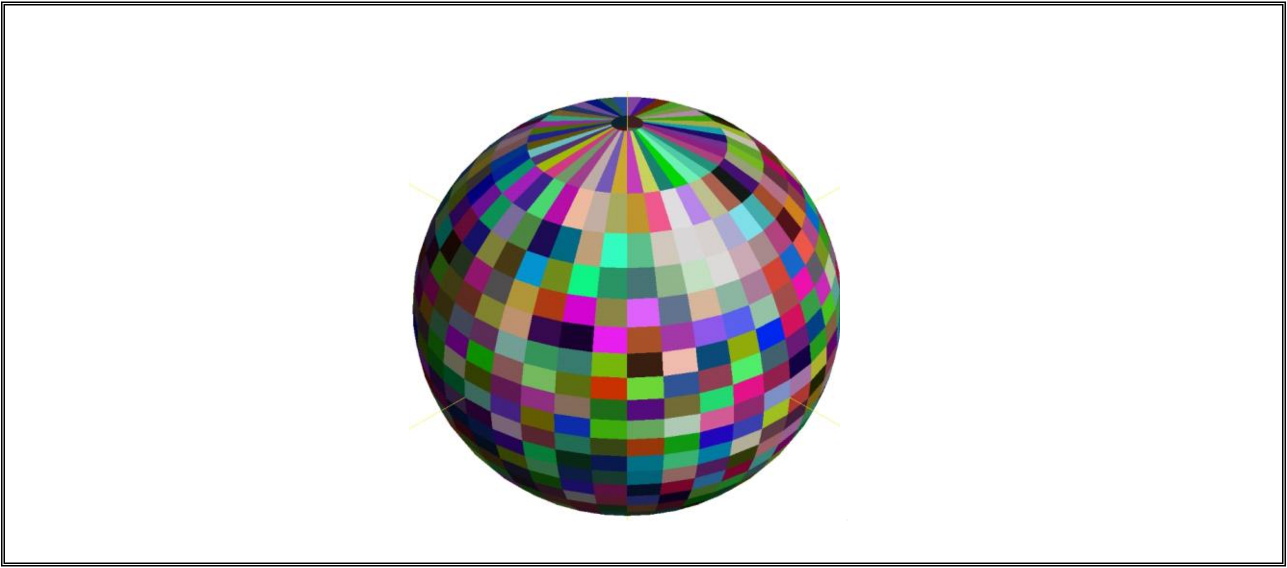
HE threats also have damage associated with the air blast effect of the explosion itself. This is independent of the fragment damage, and individual FASTGEN rays are run to calculate the effect of the air blast. These rays are optional and are created using the uniform ray method. The PGEN-replacement burst mode creates only one set of uniform rays that are used both for air blast rays and for fragment rays. COVART automatically uses these rays as needed for its processing.

2.2.1 HE Fragment Ray Generation

FASTGEN is designed to create fragment rays based on impact and proximity fused threats. Either PGEN replacement method or ADRaM can be used to model the fragment rays from these threats.

Uniform fragment rays are simply run through the target at a specific angle associated with each fragment ray. All PGEN replacement modes use uniform rays. No adjustment is made to include the effects of fragment velocity, threat velocity, or target velocity in FASTGEN. Figure 2-2 shows the uniform area distribution created when the uniform rays are generated. Each ray is created using the solid angle associated with the area on the surface of a sphere.

Figure 2-2 FASTGEN Uniform Diverging Ray (PGEN Replacement)



In order to take initial warhead and target velocities into account, ADRaM rays are adjusted according to input velocities associated with the fragments, threat and target before they are run through the target. Figure 2-3 shows threat definition based fragment rays that have not been vectored. FASTGEN calculates the impact velocity and attack aspect of these fragment rays and passes this information to COVART. Each fragment ray is flown off the threat at a location and an angle that is input in the threat definition file (CTHREAT). Figure 2-4 shows fragment rays resulting from a HE threat definition that have been vectored. For proximity burst assessments, fragment speed is adjusted to account for aerodynamic drag.

Figure 2-3 Unvectored Fragment Rays

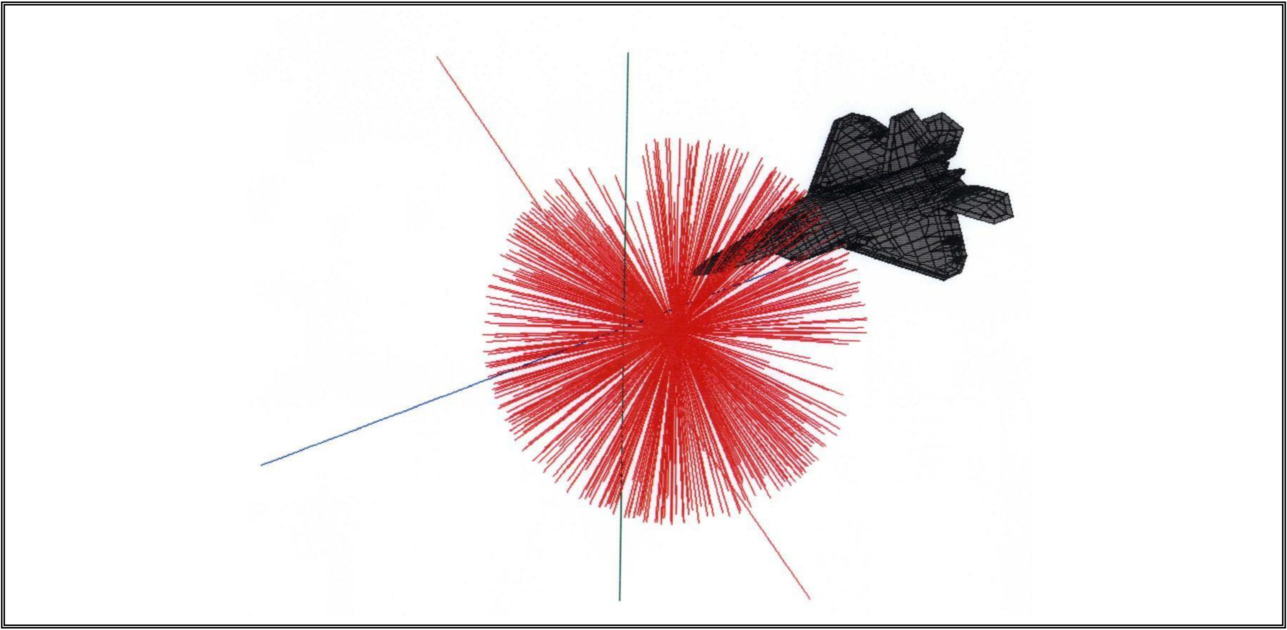
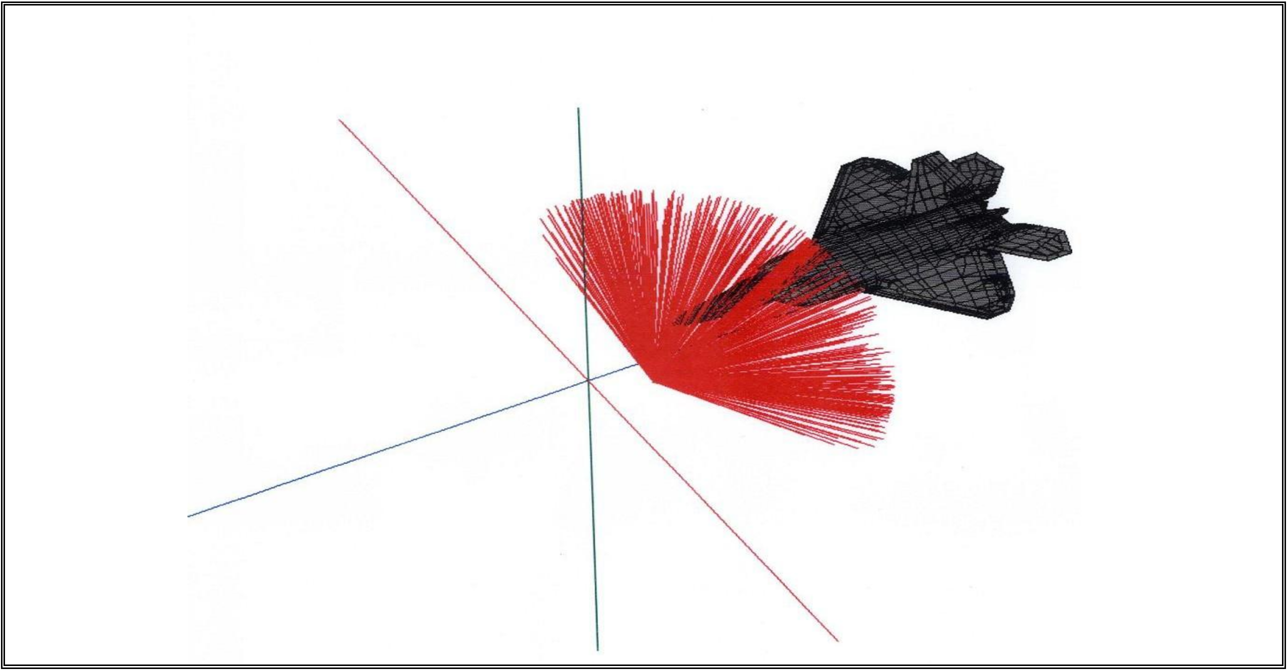


Figure 2-4 Vectored Fragment Rays



2.2.2 HE Air Blast

In FASTGEN, air blast from high-explosive threats is approximated through the use of uniform diverging rays. A user may specify air blast modeling by including a BLAST1 record in the CONTROL file. The BLAST1 record may be used with any ADRaM fragment-based burst mode (BURST1, BURST4, and BURST5), but it may not be used alone. Air blast data will not be produced unless a BLAST1 record is in the CONTROL file.

Uniform air blast rays are created by FASTGEN based on input included on the BLAST1 record and the associated BURST record. PGEN-replacement mode creates uniform rays and outputs them to the OCOVART file. These can be used to represent both fragments and air blast. The ADRaM mode will create separate fragment rays and air blast rays in the OFRAGB file.

2.2.3 HE Views

HE threats are typically run using the grid-based impact-fused mode. Grid-based burst points can only be run one view at a time. Proximity-fused HE threats are run using single burst points. Proximity-fused threats can be run for multiple views at the same time. Single view runs are preferred over multiple view runs for HE threats.

All impact fuse-based HE threats require two FASTGEN passes to create the diverging ray output data. The first pass provides the locations of the shotlines through the target. This information is passed to COVART so the location of the burst points can be established. The resultant burst point location information is then input to FASTGEN through the CCOVBP file on the second pass. The burst point location information is based on the view provided in the original pass. FASTGEN must use this same view for the second run in order to properly place the burst points along the shotlines. This forces both the first and second FASTGEN run to use a single view that is the same view for both runs.

Proximity-fused threats by definition do not require an impact to detonate. Proximity-fused threats require only a single FASTGEN run to create diverging ray output data. The user must input to FASTGEN the location of the burst point as part of the input data. This is accomplished by placing the X, Y, and Z coordinates of the burst point on the input record for these burst types. Since the burst point location is input from the user, FASTGEN can process diverging rays for multiple views in a single run. This is implemented by pairing a VIEW1 record with a BURST4 record. Each burst point can be at the same or different location, and each view can be the same or different. The output from FASTGEN provides information to COVART so that each of these burst points is properly associated with its assigned view.

2.2.4 Output Data

FASTGEN has several output files that can be selected that provide specific information. Some of these selections are not valid with specific control file selections.

Table 2-2 lists the output files that contain valid data for each mode listed. These files are selected by using the OUTPUT1, OUTPUT2, and OUTPUT3 records to choose the specific files and content desired.

2.2.4.1 Error and Warning Output File

The OERROR file contains errors and warnings that are generated during a FASTGEN run. This file contains significant information about issues found by FASTGEN during the ray trace processing. Options for the OERROR file are contained on an OUTPUT2 record. Modeling issues as well as problems completing a run are reported in this file.

2.2.4.2 Primary Output Files

The primary output files for diverging ray runs are the OCOVART, OFRAGA, and OFRAGB. The OCOVART file is the binary file that is passed along to COVART for PGEN replacement mode runs. The OFRAGA and OFRAGB files are generated by ADRaM diverging ray runs. The OFRAGA file is an ASCII file used by the analyst when a human readable version of the LOS data is needed. The OFRAGB file is the binary file that is passed along to COVART for ADRaM runs. The OUTPUT1 record is used to select the primary files for a FASTGEN run.

2.2.4.3 Additional Output Files

The ODISPLAY_THREAT file is the only additional output file for diverging ray runs. This file is used to display threat visualization for ADRaM diverging ray threat information. The OUTPUT3 record is used to select the output of this file for a FASTGEN run.

2.2.4.4 Air Blast Output Files

Uniform air blast data is included along with the fragment data in the fragment ray output files. The files are OCOVART for PGEN replacement runs, and OFRAGB for ADRaM runs.

2.2.5 CONTROL Cases for HE Modes

The following sections describe various FASTGEN modes of operation, the CONTROL file inputs, and the available output files for the most commonly used HE FASTGEN functions. Figure 2-5 shows an example of a FASTGEN HE threat type CONTROL file.

Figure 2-5 Example FASTGEN HE Threat Type CONTROL File

```
$COMMENT This is a grid based ADRaM Example
$COMMENT This does not include air blast rays
$COMMENT
$COMMENT       2       3       4       5       6       7       8       9
$COMMENT
$COMMENT    PKSB    PKSA    UPKA   BURST   COVBP   IFRGB   IFRGA
OUTPUT1        0       0       0       0       0       1       1
$COMMENT    IOCB    IOCA            LOSV     CDF    CHEM           OTHRT
OUTPUT3                                                                1
$COMMENT      AZ      EL
VIEW1        0.0     0.0
$COMMENT
$COMMENT       2       3       4       5       6       7       8       9
```

```
$COMMENT                  IGRIDS                            ISEED  IFDIST
BURST1                        10                             3321       0
$COMMENT RTHTSPD  RTHTYA  RTHTPA  RTHTRA
THRTPAR      0.0     0.0     0.0     0.0
$COMMENT RTGTSPD  RTGTYA  RTGTPA  RTGTRA
TRGTPAR      0.0     0.0     0.0     0.0
$COMMENT
UNITS        1.0
BULK
```

2.2.5.1 ADRaM Grid-based Fragment Rays with No Air Blast Rays

This mode of FASTGEN generates multiple shotlines resulting from a uniform grid of threat impacts on the target from a single attack aspect. This is accomplished by performing case AP8 in Table 2-1 above. These impact locations are passed to COVART and detonation locations are calculated. These burst locations are passed back to FASTGEN in the CCOVBP file, and ADRaM fragment rays are created and run through the target. This is accomplished by selecting a VIEW1 record that matches the previous run, and a BURST1 record. This mode will not create any air blast rays. This method is represented in

Table 2-2 as case HE1.

2.2.5.2 ADRaM Grid-based Fragment Rays with Uniform Air Blast Rays

This mode of FASTGEN generates multiple shotlines resulting from a uniform grid of threat impacts on the target from a single attack aspect. This is accomplished by performing case AP8 in Table 2-1 above. These impact locations are passed to COVART and detonation locations are calculated. These burst points are passed back to FASTGEN in the CCOVBP file, and ADRaM fragment rays are created and run through the target. This is accomplished by selecting a VIEW1 record that matches the previous run, and a BURST1 record. This mode creates uniform air blast rays with the inclusion of a BLAST1 record. This method is represented in

Table 2-2 as case HE2.

2.2.5.3 PGEN Replacement Grid Based Fragment Rays with Uniform Air Blast Rays

This mode of FASTGEN generates multiple shotlines resulting from a uniform grid of threat impacts on the target from a single attack aspect. This is accomplished by performing case AP8 in Table 2-1 above. These impact locations are passed to COVART and detonation locations are calculated. These burst points are passed back to FASTGEN in the CCOVBP file and PGEN replacement fragment rays are created and run through the target. This is accomplished by selecting a VIEW1 record that matches the previous run, and a BURST2 record. This mode will create uniform rays that are used by COVART for both air blast and fragment modeling. The BLAST1 record does not function with a BURST2 record. This method is represented in

Table 2-2 as case HE3.

2.2.5.4 Single/Multiple ADRAM Proximity-fused Fragment Rays with No Air Blast Rays

This mode of FASTGEN utilizes single threat burst point locations that are provided by the user on the BURST4 record. These burst points are intended for use with proximity fused threats. ADRAM fragment rays are created and run through the target for each burst point. This is accomplished by selecting a VIEW1 record and a BURST4 record pair. Multiple sets of ADRaM rays can be generated by using pairs of VIEW1 and BURST4 records. Each pair can have a unique view and burst point as specified on each record. This mode will not create any air blast rays. This method is represented in

Table 2-2 as case HE4.

2.2.5.5 Single/Multiple ADRAM Proximity-fused Fragment Rays with Uniform Air Blast Rays

This mode of FASTGEN utilizes single threat burst point locations that are provided by the user on the BURST4 record. These burst points are intended for use with proximity-fused threats. ADRAM fragment rays are created and run through the target for each burst point. This is accomplished by selecting a VIEW1 record and a BURST4 record pair. Multiple sets of ADRaM rays can be generated by using pairs of VIEW1 and BURST4 records. Each pair can have a unique view and burst point as specified on each record. The inclusion of the BLAST1 record results in uniform air blast rays. This method is represented in

Table 2-2 as case HE5.

2.2.5.6 ADRAM Single Impact Fragment Rays with No Air Blast Rays

This mode of FASTGEN generates multiple shotlines resulting from a threat impacting the target at several aim points from a single attack aspect (VIEW1, SHOT3). These impact locations are passed to COVART and detonation locations are calculated. The burst points are passed back to FASTGEN in the CCOVBP file and ADRaM fragment rays are created and run through the target. This is accomplished by selecting a VIEW1 record and a BURST5 record. This mode is used to provide MANPADS-style capability through the FASTGEN process. This mode will not create any air blast rays. This method is represented in

Table 2-2 as case HE6.

2.2.5.7 ADRAM Single Impact Fragment Rays with Uniform Air Blast Rays

This mode of FASTGEN generates multiple shotlines resulting from a threat impacting the target at several aim points from a single attack aspect (VIEW1, SHOT3). These impact locations are passed to COVART and detonation locations are calculated. The burst points are passed back to FASTGEN in the CCOVBP file and ADRaM fragment rays are created and run through the target. This is accomplished by selecting a VIEW1 record and a BURST5 record. This mode is used to provide MANPADS-style capability through the FASTGEN process. The inclusion of the BLAST1 record results in uniform air blast rays. This method is represented in

Table 2-2 as case HE7.

2.2.5.8 External Ray Generation Mode (VIEW3)

This mode of FASTGEN provides a single fragment end game mode to FASTGEN. In a separate run, information is created through SHAZAM. This information is then input by the analyst into a FASTGEN run. Information on the VIEW3 record allows the analyst to input the aim point, view angle, threat velocity, threat mass, and threat material type. The FOOTER1 record provides a shotline header record that is output to the OUNPKA file. The FOOTER2 record provides shotline LOS information and is output to the OUNPKA file. The shotline is run through the target at the view and aim point provided on the VIEW3 record. The resulting LOS information is output into the OUNPKA file. The OUNPKA file requires post processing to convert it to a format that can be input to COVART for penetration and statistical calculations. This method is represented in

Table 2-2 case as HE8a.

The external ray generation mode of FASTGEN has been improved with the addition of the new record combination, VIEW4 and SHOT4. Previously, the aim points found on VIEW3 records were processed individually, regardless if any of the aim points had similar attack aspects. With the VIEW4/SHOT4 combination, the user can assign a series of aim points to the same view. This allows FASTGEN legacy portion of COVART6 to process all of the related aim points as a group, increasing the efficiency of the calculation.

To use this capability, all of the aim points (SHOT4 records) that a user wants to assign to a particular attack aspect need to immediately follow a corresponding VIEW4 record. Doing this ensures that all of the aim points associated with the attack aspect are processed as one group. This method is represented in

Table 2-2 case as HE8b.

Table 2-2 FASTGEN HE/HEI/PROXIMITY DIVERGING RAY MODES

CASE / MODE	CONTROL RECORDS	INPUT FILES	PRIMARY OUTPUT FILES / OTHER OUTPUT FILES	COMMENTS
Case: HE1 ADRaM fragment rays Grid based multiple Impact burst points Single view No air blast rays	VIEW1 BURST1 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL CCOVBP CTHREAT	OFRAGA OFRAGB — OERROR ODISPLAY_THREAT	Run for one threat at a time; Contact fuse threats; Static target, moving threat
Case: HE2 ADRAM fragment rays Grid based multiple Impact burst points Single view Uniform air blast rays	VIEW1 BURST1 BLAST1 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL CCOVBP CTHREAT	OFRAGA OFRAGB — OERROR DISPLAY_THREAT	Run for one threat at a time; Contact fuse threats; Static target, moving threat
Case: HE3 PGEN replacement Grid based multiple Impact burst points Single view	VIEW1 BURST2 OUTPUT1 OUTPUT2	CBULK CONTROL CCOVBP	OCOVART — OERROR	Run for one threat at a time; Contact fuse threats
Case: HE4 ADRAM fragment rays Single proximity fused burst points Single view No air blast rays	VIEW1 BURST4 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL CTHREAT	OFRAGA OFRAGB — OERROR ODISPLAY_THREAT	Run for one threat at a time; Proximity fuse threats; Moving target, moving threat

CASE / MODE	CONTROL RECORDS	INPUT FILES	PRIMARY OUTPUT FILES / OTHER OUTPUT FILES	COMMENTS
Case: HE5 ADRAM fragment rays Single proximity fused burst points Single view Uniform air blast rays	VIEW1 BURST4 BLAST1 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL CTHREAT	OFRAGA OFRAGB	Run for one threat at a time; Proximity fuse threats; Moving target, moving threat
			OERROR ODISPLAY_THREAT	
Case: HE6 ADRAM fragment rays Single impact burst points Single view No air blast rays	VIEW1 BURST5 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL CCOVBP CTHREAT	OFRAGA OFRAGB	Run for one threat at a time; Contact fuse threats; Static target, moving threat
			OERROR ODISPLAY_THREAT	
Case: HE7 ADRAM fragment rays Single impact burst points Single view Uniform air blast rays	VIEW1 BURST5 BLAST1 OUTPUT1 OUTPUT2 OUTPUT3	CBULK CONTROL CCOVBP CTHREAT	OFRAGA OFRAGB	Run for one threat at a time; Contact fuse threats; Static target, moving threat
			OERROR ODISPLAY_THREAT	
Case: HE8a Single impact points; End Game mode	VIEW3 FOOTER1 FOOTER2 OUTPUT1 OUTPUT2	CBULK CONTROL	OUNPKA	Run for one threat at a time; 2 postprocessors required to convert the OUNPKA file to an OCOVART file.
			OERROR	
Case: HE8b Single impact points; End Game mode (a series of aim points run for each attack aspect)	VIEW4 SHOT4 FOOTER1 FOOTER2 OUTPUT1 OUTPUT2	CBULK CONTROL	OUNPKA	Runs a series of aim points for a given attack aspect; more efficient than using VIEW3 records; 2 postprocessors required to convert the OUNPKA file to an OCOVART file.
			OERROR	

2.3 Multi-hit Threats

The Multi-hit capability allows the user to define a cluster of shotlines about an aim point that are processed as a group. Each shotline can have a unique threat and velocity assigned which is used to represent a collection of threats acting together. COVART processes each group as a set rather than each individual shotline.

The aim point of the cluster is defined by either a SHOT2 or SHOT 3 record and the aim point is not used for a shotline. The location of each shotline of the cluster is defined as a relative offset along the Y and Z axis from the aim point and is defined on a MULTIHT1 hit record. The assignment of the threat type and velocity is provided by the user and defined on the MULTIHT1 record. An example Multi-hit CONTROL file is shown in Figure 2-6. When utilizing the Multi-hit capability, only VIEW1 and VIEW2 records can be used.

The Multi-hit capability creates an OCOVART output file for all types of runs.

Figure 2-6 Example Multi-hit CONTROL file

```
$COMMENT This is a grid based multi-hit ray example
$COMMENT
$COMMENT      2      3      4      5      6      7      8      9
$COMMENT
$COMMENT12345678123456781234567812345678123456781234567812345678123456781234567812345
$COMMENT   PKSB   PKSA   UPKA  BURST  COVBP  OFRAGB  OFRAGA
OUTPUT1                            1
$COMMENT --- OERROR FILE ------
$COMMENT    INF    ERR    WGT
OUTPUT2      1      1      1
$COMMENT     AZ     EL
VIEW1      0.0    0.0
$COMMENT
$COMMENT      2      3      4      5      6      7      8      9
SHOT2    20.00   5.00    0.0      1   9999
$COMMENT
$COMMENT    X      Y      TID  Velocity
MULT_HIT   20.0   20.0     1   2600
MULT_HIT  -20.0   20.0     1   2600
MULT_HIT    0.0    0.0     3   2200
MULT_HIT  -30.0    0.0     2   2000
MULT_HIT  -26.0  -15.0     2   2000
MULT_HIT  -15.0  -26.0     2   2000
MULT_HIT    0.0  -30.0     2   2000
MULT_HIT   15.0   26.0     2   2000
MULT_HIT   26.0   15.0     2   2000
MULT_HIT   30.0    0.0     2   2000
BULK
```

3. MASTER Input File

3.1 Description

The MASTER file is the new simulation control file for COVART6. This file must be directly piped into the program for every execution of the code, but the contents of this file vary depending on the desired mode of operation. When utilizing COVART6 in the integrated mode, the contents of the MASTER file will vaguely resemble those of the COVART5 BASIC file. When using either of the legacy modes, this file consists of only two records, one to denote the mode and another to denote the end of the file. Definitions for these records can be found in Section 3.2.

In order to run COVART6 in FASTGEN5 legacy mode, two pieces of information are required in the MASTER file: the mode selection and the ENDDATA record.

As highlighted in Section 1.1, COVART6 can be run in one of three operational modes. A user selects one of these modes by populating the CMODE field of the MODE record. In order to run FASTGEN legacy mode, a value of “FASTGEN” needs to be entered in this field.

The second piece of information required to be in the MASTER file is the ENDDATA record. This tells COVART6 to stop reading the MASTER file and switch into the operational mode chosen by the user. If FASTGEN legacy mode has been selected, the code will search the current working directory for a FASTGEN5-type CONTROL file. If a proper CONTROL file cannot be found, the code will return a warning and cease execution.

3.2 Input Data Types

3.2.1 MODE

Description: Defines the current COVART mode.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
MODE	CMODE	BASIC File Name (COVART5 Legacy Mode only)							
MODE	FASTGEN5								
C	C	C							

Parameters	Units	Description
CMODE	-------	A descriptor to designate the mode of the current COVART6 analysis. “FASTGEN” = FASTGEN5 Legacy Mode “COVART5” = COVART5 Legacy Mode “COVART6” = COVART6 Integrated Mode

REMARKS

1. This record is required on the first line of any MASTER file. If it does not exist, COVART will return an error and exit.

2. If the value of CMODE does not match one of the three record values, COVART will return an error and exit.

3. When specifying COVART6 to run in COVART5 legacy mode, a file name for a BASIC file must be included on this record. A BASIC file name is not required when using COVART6 in FASTGEN5 legacy mode or in COVART6 integrated mode.

3.2.2 ENDDATA

Description: Defines end of file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ENDDATA									
ENDDATA									
C									

REMARKS

1. All data following the ENDDATA data type will not be used.

4. CONTROL Input File

4.1 Description

The case control file (CONTROL) contains records that determine which FASTGEN features are used. These records include: the orientation of the target to the threat; threat size; three-dimensional analysis envelope; grid resolution; shotline density; diverging ray type; and more. The syntax of these parameters is specified on the following pages. (Note: All case control files created for use with FASTGEN must have the file name CONTROL.)

The CONTROL file records are specified using fixed format lines containing ten fields with eight columns per field. Each field contains an input variable that is a real (R), integer (I), or character (C) data type. The first field in the first line of a record contains a character variable that identifies the record, and must be left justified. Some records require two lines to hold all the information. These records use the tenth column of the first line and the first column of the second line as continuation variables. The continuation variables in field ten and one must match in value and digit location. All other input variables will be either real, character, or integer variables, and must fall within the required field. An example case control record is shown in Figure 4-1.

The CONTROL file permits BLAST1, BULK, BURST1, BURST2, BURST4, BURST5, CRANBACK, CRIT, DEL, ENV, FOOTER1, FOOTER2, LIMITS, UNITS, OUTPUT1, OUTPUT2, OUTPUT3, SHOT1, SHOT2, SHOT3, SHOT4, THRTPAR, TRGTPAR, VIEW1, VIEW2, VIEW3, VIEW4, and $COMMENT records. These records may be placed anywhere in the case control file, except for the BULK record. The BULK record must be the last record in the case control file.

All units must be consistent. Distance, radius, and thickness are measured in target specific units; and angles are measured in degrees.

Figure 4-1 Example CONTROL File Record

1	2	3	4	5	6	7	8	9	10
OUTPUT1	PKSB	PKSA	UNPKA	BURST	COVBP	IFRGB	IFRGA		
OUTPUT1	1	0	0	0	0	1	0		
C	I	I	I	I	I	I	I		

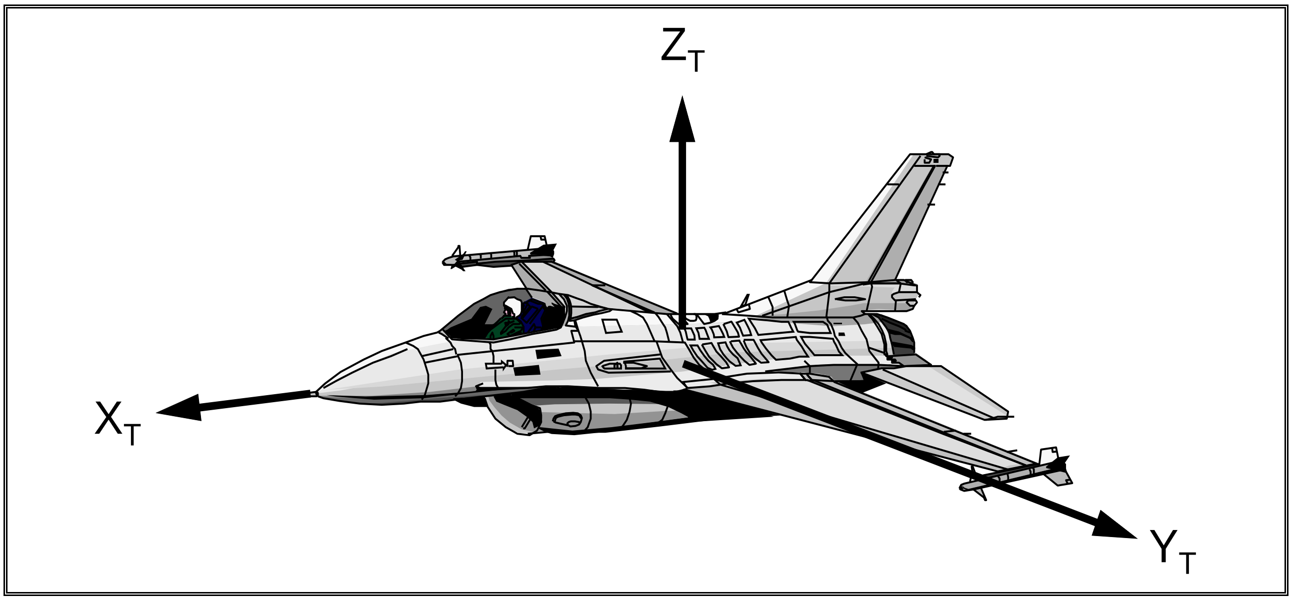
4.2 Coordinate System Representation

A series of coordinate systems is used by FASTGEN to setup the proper orientations. Standard matrix operations are used to transform spatial and velocity vectors between each of the coordinate systems as needed. In the sections that follow, each of the coordinate systems used by FASTGEN and its function is defined.

4.2.1 Target Spatial Coordinate System

The target spatial coordinate system is defined with its origin at the target center of gravity. The positive X axis is directed forward along the target body centerline. The positive Y axis is directed out the left wing (as viewed by the pilot). The positive Z axis is directed out the top of the aircraft and completes the right-hand coordinate system. See Figure 4-2. The orientation of the target as defined in this paragraph is required for any ballistic vulnerability analysis using FASTGEN and COVART. Many calculations in FASTGEN and COVART expect this orientation. Any other orientation will result in incorrect ray-tracing results, which will negatively impact the findings of a vulnerability analysis. All grid points in the target file CBULK are defined in the target spatial coordinate system. Burst point locations for the BURST4 analysis option is specified in this coordinate system.

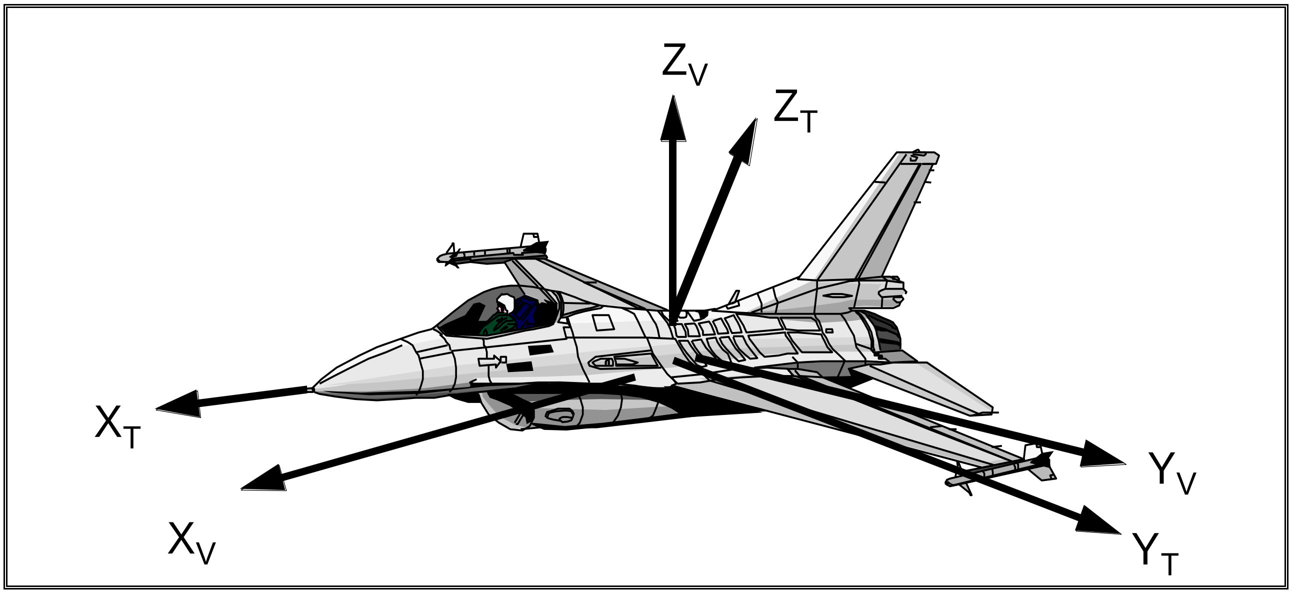
Figure 4-2 Target Coordinate System



4.2.2 Target Velocity Coordinate System

The target velocity coordinate system has its origin at the target center of gravity. The positive X axis is coincident with the target velocity vector. The Y axis is parallel to a stationary flat earth, and the positive direction is to the left of the projection of the X axis onto the flat earth plane. The positive Z axis points upward with respect to the flat earth plane and completes the right-hand coordinate system. See Figure 4-3.

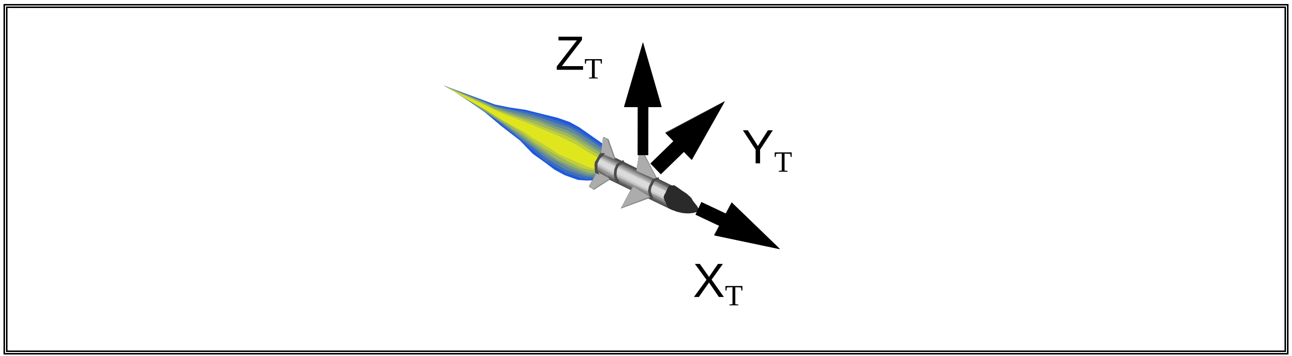
Figure 4-3 Target Velocity Coordinate System



4.2.3 Threat Spatial Coordinate System

The threat spatial coordinate system is defined with its origin at the threat center of gravity. The positive X axis is directed forward along the threat body centerline. The positive Y axis is directed out the unrotated left side of the threat. The positive Z axis is directed out the top of the threat and completes the right-hand coordinate system. See Figure 4-4. All threat definition data in the CTHREAT file are defined in the threat spatial coordinate system.

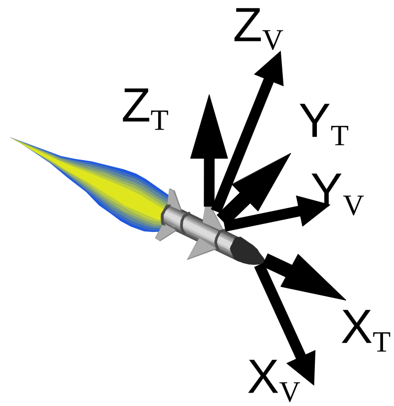
Figure 4-4 Threat Spatial Coordinate System



4.2.4 Threat Velocity Coordinate System

The origin of the threat velocity coordinate system (Figure 4-5) is also located at the threat's center of gravity. The positive x-axis coincides with the direction of the threat velocity vector and the positive y-axis is perpendicular to the x-axis of the velocity vector. The positive z-axis is perpendicular to the x and y axes, completing the orthogonality of the coordinate system

Figure 4-5 Threat Velocity Coordinate System



4.2.5 View Angle System

The user must specify an attack aspect between the target and the threat that in FASTGEN is called a VIEW angle. The VIEW angle is defined in terms of an azimuth and elevation in relation to the target. This convention is non-standard for many applications. The azimuth and elevation in relationship to a target is shown in Figure 4-6.

A VIEW angle is required for both parallel shotline and diverging ray runs. The traditional FASTGEN VIEW angle has been between the threat and the target in the target spatial coordinate system. The new ADRaM diverging ray capability has introduced additional coordinate systems and relationships. All attack aspects used for ADRaM diverging ray runs are between the threat velocity and the target velocity coordinate systems. This is shown in Figure 4-7. As a result, the VIEW records will apply differently when performing ADRaM diverging ray runs. The parallel shotline and PGEN diverging ray runs will continue to use the traditional VIEW angle definition.

Figure 4-6 VIEW Angle Representation

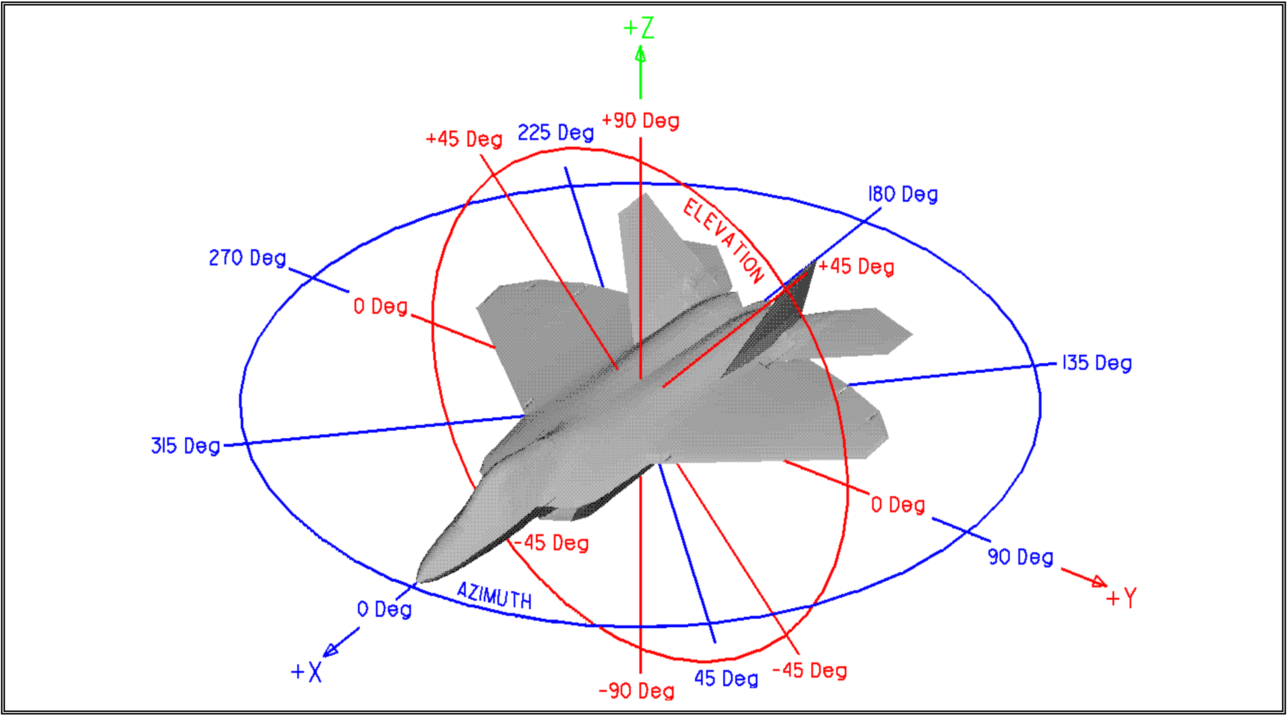
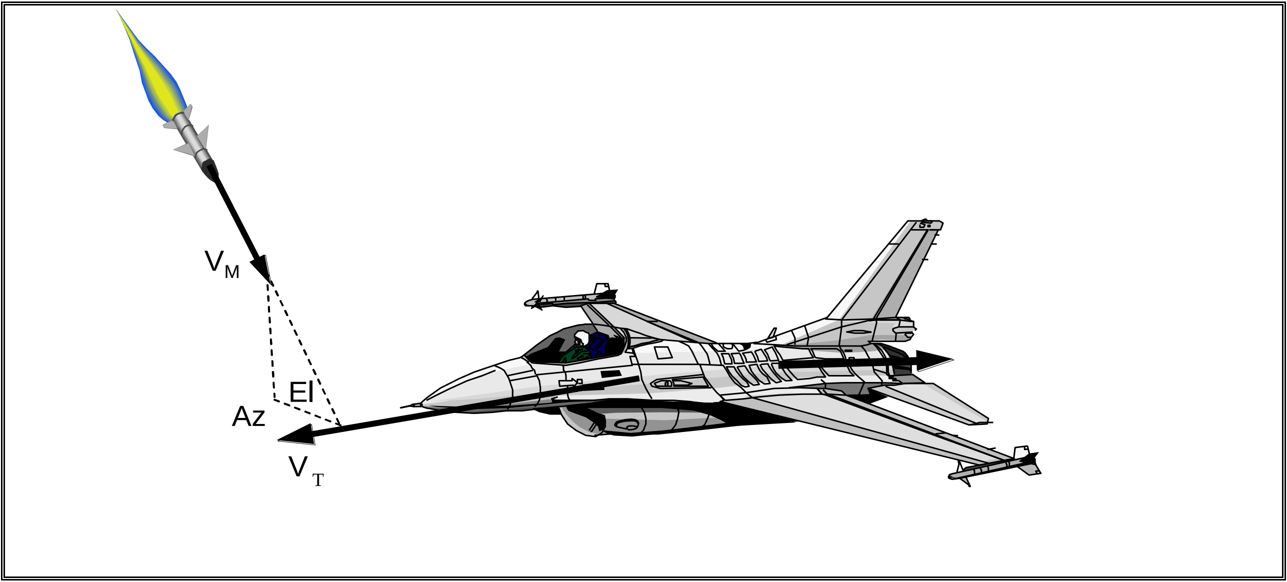


Figure 4-7 ADRaM View Angle Relationship



4.2.6 Principal Views

Shotline analysis is typically performed for 6 or 26 views. A 6-view analysis rotates the target azimuth and elevation angles by 90 degrees. A 26-view analysis rotates the target azimuth and elevation angles by 45 degrees. Table 4-1 states the view orientation in degrees.

Table 4-1 Principal Views AZ and EL

Number	AZ	El
1	0	0
2	45	0
3	90	0
4	135	0
5	180	0
6	225	0
7	270	0
8	315	0
9	0	45
10	45	45
11	90	45
12	135	45
13	180	45
14	225	45
15	270	45
16	315	45
17	0	-45
18	45	-45
19	90	-45
20	135	-45
21	180	-45
22	225	-45
23	270	-45
24	315	-45
25	90	90
26	270	-90

4.3 Input Data Records

4.3.1 ANCHOR

Description: Defines the location of the lower left corner of the target in a gridded run.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ANCHOR	X	Y	Z						
ANCHOR	0.0	0.0	0.0						
C	R	R	R						

Parameters	**Units**	**Description**
X	Target	X coordinate of the anchor point location
Y	Target	Y coordinate of the anchor point location
Z	Target	Z coordinate of the anchor point location

REMARKS

1. The ANCHOR record can only be used one time.

4.3.2 BLAST1

Description: Defines the inputs for creating uniform air blast ray data.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
BLAST1				nray/solang					
BLAST1				400.					
C				R					

Parameters	Units	Description
nray/solang	NONE / steradians per ray	If greater than 1.0, NRAY = the desired number of rays for a full sphere. If less than 1.0, SOLANG = the desired solid angle per ray (steradians per ray).

REMARKS

1. If the BLAST1 record is included uniform ray air blast data will be included in the OFRAGA or OFRAGB file.

2. BLAST1 may only be used with the BURST1, BURST4, or BURST5 record.

4.3.3 BULK

Description: Defines the end of the case control file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
BULK									
BULK									
C									

REMARKS

1. The BULK record must be used one time.
2. Any case control data following the BULK record will not be used.

4.3.4 BURST1

Description: Defines multiple burst points based on based on the CCOVBP input file with diverging rays that are threat definition specific.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
BURST1			igrids	ithsrc			iseed	ifdist	
BURST1			10	0			3456	0	
C			I	I			I	I	

Parameters	**Units**	**Description**
Igrids	------	GS1/GS2 ratio (see SHOT2 data type) for the shot line run used to generate the shot lines used as input to the COVART run which produced the burst point location file being used for this BURST1 run.
Ithsrc	-----	Flag indicating the threat velocity source. 0 = Single velocity from the THRTPAR record in the CONTROL file 1 = Individual velocity from the CCOVBP file.
Iseed	------	Random number seed used by fragment distribution routines
Ifdist	------	Fragment distribution option in polar zones 0 = uniform [DEFAULT] 1 = random
ithsrc	------	Velocity Source 0 = single velocity from THRTPAR in CONTROL file [DEFAULT] 1 = individual velocity from CCOVBP file

REMARKS

1. The BURST1 data type may be used once.

2. The BURST1 record may not be used with any other BURST record.

3. The burst points are read from the CCOVBP input file. This file is produced by hand, or as an output from a COVART run using SHOT2 data to place each of the burst points.

4. FASTGEN uses input from THRTPAR and the CTHREAT file to vector the fragment rays through the target. These inputs are also used to calculate the impact velocity for each fragment. Since this is an impact based mode, fragment drag, and target velocity inputs are not used.

4.3.5 BURST2

Description: Defines multiple burst points based on the CCOVBP input file with uniform rays diverging in all directions. This is intended as a PGEN replacement mode.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
BURST2			igrids	nray/solang	thr		iseed		
BURST2			10	400.	1.2		145789		
C			I	R	R		I		

Parameters	**Units**	**Description**
igrids	------	GS1/GS2 ratio (see SHOT2 data type) for the shot line run used to generate the shot lines used as input to the COVART run which produced the burst point location file (CCOVBP) used for this BURST2 run.
nray/solang	NONE/ steradians per ray	If greater than 1.0, NRAY = the desired number of rays for a full sphere. If less than 1.0, SOLANG = the desired solid angle per ray (steradians per ray).
thr	Target	Threat radius
iseed	------	Random number seed

REMARKS

1. The BURST2 data type may be used once.

2. The BURST2 record may not be used with any other BURST record.

3. The intent of the threat radius input is to improve evaluation of components that are small in two or three dimensions; for example, hydraulic or control lines. The threat radius increases the effective radius of CLINE components.

4. The burst points are read from the CCOVBP input file. This file is produced by hand, or as an output from a COVART run using SHOT2 data to place each of the burst points.

4.3.6 BURST4

Description: Define burst point locations based as specified on the record with diverging rays that are threat definition specific.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
BURST4	Xburst	Yburst	Zburst		ifdrag	ralt	iseed	ifdist	
BURST4	36.0	24.0	36.0		1	5000.0	3456	0	
C	R	R	R		I	R	I	I	

Parameters	**Units**	**Description**
Xburst		X coordinate of the burst point location
Yburst		Y coordinate of the burst point location
Zburst		Z coordinate of the burst point location
ifdrag		Fragment drag switch
		0 = off [DEFAULT]
		1 = on
ralt		Encounter altitude (ft)
iseed		Random number seed used by fragment distribution routines
ifdist		Fragment distribution option in polar zones
		0 = uniform [DEFAULT]
		1 = random

REMARKS

1. The BURST4 data type may be used IVIEW times to create a set of burst points.

2. The VIEW1 card is used to specify the azimuth and elevation of the threat relative to the target velocity coordinate system.

3. The BURST4 record may not be used with any other BURST record.

4. FASTGEN uses input provided by the THRTPAR, TRGTPAR, the CTHREAT file, and the ifdrag parameter to vector the fragment rays through the target. These are also used to calculate the impact velocity and distance from detonation to impact for each fragment.

5. FASTGEN computes an air density and speed of sound using a simple Standard Atmosphere lookup table based on altitude.

4.3.7 BURST5

Description: Defines burst points based on the CCOVBP input file that was generated with a SHOT3 parallel ray run. This record creates diverging rays that are threat definition specific.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
BURST5				ithsrc			iseed	ifdist	
BURST5				0			3456	0	
C				I			I	I	

Parameters	**Units**	**Description**
Ithsrc		Flag indicating the threat velocity source. 0 = Single velocity from the THRTPAR record in the CONTROL file 1 = Individual velocity from the CCOVBP file.
iseed		Random number seed used by fragment distribution routines
ifdist		Fragment distribution option in polar zones 0 = uniform [DEFAULT] 1 = random

REMARKS

1. The BURST5 data type may be used once.

2. When using a BURST5 record you must also use a UNITS record.

3. The BURST5 record may not be used with any other BURST record.

4. The burst points are read from the CCOVBP input file. This file is produced by hand, or as an output from a COVART run using SHOT3 data to place each of the burst points.

5. FASTGEN uses input provided by the THRTPAR and the CTHREAT file to vector the fragment rays through the target. These inputs are also used to calculate the impact velocity of each fragment. Since this is an impact based mode, fragment drag, and target velocity are not used.

4.3.8 *CRANBACK*

Description: Defines seed for random numbers used with backing components.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
CRANBACK	*iseedb*								
CRANBACK	*57329*								
C	*I*								

Parameters	***Units***	***Description***
iseedb		*Seed for generating random numbers for use with backing plate definitions.*

REMARKS

1. *This record should only be used if a CBACKING record is defined. Add intercept to shotline of specified thickness, only if the random number pulled is less than the CBACKING record value RBPPO (probability of occurrence of the CBACKING component).*

2. *CBACKING is not a recommended option.*

4.3.9 CRIT

Description: Defines components that are critical. Shotlines that intersect critical components are used for LOS output.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CRIT	gr	co							
CRIT	3	45							
C	I	I							

Parameters	**Units**	**Description**
gr		Group identification number (0 <= gr <= 9).
co		Component identification number (1 <= co <= 999).

REMARKS

1. The CRIT record may be used IDEL times. The FORTRAN parameter, IDEL, is further explained in the Software Size Limits section of this manual. The default behavior is that all components are critical. The CRIT record is optional.

2. Resultant shotline and vulnerable area data are valid for specified critical components. System level vulnerable area data are not generated.

3. Use of the CRIT record will reduce the output file to include only the shotlines that hit components specified. This reduces the output file size by removing all shotlines that do not hit critical components.

4.3.10 DEL

Description: Defines components that are deleted from the analysis.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
DEL	gr	co							
DEL	3	45							
C	I	I							

Parameters	**Units**	**Description**
gr		Group identification number (0<=gr<=9).
co		Component identification number (1<=co<=999).

REMARKS

1. The DEL record may be used IDEL times. The FORTRAN parameter, IDEL, is further explained in the Software Size Limits section of this manual. The default is that no components are deleted. The DEL record is optional.

4.3.11 ENV

Description: Defines the volume over the target description that the analysis is to be performed.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ENV	xmin	xmax	ymin	ymax	zmin	zmax			
ENV	-30.	-10.	-40.	40.	-10.	50.			
C	R	R	R	R	R	R			

Parameters	Units	Description
xmin,xmax, ymin,ymax, zmin,zmax		Minimum and maximum values define a region that is used for analysis. These boundaries generate a 3-D volume.

REMARKS

1. The ENV record may be used IENVN times. The FORTRAN parameter, IENVN, is further explained in the Software Size Limits section of this manual. The entire target description is used by default. The ENV record is optional.

2. This input restricts the analysis to a subset of the target description.

4.3.12 FOOTER1

Description: A comment line whose content is echoed to the FASTGEN unpacked ASCII LOS output file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
FOOTER1	text								
FOOTER1	User defined text								
C	C								

Parameters	**Units**	**Description**
text		User defined text.

REMARKS

1. This record will be output to the OUNPKA file.
2. This record is optional and is used only with the VIEW3 record.

4.3.13 FOOTER2

Description: A comment line whose content is echoed to the FASTGEN unpacked ASCII LOS output file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
FOOTER2	text								
FOOTER2	User defined text								
C	C								

Parameters	**Units**	**Description**
text		User defined text.

REMARKS

1. This record will be output to the OUNPKA file.
2. This record is optional and is used only with the VIEW3 record.

4.3.14 LIMITS

Description: Define limits on ray density and length.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
LIMITS			rlenmx						
LIMITS			60.0						
C			R						

Parameters	**Units**	**Description**
rlenmx		Maximum length (in target units) of a ray.

REMARKS

1. The default value for all items on the LIMITS card is 0.0.
2. The RLENMX limit only applies to diverging rays.

4.3.15 MULTIHT1

Description: Defines the location of the parallel Multi-hit shotlines.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
MULTIHT1	Y Delta	Z Delta	ThrID	Vel					
MULTIHT1	20.0	2.0	1	1800.0					
C	R	R	I	R					

Parameters	**Units**	**Description**
Y Delta		Y offset from the reference point.
Z Delta		Z offset from the reference point.
ThrID		Threat ID associated with this shotline.
Vel		The impact velocity of the threat identified by the Threat ID.

REMARKS

1. The optional MULTIHT1 record may be used one or more times and can only be used with a SHOT2 or SHOT3 record.

2. The grid location for a SHOT2 or the aim point for the SHOT3 is used as a reference point for the MULTIHT1 record. The Multi-hit shotline location is calculated by adding the Y and Z offset values specified to the reference point. This calculation is performed after the reference point has been rotated into the current view.

3. The threat ID corresponds to the relative position of the defined threat in the threat definition file. The threat definition file is not used by FASTGEN but an improper reference in this record will cause an error when running COVART.

4. The velocity is used by COVART as the impact velocity of the identified threat

4.3.16 OUTPUT1

Description: Defines files that are created which contain the primary LOS output data.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
OUTPUT1	pksb	pksa	unpka	burst	covbp	ifrgb	ifrga	covbpa	
OUTPUT1	1	0	0	0	0	1	0	0	
C	I	I	I	I	I	I	I	I	

Parameters	**Units**	**Description**
pksb		Output pack shotlines LOS data on file OPKSB in binary FASTGEN format 0 = no [DEFAULT]; 1 = yes
pksa		Output pack shotlines LOS data on file OPKSA in ASCII FASTGEN format 0 = no [DEFAULT]; 1 = yes
unpka		Output unpack shotlines LOS data on file OUNPKA in ASCII format 0 = no [DEFAULT]; 1 = yes
burst		Output burst points in BRL-CAD burst format on file OBURST 0 = no [DEFAULT]; 1 = yes
covbp		Output burst points in COVART format on the file OCOVART 0 = no [DEFAULT]; 1 = yes
ifrgb		Output burst ray header and LOS information to file OFRAGB in binary format for all burst rays that hit the target. 0 = no [DEFAULT]; 1 = yes
ifrga		Output burst ray header and LOS information to file OFRAGA in ASCII format for all burst rays. 0 = no [DEFAULT]; 1 = yes
covbpa		Output burst points in ASCII format in the file OCOVARTA file. 0 = no [DEFAULT]; 1 = yes

REMARKS

1. The OUTPUT1 record may be used one time. The OUTPUT1 record is optional.

2. If an OUTPUT1 record is not included, no primary LOS data will be output.

4.3.17 OUTPUT2

Description: Defines type of information output to the OERROR file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
OUTPUT2	inf	err	wght				warn	diag	
OUTPUT2	1	1	1				0	0	
C	I	I	I				I	I	

Parameters	**Units**	**Description**
inf		Output WALL records for elements with undefined interferences to the OERROR file. 0 = no; 1 = yes [DEFAULT]
err		Create and output selected messages to the OERROR file. 0 = no; 1 = yes [DEFAULT]
wght		Output presented area and volume of each component to the OERROR file. Given the density of the component, the weight can be determined. 0 = no; 1 = yes [DEFAULT]
warn		Output warning messages to the OERROR file. 0 = no ; 1 = yes [DEFAULT]
diag		Supplemental diagnostic messages files. 0 = no[DEFAULT] ; 1 = yes

REMARKS

1. The OUTPUT2 record may be used one time.
2. The OUTPUT2 record is optional.
3. Selection of the diag parameter will cause the creation of the ODIAGMSGS and ODIAGLIST files.

4.3.18 OUTPUT3

Description: Defines files that are created which contain additional data.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
OUTPUT3	icob	icoa		losv	cdf	chem		ithrt	irburst
OUTPUT3	0	1		0	1	1		0	0
C	I	I		I	I	I		I	I

Parameters	**Units**	**Description**
icob		Output six direction cosines to file OCOEFB in binary format 0 = no [DEFAULT]; 1 = yes
icoa		Output six direction cosines to file OCOEFA in ASCII format 0 = no [DEFAULT]; 1 = yes
losv		Output LOS data to file OLOSV. Data is in the target coordinate system using the unpacked data format. 0 = no [DEFAULT]; 1 = yes
cdf		Output volume overlap data to file OCDF. Contour Data File (CDF) can be displayed in the VISAGE graphics program. 0 = no [DEFAULT]; 1 = yes
chem		Output LOS data to file OCHEM. LOS data is written out in the target coordinate system using the unpacked format. Only the first and last hits are included in file. 0 = no [DEFAULT]; 1 = yes
ithrt		Output threat, warhead, and burst ray geometric information to file ODISPLAY_THREAT in ASCII format. 0 = no [DEFAULT]; 1 = yes
irburst		Output component data to file RBURST file in ASCII format, to be used with COVART 5.1 and the Combat Assessment Tool. 0 = no [DEFAULT]; 1 = yes

REMARKS

1. The OUTPUT3 record may be used one time. The OUTPUT3 record is optional.

2. Direction cosines for the entrance and exit of each intersection are written in component form.

3. The irburst flag can only be used with SHOT1, SHOT2, SHOT3, and BURST4 modes.

4.3.19 SHOT1

Description: Defines the location of shotlines. Single shotline at an aim point or several shotlines distributed about an aim point by using a Rayleigh distribution.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
SHOT1	Xaim	Yaim	Zaim	ysg	zsg	thr	nsh	iseed	
SHOT1	-40.0	2.0	1.2	2.	3.	1.2	10	9999	
C	R	R	R	R	R	R	I	I	

Parameters	**Units**	**Description**
Xaim		X location of the shotline aim point.
Yaim		Y location of the shotline aim point.
Zaim		Z location of the shotline aim point.
ysg, zsg		Weapon detonation radius in sigmas about the aim point used to locate shotlines (YSG>0.0, ZSG>0.0).
thr		Radius of the threat.
nsh		Number of shotlines about the aim point (0<NSH<=IRAN).
iseed		Random number generator seed number. The seed number must be a large odd number, e.g., 9999.

REMARKS

1. The SHOT1 record may be used one time.

2. The SHOT1 record is optional.

3. The SHOT1 record may not be used with any other SHOT record.

4. If the number of shotlines, NSH, equals one, then the shotline is located at the aim point.

5. The random two dimensional normal distribution location of a shotline is calculated by using the Rayleigh distribution.

6. Often an analyst needs to relate sigmas in terms of circular error probable (CEP). Conversion factor of 1 sigma to inches is 1.1774. One can calculate the equivalent CEP and sigma by using the following equations[6]:

Equation 4-1 Calculating CEP

a. Determine the value, ratio = YSG/ZSG.

*b. If (ratio = 1.0), then CEP = (1.1774*ratio)*(sigma max).*

*c. If (ratio > 0.3), then CEP = (0.53 + 0.72*ratio - 0.074* ratio**2)*(sigma max).*

*d. If (ratio <= 0.3), then CEP = (0.673 - 0.023*ratio + 0.775*ratio**2)*(sigma max).*

Equation 4-2 Calculating Sigma

a. Determine the value, ratio = YSG/ZSG.

*b. If (ratio > 0.3), then sigma = (0.447 + 0.58*ratio - 0.026* ratio**2)*(sigma max).*

*c. If (ratio <= 0.3), then sigma = (0.515 - 0.0025*ratio + 1.125* ratio**2)*(sigma max).*

In general, the theoretical (user input of sigma) and the actual solution (FASTGEN generated shotlines sigmas) result in an error less than 4% for a small (50) number of shots and 2% for a large (1000) number of shots.

7. The intent of the weapon threat radius and random shotline option is to hit small objects, such as fuel lines. The weapon threat radius option increases the effective radius of CLINE elements.

4.3.20 SHOT2

Description: Defines the location of shotlines distributed over the target using a uniform grid.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
SHOT2	gs1	gs2	thr	loc	iseed				
SHOT2	20.0	2.0	1.2	1	9999				
C	R	R	R	I	I				

Parameters	Units	Description
gs1		Grid size (GS1>GS2).
gs2		Subgrid size or shotline density (GS1>GS2).
thr		Radius of the threat.
loc		Shotline location within sub-grid; 1 = Shotline in center of sub-grid [Recommended] 2 = Shotline in an arbitrary location within the sub-grid.
iseed		Arbitrary number generator seed number. The seed number must be a large odd number, e.g., 9999.

REMARKS

1. The optional SHOT2 record may be used one time and cannot be used with any other SHOT record.

2. The sub-grid will affect the accuracy and computer run time. The recommended sub-grid is approximately 2 inches for fighter size aircraft and 3 inches for cargo and bomber aircraft.

3. The software modifies the grid so that the sub-grid divides evenly into the grid: grid /sub-grid = integer; 41 / 2 = 20. This integer value is the number of increments across the grid. The ratio between grid and sub-grid **must** be less than 20 and is recommended to be 10 or 5 for optimal performance.

4. The intent of the threat radius is to hit small objects, such as fuel lines. The threat radius option increases the effective radius of CLINE element to account for the size of the threat.

5. The loc arbitrary option places the shotline in an arbitrary location within a sub-grid. This location repeats for every FASTGEN run with the same seed. Use of this option may provide differing results when the grid/sub-grid size is changed. **Caution should be used when using the random placement option, and is generally not recommended.**

4.3.21 SHOT3

Description: Defines the location of shotlines. The aim point locations are user defined.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
SHOT3	Xaim	Yaim	Zaim						
SHOT3	-5.0	10.0	3.0						
C	R	R	R						

Parameters	**Units**	**Description**
Xaim		X location of the shotline aim point.
Yaim		Y location of the shotline aim point.
Zaim		Z location of the shotline aim point.

REMARKS

1. The SHOT3 record may be used IRAN times. The FORTRAN parameter IRAN is further explained in the Software Size Limits section of this manual.

2. The SHOT3 record is optional.

3. The SHOT3 record may not be used with any other SHOT record.

4.3.22 SHOT4

Description: Defines the location of shotlines grouped together by the VIEW4 record. The aim point locations are user defined.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
SHOT4	Xaim	Yaim	Zaim	vel	mass	imat			
SHOT4	-5.0	1.75	12.40	2000.	20.	5			
C	R	R	R	R	R	I			

Parameters	**Units**	**Description**
Xaim	Target	X coordinate of the shotline aim point.
Yaim	Target	Y coordinate of the shotline aim point.
Zaim	Target	Z coordinate of the shotline aim point.
Vel	fps	Threat velocity
Mass	grains	Threat mass
Imat	-------	Threat material type code

REMARKS

1. The SHOT4 record may be used IRAN times. The FORTRAN parameter IRAN is further explained in the Software Size Limits section of the FASTGEN 5.5 User's Manual.

2. The SHOT4 record is optional.

3. The SHOT4 records following a VIEW4 record are all run at the same view angle.

4. Multiple SHOT4 records may be used with any VIEW 4 record.

5. The SHOT4 record may not be used with any other SHOT record.

6. This record is intended for use with the UEDDAM tool to support commercial aircraft analysis through FASTGEN and COVART.

7. The SHOT4 record produces data that is only supported by the OUNPKA output file.

8. Units for velocity and mass are determined by the use of the output files.

4.3.23 THRTPAR

Description: Defines threat speed and orientation.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
THRTPAR	thrtspd	thrtya	thrtpa	thrtra					
THRTPAR	500.0	20.0	5.0	5.0					
C	R	R	R	R					

Parameters	**Units**	**Description**
thrtspd		Threat speed (ft/s) [DEFAULT = 0 ft/s]
thrtya		Threat yaw angle (deg) [DEFAULT = 0 deg]
thrtpa		Threat pitch angle (deg) [DEFAULT = 0 deg]
thrtra		Threat roll angle (deg) [DEFAULT = 0 deg]

REMARKS

1. The THRTPAR record may be used once in a FASTGEN simulation, and will only produce results when used with a BURST1, BURST4, or BURST5 record.

2. Multiple threat speeds and orientations must be performed with multiple FASTGEN runs.

3. The threat's attack orientation relative to the target velocity coordinate system is defined using the VIEW1 control card for a FASTGEN simulation that uses the BURST1, BURST4, or BURST5 records.

4. Threat speed must be greater than or equal to zero. Threat pitch angle is relative to the plane defined by the threat velocity vector and the target velocity vector. See Figure 4-8, Figure 4-9, and Figure 4-10 for an illustration of these angles. These are applied to the threat rather than the target.

4.3.24 TRGTPAR

Description: Defines target speed and orientation.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
TRGTPAR	tgtspd	tgtya	tgtpa	tgtra					
TRGTPAR	1000.0	45.0	15.0	5.0					
C	R	R	R	R					

<u>**Parameters**</u>	<u>**Units**</u>	<u>**Description**</u>
tgtspd		Target speed (ft/s) [DEFAULT = 0.0 ft/s]
tgtya		Target yaw angle (deg) [DEFAULT = 0.0 deg]
tgtpa		Target pitch angle (deg) [DEFAULT = 0.0 deg]
tgtra		Target roll angle (deg) [DEFAULT = 0.0 deg]

REMARKS

1. The TRGTPAR record may be used once in a FASTGEN simulation, and will only produce results when used with a BURST4 record.

2. Multiple target speeds or orientations must be performed with multiple FASTGEN runs.

3. Yaw, pitch, and roll angles are used to transform between the target spatial coordinate system and the target velocity coordinate system.

4. Target speed must be greater than or equal to zero.

5. The target yaw, pitch, and roll angles (yaw, pitch, and roll) are measured between the target coordinate system and the velocity coordinate system. The rotation angle convention is defined in the following order yaw, pitch and roll. Positive yaw increases nose left. Positive pitch increases nose up. Positive roll increases as the left wing goes up. This is <u>not</u> a strict right handed definition. Figure 4-8, Figure 4-9, and Figure 4-10 show positive yaw, pitch, and roll angles respectively.

Figure 4-8 Yaw – positive direction

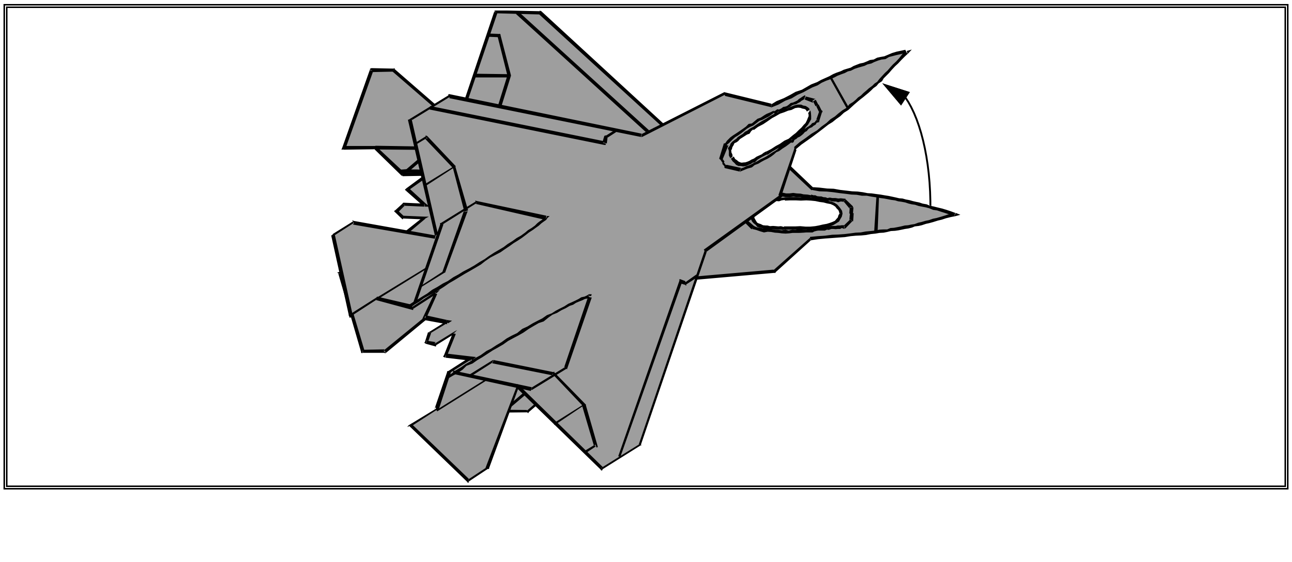


Figure 4-9 Pitch – positive direction

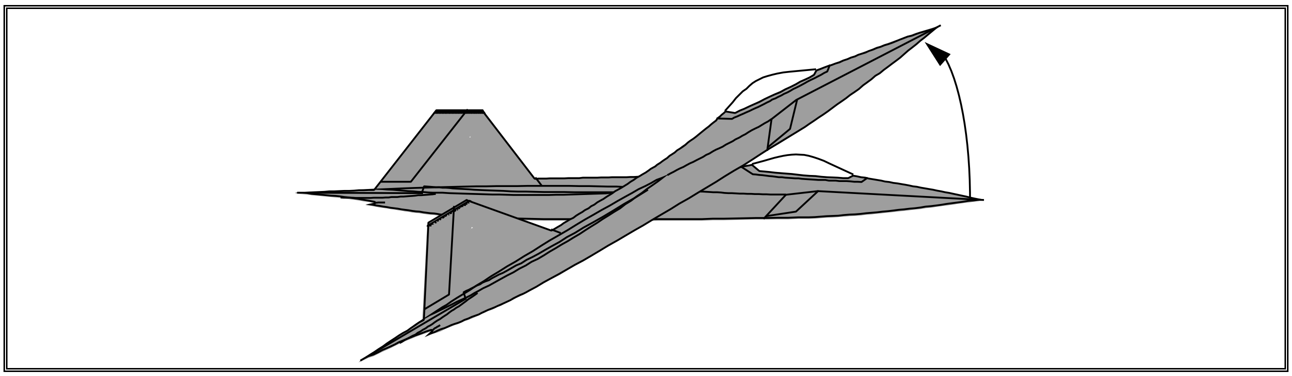
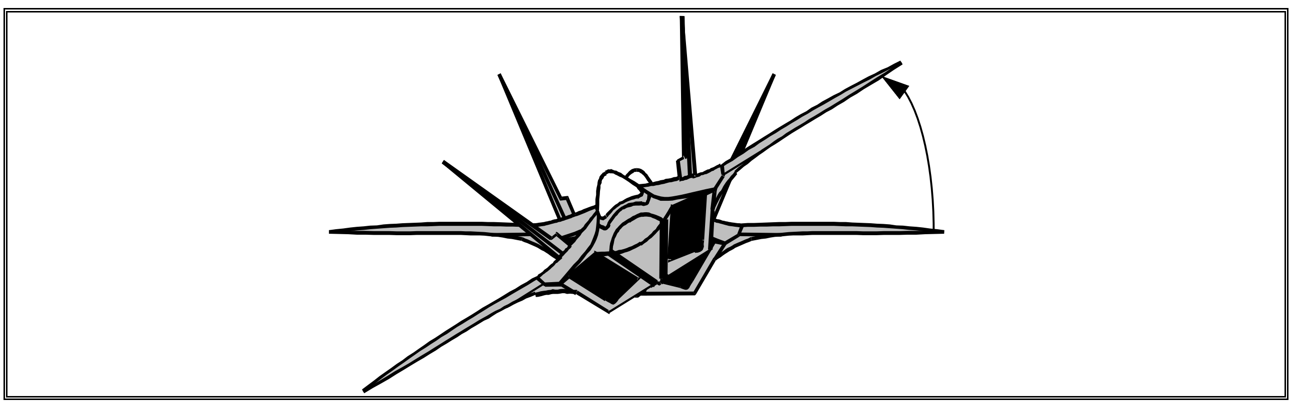


Figure 4-10 Roll – positive direction



4.3.25 UNITS

Description: Defines units of measurement in the target description.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
UNITS	size	name							
UNITS	1.0	Inches							
C	R	C							

Parameters	**Units**	**Description**
size		Size in inches of units of distance used in the target description. Inches = 1.0, mm = 0.03937, meters = 39.37, feet = 12.0, furlongs = 7920.
name		Name of units of distance used in the target description.

REMARKS

1. The UNITS data type is required for any target models not based in inches. All other units must be consistent with the target description units. NOTE: Inputs associated with the ADRaM threat are defined in inches. When using FASTGEN with an ADRaM threat, all inputs MUST be defined in inches.

4.3.26 VIEW1

Description: Defines the target description orientation.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
VIEW1	az	el							
VIEW1	45.0	45.0							
C	R	R							

Parameters	**Units**	**Description**
az		Azimuth angle used to define direction for LOS calculations (0<=az<=360 deg).
el		Elevation angle used to define direction for LOS calculations (-90<=el<=+90 deg).

REMARKS

1. The VIEW1 record may be used IVIEW times. The FORTRAN parameter IVIEW is further explained in the Software Size Limits section of this manual.

2. The VIEW1 record is optional. At least one VIEW record type is required for a FASTGEN run.

3. The VIEW1 record cannot be used with any other VIEW record.

4. The Principal Views Chart (Table 4-1) has a detailed description of the azimuth and elevation angles.

5. The attack aspect is defined between the threat velocity and target velocity coordinate systems for BURST1, BURST4, and BURST5 modes. The attack aspect is defined relative to the target spatial coordinate system for BURST2 and all shotline modes.

4.3.27 VIEW2

Description: Defines the target description orientation.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
VIEW2	opt								
VIEW2	6								
C	I								

Parameters	**Units**	**Description**
opt		Predefined set of azimuth and elevation angles used to define direction for LOS calculations.

opt	Description	View Number
3	3 principal views at 90 degree increments	1, 3, 25
6	6 principal views at 90 degree increments	1, 3, 5, 7, 25, 26
13	13 views at 45 degree increments	1-4, 9-12, 17-20, 25
26	26 views at 45 degree increments	1-26

REMARKS

1. The VIEW2 record may be used one time.
2. The VIEW2 record is optional. At least one VIEW record type is required for a FASTGEN run.
3. The VIEW2 record cannot be used with any other VIEW record.
4. The Principal Views Chart (Table 4-1) has a detailed description of the azimuth and elevation angles
5. The attack aspect is defined relative to the target spatial coordinate system.
6. Due to limitations in FASTGEN and COVART, a VIEW2 record cannot be used with a BURST1, BURST2, BURST4, or BURST5 record.

4.3.28 VIEW3

Description: Defines the target orientation for one view and a shotline aim point location that is specified on this record.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
VIEW3	az	el	Xaim	Yaim	Zaim	vel	mass	imat	
VIEW3	35.0	15.0	54.26	1.75	12.40	2000.	20.	5	
C	R	R	R	R	R	R	R	I	

Parameters	Units	Description
az		Azimuth angle used to define the direction of the shotline for the LOS calculations (0<= az <= 360 deg.).
el		Elevation angle used to define the direction of the shotline for the LOS calculations (-90 <= el <= 90 deg.).
Xaim		X coordinate of the shotline aim point.
Yaim		Y coordinate of the shotline aim point.
Zaim		Z coordinate of the shotline aim point.
vel		Threat velocity
mass		Threat mass
imat		Threat material type code

REMARKS

1. X, Y, Z coordinates are defined in the target coordinate system.
2. This record is intended for use with the SHAZAM tool to support an end-game process through FASTGEN and COVART.
3. Units for velocity and mass are determined by the use of the output files.
4. Attack aspect is defined relative to the target spatial coordinate system.

4.3.29 VIEW4

Description: Defines the target description orientation.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
VIEW4	az	el							
VIEW4	45.0	45.0							
C	R	R							

Parameters	**Units**	**Description**
az	deg.	Azimuth angle used to define direction for LOS calculations (0<=az<=360 deg).
el	deg.	Elevation angle used to define direction for LOS calculations (-90<=el <=+90 deg).

REMARKS

1. The VIEW4 record may be used IVIEW times. The FORTRAN parameter IVIEW is further explained in the Software Size Limits section of the FASTGEN 5.5 User's Manual.

2. The VIEW4 record is optional.

3. The SHOT4 records following a VIEW4 record are all run at the same view angle.

4. The VIEW4 record cannot be used with any other VIEW record.

5. This record is intended for use with the UEDDAM tool to support commercial aircraft analysis through FASTGEN and COVART.

4.3.30 $COMMENT

Description: Defines user comments.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
$COMMENT	text								
$COMMENT	User defined text								
C	C								

Parameters	Units	Description
text		User defined text

REMARKS

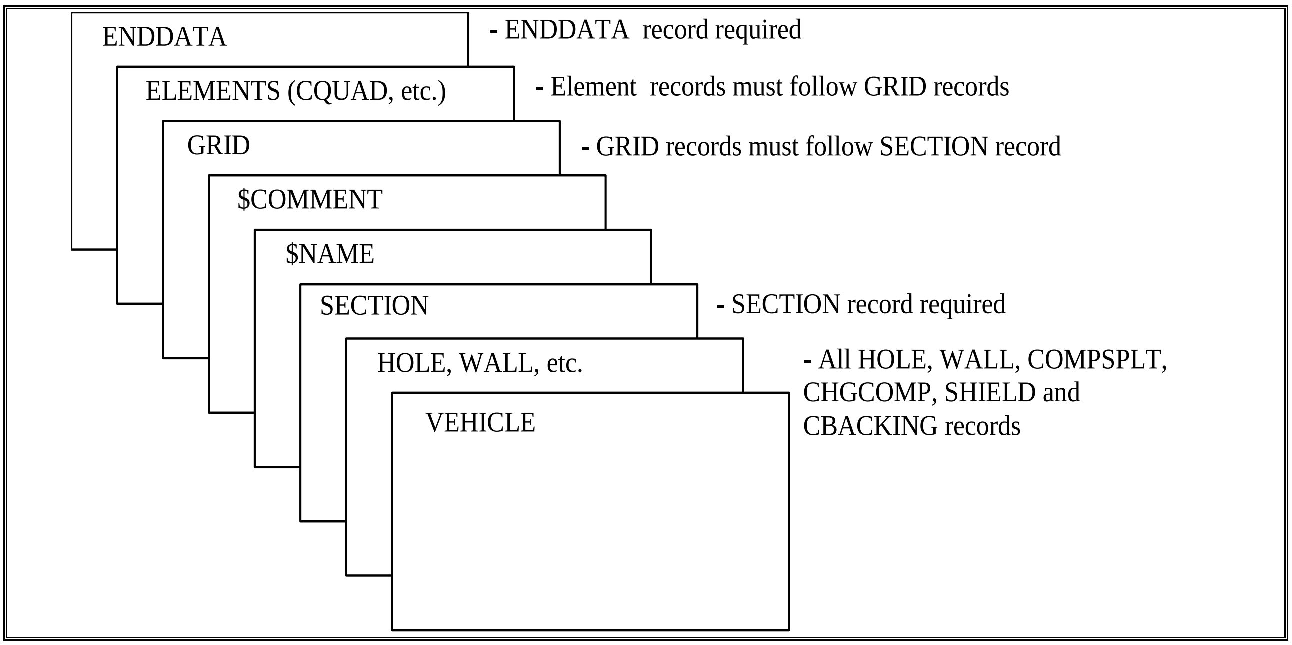
1. The $COMMENT record may be used multiple times.

5. CBULK Input File

5.1 Description

Versions of FASTGEN prior to 4.1 required order-dependent data. FASTGEN uses a different input format that greatly reduces the quantity of order-dependent data. All versions of FASTGEN assume that components are spatially compact, i.e., the absolute differences between the coordinate minimums and maximums are small in size. Keeping components small in size decreases the number of times the elements in a component must be compared to shotline locations. Previous versions of FASTGEN enforced this approach by requiring order-dependent data. The new format assumes the user will build the component in a compact form. Non-spatially compact components will increase the execution time of FASTGEN.

Figure 5-1 CBULK Input File



The CBULK file records are specified using fixed format lines containing ten fields with eight columns per field. Each field contains an input variable that is a real (R), integer (I), or character (C) data type. The first field in the first line of a record contains a character variable that identifies the record, and must be left justified. Some records require two lines to hold all the information. These records use the tenth column of the first line and the first column of the second line as continuation variables. The continuation variables in field ten and one must match in value and digit location. All other input variables will be either real, character, or integer variables, and must fall within the required field.

The bulk data file has VEHICLE, HOLE, WALL, SECTION, $COMMENT, $NAME, GRID, *CBACKING*, *CBAR*, CLINE, CHEX1, CHEX2, CTRI, CQUAD, *CCONE1*, CCONE2, *CCONE3*, CSPHERE, COMPSPLT, CHGCOMP, SHIELD and ENDDATA records.

All COMPSPLT, *CBACKING*, CHGCOMP, SHIELD, HOLE and WALL records should precede the first SECTION record. Each component starts with a SECTION record. GRID records must follow the SECTION record. The element records *CBAR*, CLINE, CHEX1, CHEX2, CTRI, CQUAD, *CCONE1*, CCONE2, *CCONE3*, and CSPHERE must follow GRID records. The number of records per section is limited by the software parameters stated in the SOFTWARE DESCRIPTION chapter.

Most graphics packages require unique grid point and element identification numbers throughout the bulk data file. FASTGEN only requires unique grid point and element identification numbers within a component. It is recommended that unique identification numbers be used throughout the bulk data file. $COMMENT and $NAME records may be placed anywhere in the bulk data file. The ENDDATA record may only be used once. Any data following the ENDDATA record will be ignored.

The user should refer to the FASTGEN6 Target Description document for changes to the CBULK description.

5.2 FASTGEN and NASTRAN

The FASTGEN bulk data file is derived from FASTGEN and NASTRAN input formatting requirements. Vulnerability analysts have used FASTGEN for many years. Structural analysts have used NASTRAN since the early 70's. NASTRAN input format is highly structured and flexible. This flexibility is difficult to support. FASTGEN is structured around the NASTRAN format, but several differences exist. A cross-reference of FASTGEN and NASTRAN elements is shown in Table 5-1.

Table 5-1 FASTGEN vs. NASTRAN Format

FASTGEN Records	NASTRAN Records
GRID	GRID
CBAR	CBAR
CLINE	CROD, CBAR, CBEAM
CTRI	CTRIA1, CTRIA2, CTRIA4
CQUAD	CQUAD1, CQUAD2, CQUAD4
CCONE1	None
CCONE2	None
CCONE3	None
CSPHERE	None
CHEX1	CHEXA1
CHEX2	CHEXA1

The basic difference between FASTGEN and finite element models (FEM), such as NASTRAN, is that FEM requires each structural element to be connected to another structural element, while FASTGEN does not permit connectivity between groups and/or components.

5.3 Work Unit Code (WUC)

WUC group names are classified by equipment types and functions, and by special interest items. Group identification numbers range from 11 to 99. New FASTGEN models should be organized by groups as shown in Table 5-2:

Table 5-2 Work Unit Code (WUC) Group Chart

Code	Group Name
Aircraft Basic	
11	airframe
12	cockpit and fuselage compartments
13	landing gear
14	flight control
16	escape capsule
17	aerial recovery system
Propulsion, Secondary Power	
22	turbo prop power plant
23	propulsion system
24	auxiliary power plant
32	hydraulic propeller
Utilities	
41	air conditioning, pressurization and surface ice control
42	electric power supply
44	lighting system
45	hydraulic and pneumatic power supply
46	fuel system
47	oxygen system
49	miscellaneous utilities
Instrumentation	
51	instruments
52	autopilot
55	malfunction analysis and recording equipment
56	accident investigation recording system
57	integrated guidance and flight control

Code	Group Name
Communications	
61	HF communications
62	VHF communications
63	UHF communications
64	intercommunications
65	IFF
66	emergency communications
68	satellite communications
69	miscellaneous communications equipment
Navigation, Fire Control, Weapons Delivery, ECM, Photo	
71	radio navigation
72	radar navigation
73	bombing navigation
74	fire control
75	weapon delivery
76	electronic countermeasure
77	reconnaissance systems
78	special system
81	surveillance radar
89	airborne battlefield command control center (capsule)
Miscellaneous Equipment	
91	emergency equipment
92	tow-target equipment
93	drag chute equipment
94	voice warning system
95	airborne operational equipment
96	personnel equipment
97	explosive devices and components
98	atmospheric research equipment

5.4 Component Names

Component names vary from application to application. The names listed in Table 5-3 are to be used as a guide, not as an all-inclusive list of names. Names are classified as equipment types, functions, and special-interest items.

Table 5-3 Component Names Chart

Component Name	Component Name
Skin	**Ammunition**
Skin Panel	Bomb
Windscreen	Bomb Rack
Door	Missile
-Bomb Bay	
-Access	**Armament**
-Entry	LRU
-Nose Wheel	Gun
-Landing Gear	Ammunition Storage
Power Plant	**Structural Members**
Line Replacement Unit (LRU)	Stringer
Electric Power Generator	Frame
Fuel Nozzle	Bulkhead
Blade	
Combustor	
Compressor	
Afterburner	
Turbine	
Crew	**Electric System**
Head	LRU
Trunk	Electric Cable
Leg	Antenna
Arm	

Component Name	Component Name
Flight Control System	**Sensor**
LRU Hydraulic Line Hydraulic Reservoir Hydraulic Pump	Display Instrument Panel
Fuel System	**Miscellaneous**
LRU Fuel Line Fuel Pump Tank -Internal -External	Seat Tire Landing Gear Armor

5.5 COVART Materials

Materials allowed within COVART are shown in Table 5-4. The FASTGEN database should represent the equipment configuration, not COVART limitations.

Table 5-4 Threat Material Code Numbers

	JTCG Fragments and HE casings	
1	Steel (BHN = 100)	
2	Steel (BHN = 150)	
3	Steel (BHN = 200)	
4	Steel (BHN = 250)	
5	Steel (BHN = 300)	
6	Steel (BHN = 350)	
	JTCG Projectile Cores and FATEPEN Fragments	
1	Steel (BHN = 100)	
2	Steel (BHN = 150)	
3	Steel (BHN = 200)	
31018	Steel (BHN = 200)*†	FATEPEN only alloy 1018.*
34140	Steel (BHN = 200)* †	FATEPEN only alloy 4140.*
4	Steel (BHN = 250)	
44140	Steel (BHN = 250)* †	FATEPEN only alloy 4140.*
5	Steel (BHN = 300)	
54140	Steel (BHN = 300)* †	FATEPEN only alloy 4140.*
54130	Steel (BHN = 300)* †	FATEPEN only alloy 4130.*
6	Steel (BHN = 350)	
64140	Steel (BHN = 350)* †	FATEPEN only alloy 4140.*
64130	Steel (BHN = 350)* †	FATEPEN only alloy 4130.*
7	Titanium (BHN = 285)	
8	Aluminum 2024	
9	Aluminum 5083	
10	Aluminum 5154	
11	Aluminum 5356	
12	Aluminum 6061	
13	Aluminum 7075	
14	Aluminum 7039	

	JTCG Projectile Cores and FATEPEN Fragments
16	Face Hardened Steel ‡
17	Cast Iron ‡
18	Copper ‡
19	Lead %
30	Depleted Uranium *
31	Steel (BHN = 550) *‡
32	Steel(BHN = 600) *‡
33	Tungsten *
42	Tantalum (NRC 76, BHN = 255)* †
43	Tantalum (pure, BHN =90)* †
44	Tantalum (pure, BHN = 70)* †
45	Titanium (BHN = 180)*

Notes on Table 5-4:

The 5 digit steel material codes are broken down as follows:

- First digit indicates the hardness. (See Sheet 1.)
- Digits 2 - 5 indicate the alloy steel
- For FATEPEN fragments, using material codes 1, 2, 3, 4, 5, or 6 results in a default alloy of 4140. Thus the following are equivalent:

  3 and 34140
  4 and 44140
  5 and 54140
  6 and 64140

* not in the JTCG Penetration Handbook (61/JTCG/ME-77-16, Revision 1)
† not valid for JTCG projectile cores
‡ not valid for FATEPEN fragments (IPROJ = -2, -3 or -4)

5.6 Input Data Records

5.6.1 *CBAR*

Description: Defines a reinforcing member element.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
CBAR	*EID*	*MID*	*G1*	*G2*	*IGRA*	*ICOA*	*TH*	*R1*	
CBAR	*55*	*14*	*991*	*992*	*1*	*099*	*0.04*	*3.0*	
C	*I*	*I*	*I*	*I*	*I*	*I*	*R*	*R*	

Parameters	***Units***	***Description***
EID	------	*Element identification number (EID > 0).*
MID	------	*Material identification number (MID > 0).*
G1,G2	------	*Grid point identification numbers (G1 and G2 > 0, no repeated grid identification numbers).*
IGRA	------	*Optional. Group number for component that element is associated with. See Remark 4. This is not the same as the component this element is part of.*
ICOA	------	*Optional. Component number for component that element is associated with. See Remark 4. This is not the same as the component this element is part of.*
TH	------	*Normal thickness (TH > 0.0, and TH <= R1). Bar elements should be used in plate mode only.*
R1	------	*Half-width (R1 > 0.0).*

REMARKS

1. *Element identification numbers must be unique with respect to all other element identification numbers within a component.*

2. *The maximum difference between the highest and lowest element identification number is parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.*

3. *The material identification numbers for several materials are defined in the FASTGEN Materials Chart.*

4. *This element is intended to provide an approximate model of reinforcing members that may require much effort to treat exactly. Common cross sectional shapes for reinforcing members include L, U, T, and hat.*

5. *The input width determines the intersection, using the influence mode computation in the same way the CLINE intersections are modeled. LOS thickness is determined using the normal thickness and the obliquity of the adjacent component. The optional input of the associated component affects the exact modeling of the intersection with the bar. If the associated component is not specified, and the computed intersection is within one grid spacing of one of the adjacent components on the shotline, that intersection is moved to be contiguous with the adjacent component and given the same obliquity as the adjacent component. If the associated component is specified and one of the adjacent components on the shotline is the associated component, then the same procedure is used, with the bar placed contiguous to the associated component. If no associated component is specified and the bar is not near any component, or if the associated component is specified, but neither of the adjacent components on the shotline are the associated component, then the intersection computed using the CLINE technique is used. In any case, if the computed intersection places the bar component within a volume mode component, the bar will be moved to a location outside the volume mode component. Also, if possible, a bar component will not be placed as the first or last component on a shotline. If there is a plate mode component adjacent to a bar at the beginning or end of a shotline, the components will be moved so the plate mode component (typically aircraft skin) is on the outside.*

5.6.2 *CBACKING*

Description: Defines backing component occurrence.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
CBACKING	*igrp1*	*icmp1*	*igrp2*	*icmp2*	*rbptn*	*rbppo*	*ibmpt*		
CBACKING	*0*	*123*	*7*	*123*	*0.25*	*0.3*	*8*		
C	*I*	*I*	*I*	*I*	*R*	*R*	*I*		

Parameters	***Units***	***Description***
igrp1	------	*Group number of a component in the bulk file.*
icmp1	------	*Component number of a component in the bulk file.*
igrp2	------	*Group number of the backing component (not in the bulk file).*
icmp2	------	*Component number of the backing component (not in the bulk file).*
rbptn	*Target*	*Normal thickness of the backing component (inches).*
rbppo	------	*Probability of occurrence of the backing component.*
ibmpt	------	*Material type of the backing component.*

REMARKS

1. *Used under special circumstances were the effects of increasing modeling fidelity is desired without spending the resources in explicitly modeling the additional components.*

2. *Use only in conjunction with plate mode components.*

3. *Randomly inserts a component behind a known component to capture the effect of a non-uniformly placed component.*

4. *Intended to be used with older target descriptions.*

5.6.3 *CCONE1*

Description: Defines a thin wall cone/cylinder shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CCONE1	*eid*	*mid*	*g1*	*g2*			*th*	*r1*	*c1*
CCONE1	*55*	*14*	*981*	*982*			*3.0*	*8.0*	*55*
C	*I*	*I*	*I*	*I*			*R*	*R*	*C*

1	2	3	4	5	6	7	8	9	10
c2	***r2***	***end1***	***end2***						
55	*6.5*	*2*	*1*						
C	*R*	*I*	*I*						

Parameters	***Units***	***Description***
eid		*Element identification number (eid > 0).*
mid		*Material identification number (mid > 0).*
g1, g2		*Grid point identification numbers (g1 and g2 > 0, no repeated grid identification numbers).*
th		*Normal wall thickness (th > 0.0).*
r1, r2		*Radius at g1 and g2 (r1 and r2 >= 0.0).*
c1, c2		*Continuation record flag c1 must equal the value and position (left justified) of c2. This flag allows the user to locate misplaced continuation records. Normally, c1 and c2 equal eid.*
end1, end2		*End plate closure condition at g1 and g2:* *1 = open (if radius = 0., end is open) [DEFAULT]* *2 = closed.*

REMARKS

1. *Element identification numbers must be unique with respect to all other element identification numbers within a component.*

2. *The maximum difference between the highest and lowest element identification number is parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.*

3. *The thickness is assumed to be small, i.e., less than 2 inches. An element thicker than 2 inches should be modeled with a CCONE2 element.*

4. *Continuation record must follow parent.*

5. *The material identification numbers for several materials are defined in the FASTGEN Materials Chart Table 5-4.*

6. *The normal wall thickness is measured perpendicular from the cone wall, which in general, is not parallel to the cone's radial direction. For a cylinder, the normal wall thickness and the wall height are equal. For a cone, the normal wall thickness and the wall height are different. See Figure 5-2 or a more descriptive illustration.*

7. *End plate thickness is equal to the normal wall thickness. For very small cone lengths, the end plate thickness is set equal to the cone length if one end plate is specified, or set equal to the half the cone length if both end plates are active.*

8. *Special care should be taken when multiple CCONE1 elements are used in sequence to construct a complex object to insure that the cone ends match up correctly and that interferences are not generated.*

9. *When building complex objects without end plates, use of the CCONE2 element is recommended.*

10. *Figure 5-3 is a schematic of a complex object composed of 3 CCONE1 elements. The first two elements (A and C) are identical with specified outer radii and thickness ta. Element B is a transition CCONE1 element between A and C. The normal wall thickness for element B (tb) is different from the thickness of elements A and C. Each of these thicknesses is designated with red arrows.*

Figure 5-2 CCONE1

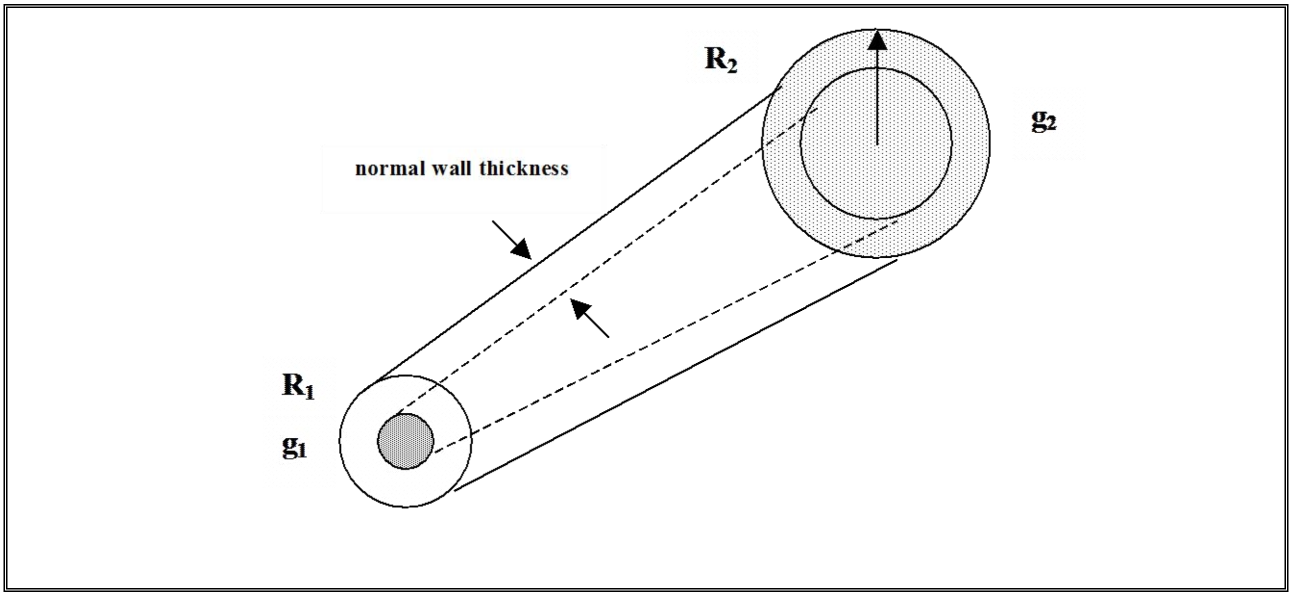
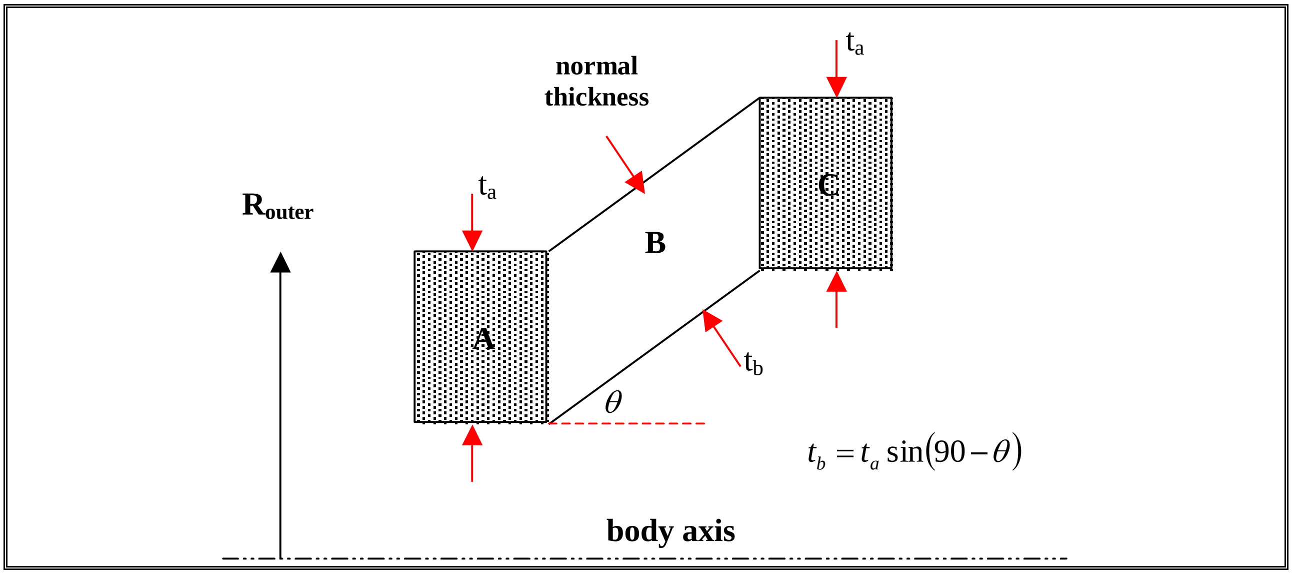


Figure 5-3 CCONE1 Normal Wall Thicknesses



5.6.4 CCONE2

Description: Defines a thick wall cone/cylinder shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CCONE2	eid	mid	g1	g2				ro1	c1
CCONE2	55	14	981	982				5.0	55
C	I	I	I	I				R	C

1	2	3	4	5	6	7	8	9	10
C2	ro2	ri1	ri2						
55	10.0	3.0	7.0						
C	R	R	R						

Parameters	Units	Description
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1, g2		Grid point identification numbers (g1 and g2 > 0, no repeated grid identification numbers).
ro1, ro2		Outer normal radius at g1 and g2 (ro1 and ro2 >= 0.0).
ri1, ri2		Inner normal radius at g1 and g2 (ri1 and ri2 >= 0.0).
c1, c2		Continuation record flag c1 must equal the value and position (left justified) of c2. This flag allows the user to locate misplaced continuation records. Normally, c1 and c2 equal eid.

REMARKS

1. Element identification numbers must be unique with respect to all other element identification numbers within a component.

2. The maximum difference between the highest and lowest element identification number is parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN

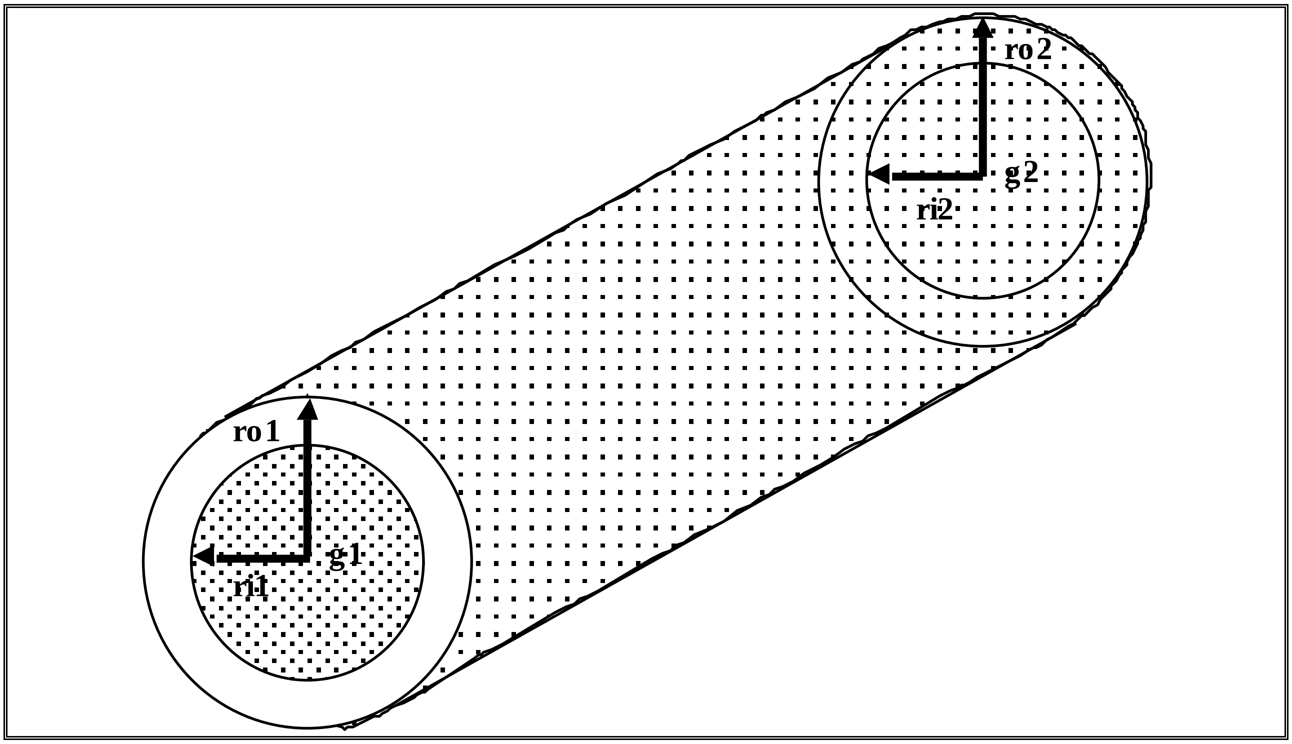
parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.

3. Continuation record must follow parent.

4. CCONE2 elements may only be used in volume mode components.

5. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-4 CCONE2



5.6.5 *CCONE3*

Description: Defines a compound thick wall cone/cylinder shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CCONE3	*eid*	*mid*	*g1*	*g2*	*g3*	*g4*			*c1*
CCONE3	*55*	*14*	*981*	*982*	*983*	*984*			*55*
C	*I*	*I*	*I*	*I*	*I*	*I*			*C*

1	2	3	4	5	6	7	8	9	10
c2	*ro1*	*ro2*	*ro3*	*ro4*	*ri1*	*ri2*	*ri3*	*ri4*	
55	*10.0*	*3.0*	*7.0*	*8.0*	*5.0*	*2.0*	*3.0*	*4.0*	
C	*R*	*R*	*R*	*R*	*R*	*R*	*R*	*R*	

Parameters	***Units***	***Description***
eid		*Element identification number (eid > 0).*
mid		*Material identification number (mid > 0).*
g1, g2, g3, g4		*Grid point identification numbers (g1, g2, g3 and g4 > 0, no repeated grid identification numbers).*
ro1, ro2, ro3, ro4		*Outer normal radius at g1, g2, g3, g4 (ro1, ro2, ro3 and ro4 >= 0.0).*
ri1, ri2, ri3, ri4		*Inner normal radius at g1, g2, g3, g4 (ri1, ri2, ri3 and ri4 >= 0.0).*
c1, c2		*Continuation record flag c1 must equal the value and position (left justified) of c2. This flag allows the user to locate misplaced continuation records. Normally, c1 and c2 equal eid.*

REMARKS

1. *Element identification numbers must be unique with respect to all other element identification numbers within a component.*

2. *The maximum difference between the highest and lowest element identification number within a component is defined by parameter ILOS. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.*

3. *Continuation record must follow parent.*

4. *The CCONE3 element may only be used in volume mode components.*

5. *The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).*

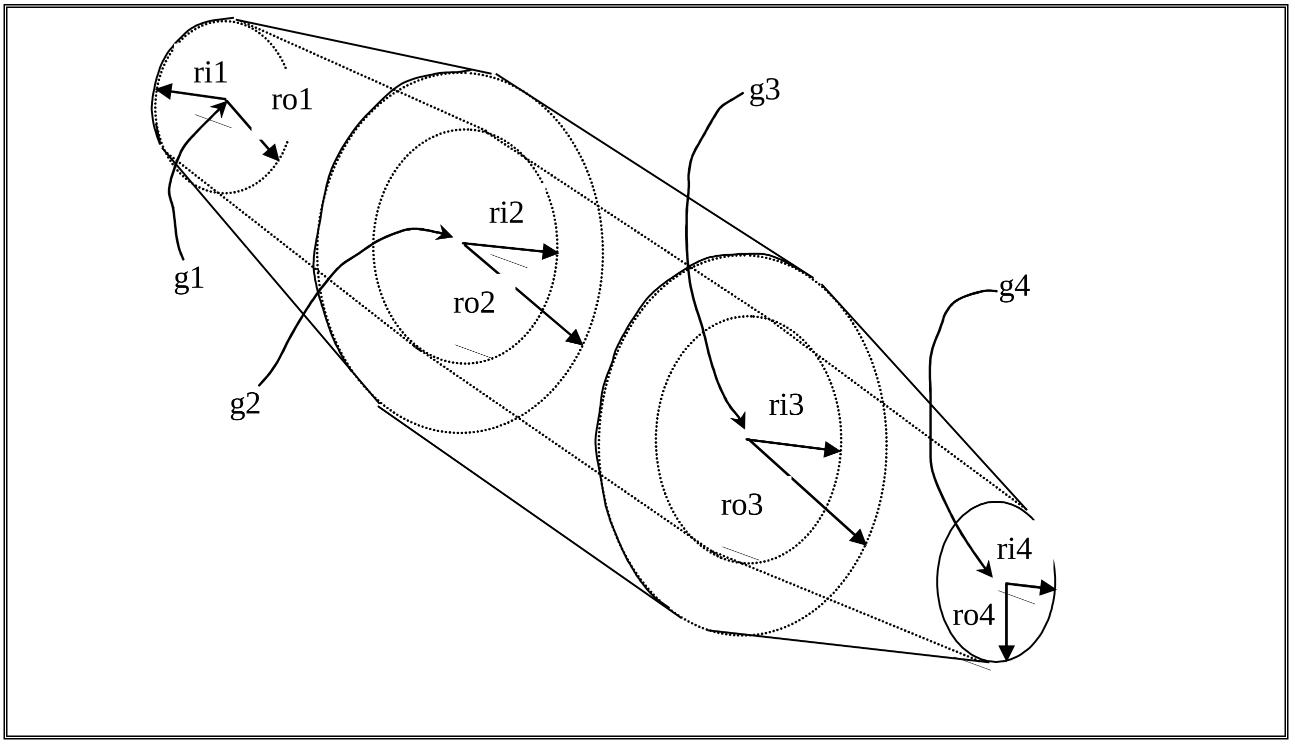
6. *The CCONE3 element is treated internally as 3 CCONE2 type elements.*

7. *It is recommended that CCONE3 grid points be input so that points 1 and 4 represent the ends and points 2 and 3 are sequential between them. If this is not done, FASTGEN will reorder the points and associated radii so that this is the case, and it will be more difficult for the user to understand the target description. The discussion in the following Remarks assumes that the grid points are ordered in this way.*

8. *Points 1 and 2 may coincide and points 3 and 4 may coincide. Points 2 and 3 may coincide as long as points 1 and 4 are distinct. A warning message is output if 3 of the 4 points coincide.*

9. *It is not necessary to define all of ro1, ro2, ro3, ro4, ri1, ri2, ri3, and ri4. At least one radius must be defined at points 1 and 4; if only one radius is defined, that radius is used for both the inner and outer radius at that end. If ro2 is not defined, its value is interpolated between ro1 and ro3 or ro4 (ro4 is used if ro3 is not defined). If ro3 is not defined, its value is interpolated between ro2 or ro1 (ro1 is used if ro2 is not defined) and ro4. An analogous process is used if ri2 or ri3 is not defined. If two points coincide, it doesn't matter which point a radius is assigned to. For example, if points 2 and 3 coincide, ri2 and ro3 could be defined, or ro2 and ri3 could be defined; the result would be the same. If different values are read in for the inner or outer radii at coincident grids, the result is undefined and no error is reported.*

Figure 5-5 CCONE3 Nomenclature



5.6.6 CHEX1

Description: Defines a thin wall hexahedron shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CHEX1	eid	mid	g1	g2	g3	g4	g5	g6	c1
CHEX1	55	14	991	992	993	994	996	997	6
C	I	I	I	I	I	I	I	I	C

1	2	3	4	5	6	7	8	9	10
c2	g7	g8					th	pos	
6	998	999					0.05	1	
C	I	I					R	I	

Parameters	**Units**	**Description**
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1, g2, g3, g4 g5, g6, g7, g8		Grid point identification numbers (g1 through g8 > 0, no repeated identification number).
th		Normal thickness (th > 0.0).
pos		Grid point position relative to normal thickness. 1 = center 2 = front face [DEFAULT]

REMARKS

1. Element identification numbers must be unique with respect to all other element identification numbers within a component.

2. The maximum difference between the highest and lowest element identification number is parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN

parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as four elements.

3. Grid points g1 through g8 must be ordered around the perimeter of the element. The direction of order (clockwise or counterclockwise) is not specified. Grid points g5 through g8 must be ordered in the same direction as grid points g1 through g4.

4. Continuation record must follow parent.

5. The software divides a CHEX element into twelve triangles. Grid points g1, g2, and g5 are used to define the first triangle, while g2, g6, and g5 are used for the second triangle and so on until each triangle is defined.

6. When a shotline enters and exits the CHEX element no additional triangles are analyzed.

7. If two or more points are positioned at the same location, the triangles will degenerate into a line or a point. The CHEX element is sufficiently general to properly account for degenerated triangles.

8. The center of an element is well defined. The front face of an element is orientation dependent. The front face option is supported to simplify the translation of FASTGEN-3 target descriptions into FASTGEN-4 target descriptions.

9. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-6 CHEX1

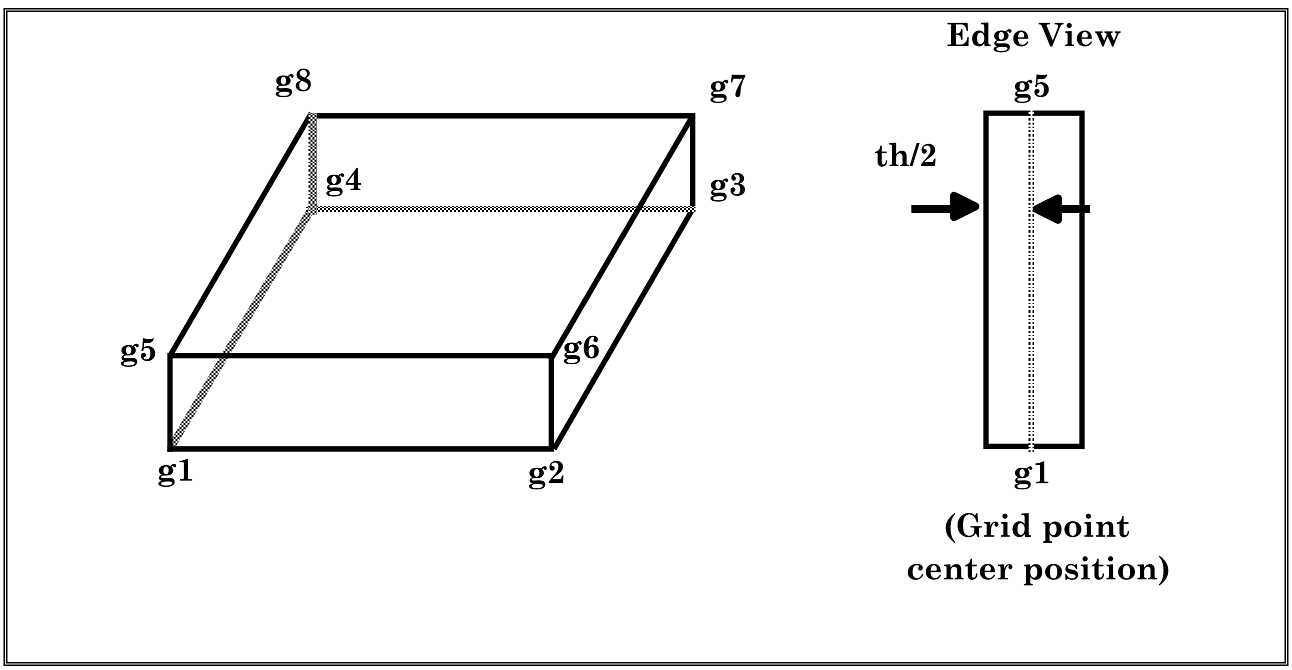


Table 5-5 CHEX1 Triangles & Associated Grid Points

Triangles	Grid Identification Numbers		
1	g1	g2	g5
2	g2	g6	g5
3	g2	g3	g6
4	g3	g7	g6
5	g3	g4	g7
6	g4	g8	g7
7	g4	g1	g8
8	g1	g5	g8
9	g5	g7	g8
10	g5	g6	g7
11	g1	g2	g3
12	g1	g3	g4

5.6.7 CHEX2

Description: Defines a solid hexahedron shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CHEX2	eid	mid	g1	g2	g3	g4	g5	g6	c1
CHEX2	55	14	991	992	993	994	996	997	6
C	I	I	I	I	I	I	I	I	C

1	2	3	4	5	6	7	8	9	10
c2	g7	g8							
6	998	999							
C	I	I							

Parameters	**Units**	**Description**
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1, g2, g3, g4, g5, g6, g7, g8		Grid point identification numbers (g1 through g8 > 0, no repeated grid identification numbers).

REMARKS

1. Element identification numbers must be unique within a component.

2. The maximum difference between the highest and lowest element identification number is parameter ILOS within a component. ILOS elements are allowed within a component This element counts as four elements.

3. Grid points g1 through g8 must be ordered around the perimeter of the element. The direction of order (clockwise or counterclockwise) is not specified. Grid points g5 through g8 must be ordered in the same direction as grid points g1 through g4.

4. Continuation record must follow parent.

5. The software divides a CHEX element into twelve triangles. Grid points g1, g2, and g5 are used to define the first triangle, while g2, g6, and g5 are used for the second triangle and so on until each triangle is defined.

6. The CHEX2 element may only be used in volume mode components.

7. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-7 CHEX2

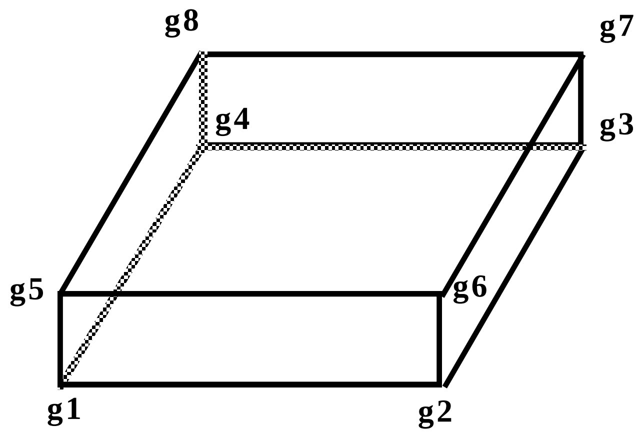


Table 5-6 CHEX2 Triangles & Associated Grid Points

Triangles	Grid Identification Number		
1	g1	g2	g5
2	g2	g6	g5
3	g2	g3	g6
4	g3	g7	g6
5	g3	g4	g7
6	g4	g8	g7
7	g4	g1	g8
8	g1	g5	g8
9	g5	g7	g8
10	g5	g6	g7
11	g1	g2	g3
12	g1	g3	g4

5.6.8 CHGCOMP

Description: Defines a component number to be changed.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CHGCOMP	numchg	nbtw	nunum						
CHGCOMP	5010	5020	5011						
C	I	I	I						

Parameters	**Units**	**Description**
numchg		The component number to be changed.
nbtw		The component number that exists on the shotline that will trigger the component number change. (see remark 3)
nunum		The new component number

REMARKS

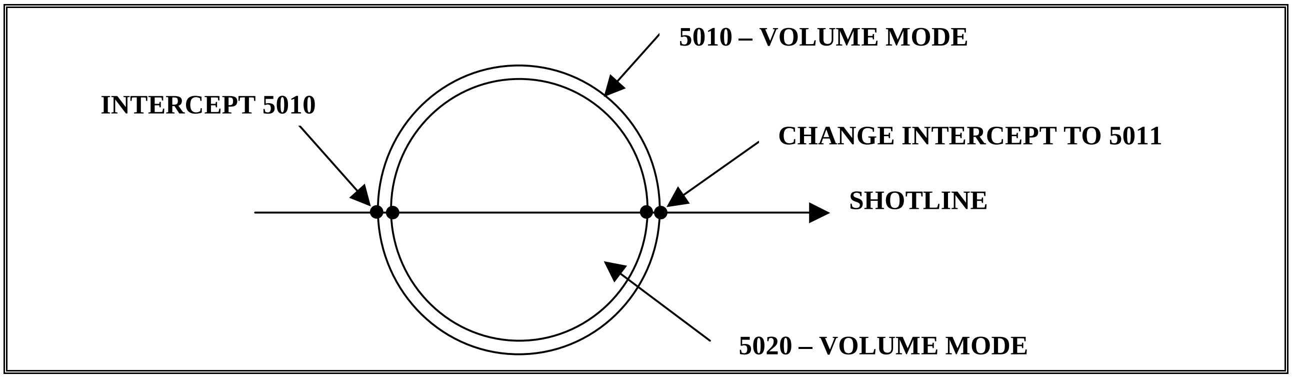
1. This record should be used for volume mode components only. If used on plate mode components the shotline may be modified incorrectly.

2. This record was developed for use under special circumstances. The purpose behind this record is to modify the exit intercept of a volume mode component.

3. This variable identifies a component that will typically be enclosed within a volume that always appears as a shotline intercept between the entrance and exit of the surrounding volume (See Figure 5-8 below).

4. BRL-CAD users need to run a post-processor, which will reproduce these results from a BRL-CAD generated log file.

Figure 5-8 CHGCOMP Diagram



5.6.9 CLINE

Description: Defines a line (rod) shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CLINE	eid	mid	g1	g2			th	r1	
CLINE	55	14	991	992			0.04	3.0	
C	I	I	I	I			R	R	

Parameters	**Units**	**Description**
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1, g2		Grid point identification numbers (g1 and g2 > 0, no repeated grid identification numbers).
th		Normal thickness (th >= 0.0 and th <= r1). If th equals 0.0, then the element must be in a volume mode component.
r1		Normal radius (r1 > 0.0)

REMARKS

1. Element identification numbers must be unique with respect to all other element identification numbers within a component.

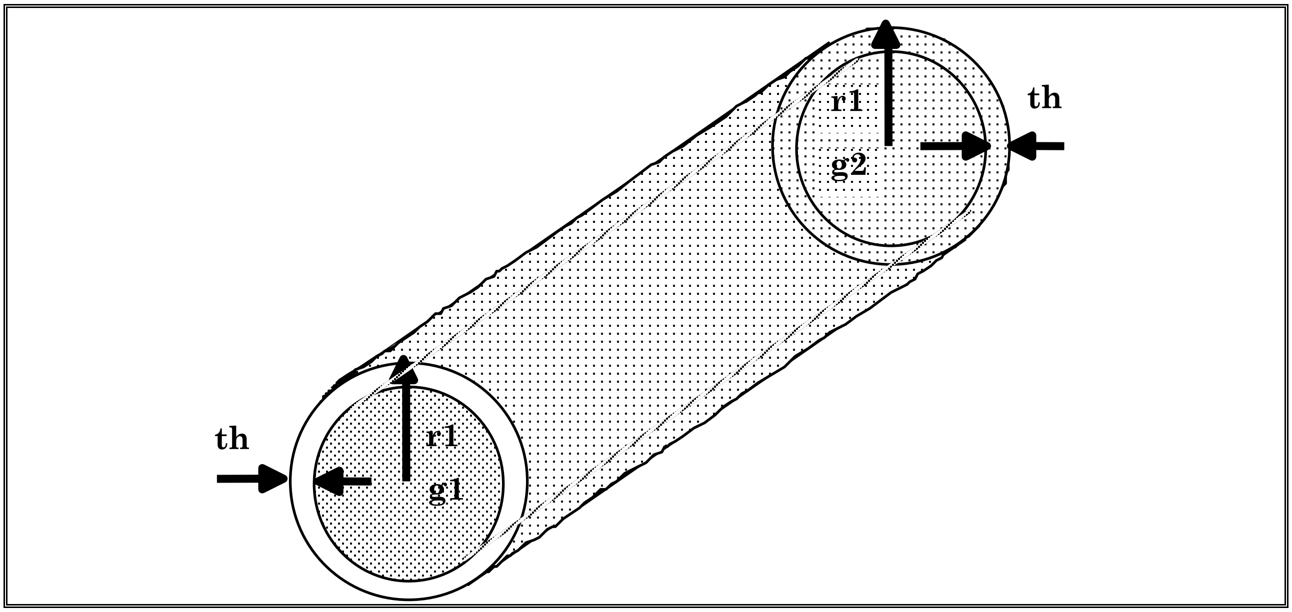
2. The maximum difference between the highest and lowest element identification number is parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.

3. The radius is assumed to be small, i.e., less than 2 inches.

4. The zero thickness volume mode option is supported to simplify the translation of FASTGEN-3 target descriptions into FASTGEN-4 target descriptions. New models should use volume mode components when modeling solid CLINE elements.

5. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-9 CLINE Geometry Definitions



5.6.10 COMPSPLT

Description: Defines a component to be split by a plane perpendicular to the z-axis.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
COMPSPLT	gr	co	gr1	co1	z				
COMPSPLT	4	105	4	205	7.5				
C	I	I	I	I	R				

Parameters	**Units**	**Description**
gr		Group number of the component in the target description that is to be split.
co		Component identification number of the component in the target description that is to be split.
gr1		Group number of the new component (upper part).
co1		Component number of the new component (upper part).
z		The z-coordinate of the plane which splits the component into two parts. This plane is parallel to the x-y plane in the target coordinate system

REMARKS

1. This record is read in with HOLE and WALL records in the CBULK file.

2. This input is intended to allow easy separation of an entire fuel tank into a fuel region and an ullage region with separate component numbers.

5.6.11 CQUAD

Description: Defines a quadrilateral shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CQUAD	eid	mid	g1	g2	g3	g4	th	pos	
CQUAD	55	14	991	992	993	994	0.04	1	
C	I	I	I	I	I	I	R	I	

Parameters	**Units**	**Description**
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1, g2, g3, g4		Grid point identification numbers (g1 through g4 > 0, no repeated grid identification numbers).
th		Normal thickness (th > 0.0).
pos		Grid point position relative to normal thickness. 1 = center 2 = front face [DEFAULT]

REMARKS

1. Element identification numbers must be unique with respect to all other element identification numbers within a component.

2. The maximum difference between the highest and lowest element identification number is the parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.

3. Grid points g1 through g4 must be ordered around the perimeter of the element. The direction of order (clockwise or counterclockwise) is not specified.

4. FASTGEN divides a CQUAD element into two triangle elements. Grid points g1, g2, and g3 are used for the first triangle element, while g1, g3, and g4 are used for the second triangle element.

Table 5-7 CQUAD Triangles & Associated Grid Points

Triangles	Grid ID Number		
1	g1	g2	g3
2	g1	g3	g4

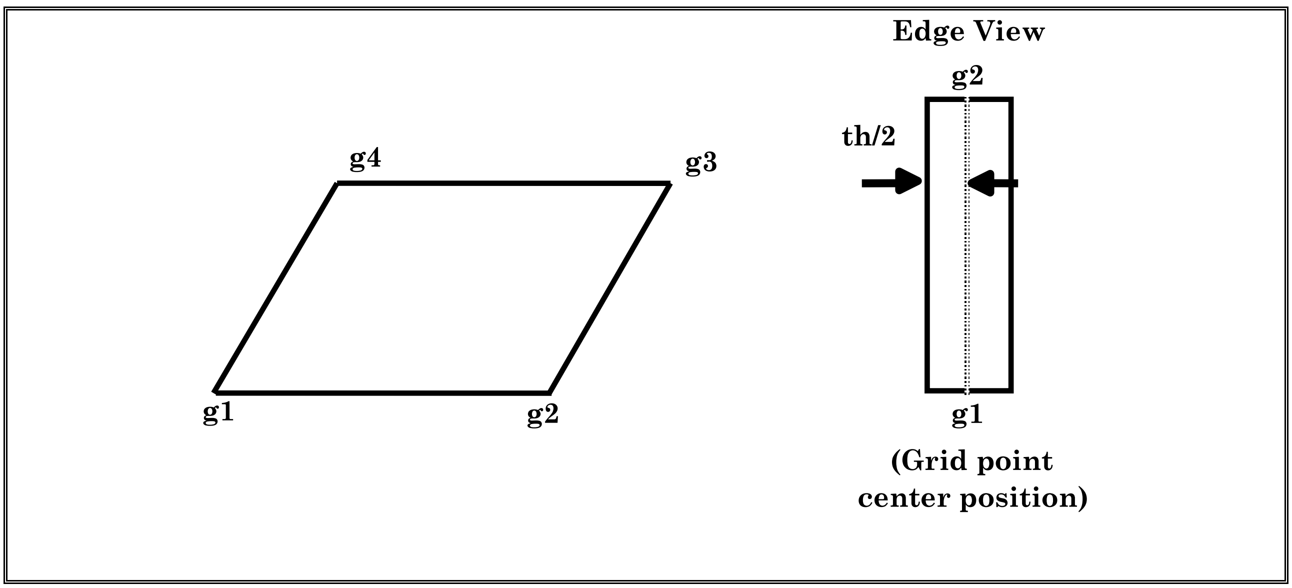
5. If two or more points are positioned at the same location the triangles will degenerate to a line or a point. The CQUAD element is omitted when the element degenerates to a line or a point. Any CQUAD element with a thickness greater than 2 inches should be modeled with a CHEX2 element.

6. The CQUAD is assumed to be nearly planar. For any given shotline, only one triangle (of the two triangles that defines the quadrilateral) will be hit.

7. The center of an element is well defined. The front face of an element is orientation dependent. The front face option is supported to simplify the translation of FASTGEN-3 target descriptions into FASTGEN-4 target descriptions. New models should use the center option.

8. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-10 CQUAD Geometry Definitions



5.6.12 CSPHERE

Description: Define a sphere shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CSPHERE	eid	mid	g1				th	r1	
CSPHERE	55	14	981				0.125	8.2	
C	I	I	I				R	R	

Parameters	**Units**	**Description**
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1		Grid point identification number (g1 > 0).
th		Normal thickness (th > 0.0).
r1		Normal radius (r1 > 0.0).

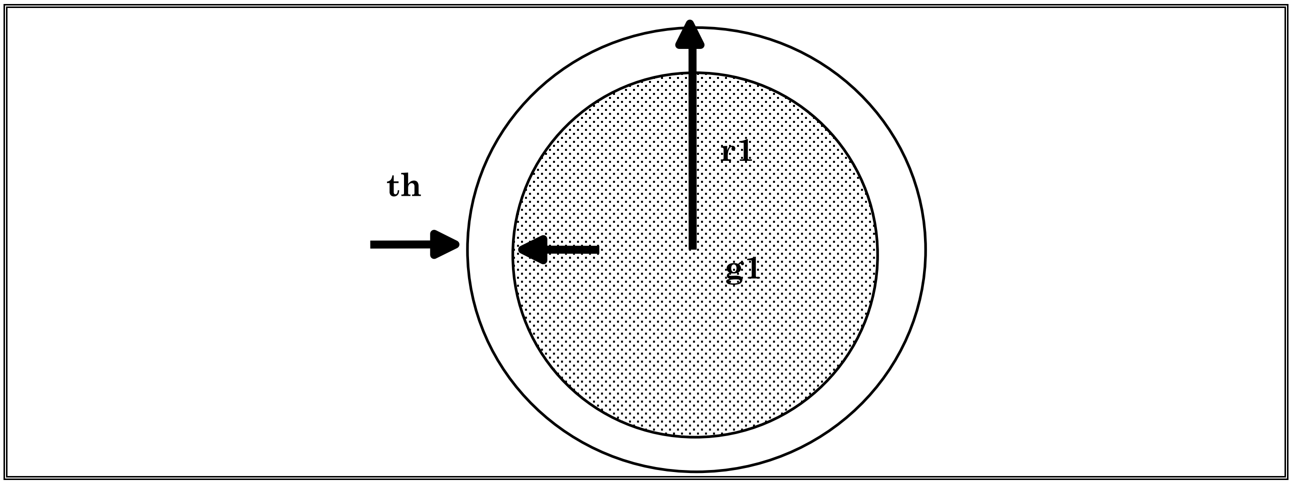
REMARKS

1. Element identification numbers must be unique with respect to all other element identification numbers within a component.

2. The maximum difference between the highest and lowest element identification number is the parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.

3. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-11 CSPHERE



5.6.13 CTRI

Description: Defines a triangular shaped element.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CTRI	eid	mid	g1	g2	g3		th	pos	
CTRI	55	14	991	992	993		0.03	1	
C	I	I	I	I			R	I	

Parameters	**Units**	**Description**
eid		Element identification number (eid > 0).
mid		Material identification number (mid > 0).
g1, g2, g3		Grid point identification numbers (g1 through g3 > 0, no repeated grid identification numbers).
th		Normal thickness (th > 0.0).
pos		Grid point position relative to normal thickness. 1 = center 2 = front face [DEFAULT]

REMARKS

1. Element identification numbers must be unique with respect to all other element identification numbers within a component.

2. The maximum difference between the highest and lowest element identification number is the parameter ILOS within a component. ILOS elements are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual. This element counts as one element.

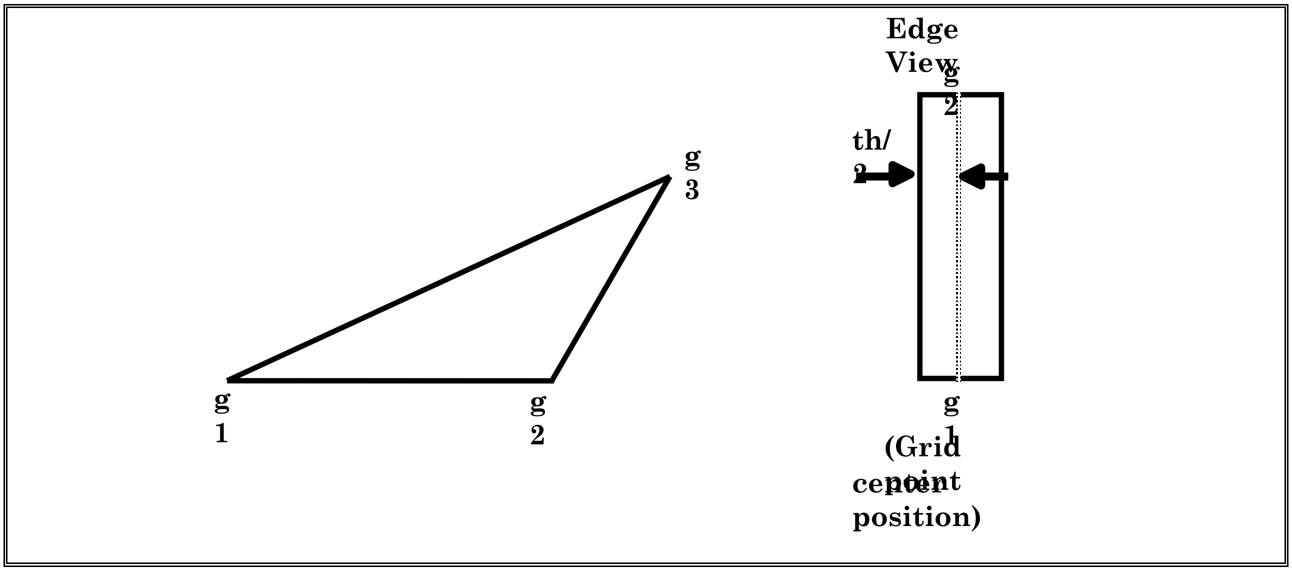
3. Grid points g1 through g3 must be ordered around the perimeter of the element. The direction of order (clockwise or counterclockwise) is not specified.

4. The thickness is assumed to be small, i.e., less than 2 inches. An element thicker than 2 inches should be modeled with a CHEX2 element.

5. The center of an element is well defined. The front face of an element is orientation dependent. The front face option is supported to simplify the translation of FASTGEN-3 target descriptions into FASTGEN-4 target descriptions. New models should use the center option.

6. The material identification numbers for several materials are defined in the FASTGEN Materials Chart (Table 5-4).

Figure 5-12 CTRI Geometry Definitions



5.6.14 ENDDATA

Description: Defines the end of the Bulk Data File.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ENDDATA									
ENDDATA									
C									

REMARKS

1. Any information following the ENDDATA record is ignored.

2. The ENDDATA record may be used one time.

5.6.15 GRID

Description: Defines the location of a 3-D geometric point.

Format, Example and Date Type:

1	2	3	4	5	6	7	8	9	10
GRID	g1		x	y	z				
GRID	6		10.25	10.25	-10.25				
C	I		R	R	R				

Parameters	**Units**	**Description**
g1		Grid point identification number (g1 > 0).
x, y, z		Location of the grid point:
		x increasing is toward the front
		x decreasing is toward the back/aft
		y increasing is toward the left from pilot's view point
		y decreasing is toward the right from pilot's view point
		z increasing is toward the top
		z decreasing is toward the bottom

REMARKS

1. All grid point identification numbers must be unique with respect to all other grid point identification numbers within a component.

2. The maximum difference between the highest and lowest grid identification number is parameter ILOS within a component. ILOS GRID records are allowed within a component. The FORTRAN parameter, ILOS, is further explained in the Software Size Limits section of this manual.

3. GRID records must follow each SECTION record. The GRID record directly after the SECTION record must have the smallest grid identification number of all GRID records within a component.

4. The value of the grid identification number is limited by the field size.

5. X, Y and Z values must include a decimal point.

5.6.16 HOLE

Description: Define a hole within a surrounding volume. This procedure subtracts a volume or a plate from the outer volume.

Format, Example, and Data Type:

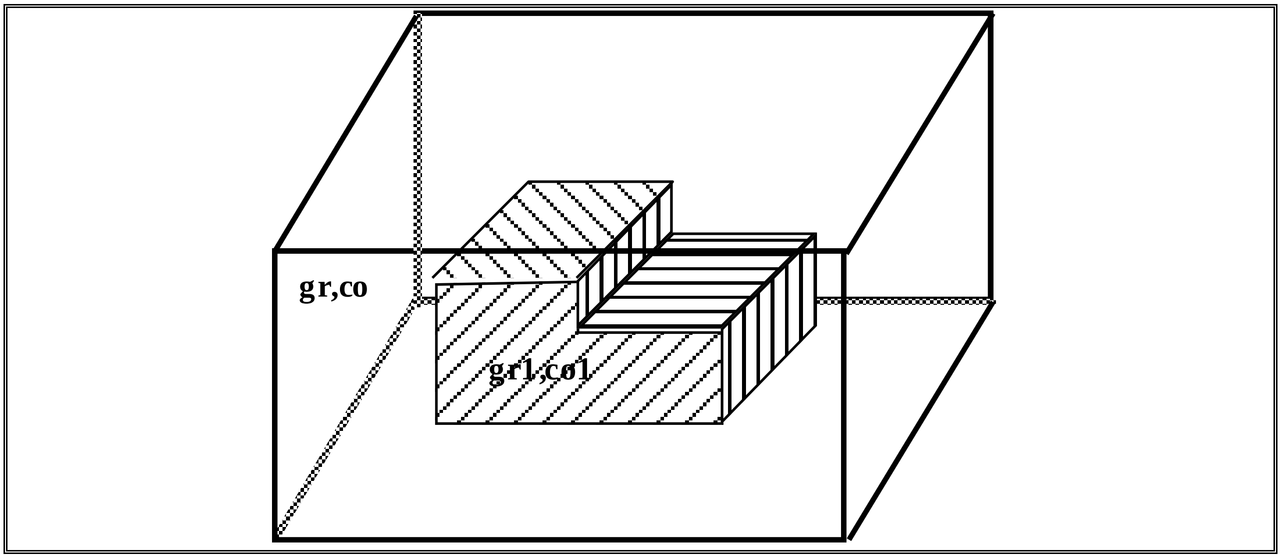
1	2	3	4	5	6	7	8	9	10
HOLE	gr	co	gr1	co1	gr2	co2	gr3	co3	
HOLE	3	12	9	111	10	107	14	263	
C	I	I	I	I	I	I	I	I	

Parameters	**Units**	**Description**
gr,co		Group and component identification number of the surrounding volume (0<=gr<=9,1<=co<=999).
gr1,co1, gr2,co2, gr3,co3		Group and component identification number of the subtracted components (0<=gr<=9,1<=co<=999).

REMARKS

1. Surrounding components entered on the HOLE record must be in volume mode.
2. A surrounding component must totally enclose the interfering components.
3. An interfering component entered on the HOLE record may be either in a volume or a plate mode.
4. All HOLE records should precede the first SECTION record.
5. IHW records are allowed within the bulk data file. The FORTRAN parameter IHW is further explained in the Software Size Limits section of this manual.

Figure 5-13 HOLE Geometry Definitions



5.6.17 SECTION

Description: Defines the beginning of a new component.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
SECTION	gr	co	mo	sp					
SECTION	2	173	1	4					
C	I	I	I	I					

Parameters	**Units**	**Description**
gr		Group identification number (0 <= gr <= 49). The following is a suggestion for component groupings for aircraft targets. (See remark 6 for older definitions)
co		Component identification number (1 <= co <= 999). Components are subsets of groups, i.e. a radar power supply line replaceable unit (LRU) on the right wing is a component within the electrical group.
mo		Plate/volume mode (mo = 1 or 2): 1 = plate 2 = volume
sp		Space code (0 <= sp <= 5) [not required]

Aircraft	Ground Vehicles
0 = redefinition component	0 = redefinition component
1 = fuselage and engine pods	1 = engine compartment
2 = cockpit	2 = crew compartment
3 = interior of wings	3 = cargo compartment
4 = vertical fins and elevators	4 = not used
5 = exterior	5 = exterior

REMARKS

1. $COMMENT and $NAME records should follow each SECTION record. Descriptive keywords such as line replaceable unit (LRU) should be used throughout the database. Typical component names are defined in the Component Name Chart.

2. The SECTION record may be used one time per component.

3. Elements defined in volume mode components should have element thickness set equal to 0.0.

4. Military analysts require battle damage repair times to determine how sortie generation rates are affected by non-fatal combat damage. Non-battle damage repair times are available from logistics organizations. These repair times can be used as the basis for battle damage repair times. Repair time data and FASTGEN target descriptions are built independently. Relating shotline data with repair times is not possible. If shotlines and repair times use the same component descriptions, shotline data and repair times can be related.

5. Repair time data are organized by logistics control number (LCN), part number, and work unit code (WUC). The LCN and part number is strictly equipment related, while WUC's are repair tasks for classes of equipment.

6. The WUC contains five digits. The first two digits are classes of equipment. A list of these equipment classes is provided in the WUC chart. MIL-STD-780F, Work Unit Codes for Aeronautical Equipment, Uniform Numbering System, 18 July 1984, contains additional information about WUC's.

7. New FASTGEN target descriptions should relate the LCN to define FASTGEN groups. Repair times and FASTGEN components should be organized by an LCN/part number. $NAME records should contain the group, component, WUC, and LCN/part number.

8. Space codes are not used within FASTGEN. Space codes entered into FASTGEN on the SECTION record are passed through the software without error checking or modification except to denote the end of a shotline.

9. Group identification numbers (0 <= GR <= 9) are used for older FASTGEN target descriptions.

Table 5-8 Common Aircraft Organization by Group Number

Group No.	Components	Group No.	Components
0	skin forward fuselage	24	hydraulic system # 4
1	skin forward intermediate fuselage	25	fuel forward tank
2	skin center fuselage	26	fuel forward intermediate fuselage tank
3	skin aft intermediate fuselage	27	fuel center fuselage tank
4	skin aft fuselage	28	fuel aft intermediate fuselage tank
5	skin left wing	29	fuel aft fuselage tank
6	skin right wing	30	fuel left wing tank
7	skin horizontal tail	31	fuel right wing tank
8	skin vertical tail	32	fuel lines
9-10	engine # 1	33	ammunition
11-12	engine # 2	34	armament
13-14	engine # 3	35	structure forward fuselage
15-16	engine # 4	36	structure forward intermediate fuselage
17	crew	37	structure center fuselage
18	flight control pitch	38	structure aft intermediate fuselage
19	flight control yaw	39	structure aft fuselage
20	flight control roll	40	structure left wing
21	hydraulic system # 1	41	structure right wing
22	hydraulic system # 2	42	structure horizontal tail
23	hydraulic system # 3		
43	structure vertical tail		
44	electrical boxes		
45	electrical lines		
46	electrical PAO lines		
47	electrical antenna/radar/ECM		
48-49	miscellaneous		

Table 5-9 Legacy Common Group Identification Number Definitions

Aircraft	Ground Vehicles
0 = skin	0 = body
1 = power plant	1 = engine and accessories
2 = crew	2 = crew
3 = flight control system	3 = personnel or cargo
4 = fuel system	4 = fuel system
5 = ammunition including bombs	5 = ammunition
6 = armament	6 = armament
7 = structural members	7 = power train & suspension system
8 = electrical system/avionics	8 = electrical system
9 = miscellaneous	9 = miscellaneous

5.6.18 VEHICLE

Description: Defines the vehicle code.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
VEHICLE	code	date	iveh						
VEHICLE	B-2	9/2/92	65535						
C	C	C	C						

Parameters	**Units**	**Description**
code		User defined vehicle code.
date		Date database was last updated.
iveh		Vehicle code number.

REMARKS

1. The VEHICLE record may be used one time.

2. The vehicle code number is only used for output to a COVART-format burst point file. If no vehicle code number is entered, FASTGEN will calculate one.

5.6.19 WALL

Description: Identifies the intentional intersection of two or more components.

Format, Example, and Data Type:

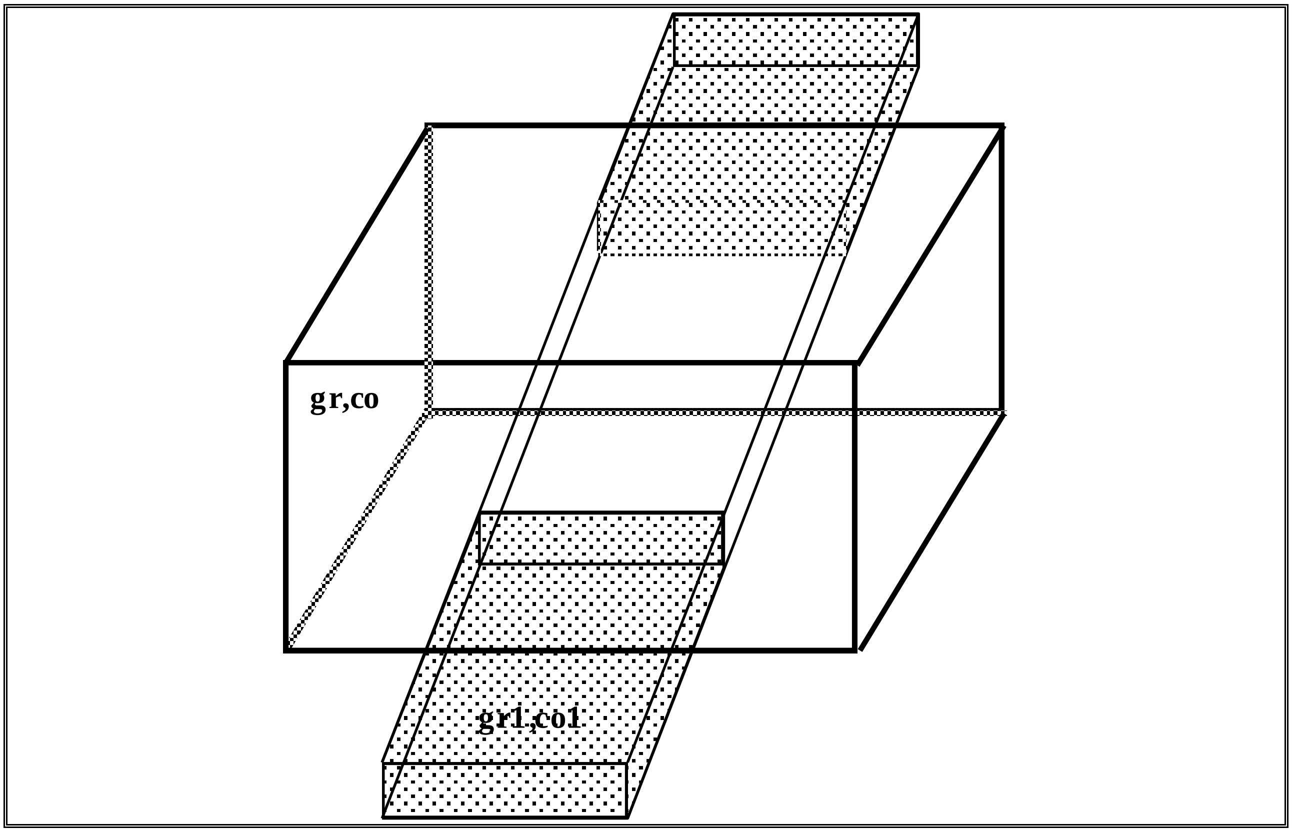
1	2	3	4	5	6	7	8	9	10
WALL	gr	co	gr1	co1	gr2	co2	gr3	co3	
WALL	9	123	9	124	3	311	8	097	
C	I	I	I	I	I	I	I	I	

Parameters	**Units**	**Description**
gr, co		Group and component identification number of the surrounding volume (0 <= gr <= 9, 1 < = co <= 999).
gr1, co1 gr2, co2 gr3, co3		Group and component identification number of the interfering component (0 <= gr <= 9, 1 <= co <= 999).

REMARKS

1. Surrounding components entered on the WALL record must be in the volume mode.
2. A surrounding component may have several interfering components.
3. An interfering component entered on the WALL record may be either in a volume or a plate mode.
4. All WALL records should precede the first SECTION record.
5. IHW records are allowed within the bulk data file. The FORTRAN parameter IHW is further explained in the Software Size Limits section of this manual.

Figure 5-14 WALL Geometry Definitions



5.6.20 $COMMENT

Description: Defines user comments.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
$COMMENT	text								
$COMMENT	B-2	target	model						
C	C								

Parameters	**Units**	**Description**
text		User defined text.

REMARKS

1. See SECTION record for group names.
2. Typical component names are defined in the Component Name Chart.
3. The $COMMENT record may be used any number of times.

5.6.21 $NAME

Description: Defines names and components.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
$NAME	gr	co		wuc	lcn		text		
$NAME	0	172		11			LRU, flight control		
C	I	I		I	C		C		

Parameters	**Units**	**Description**
gr		Group identification number (0 <= gr < =9).
co		Component identification number (0 <= co <= 999).
wuc		Work Unit Code (wuc) number (11 <= wuc <= 99).
lcn		Logistics Control Number (lcn).
text		Descriptive name of components.

REMARKS

1. Group and component identification numbers are defined on the SECTION record.
2. Work Unit Code numbers are provided on the Work Unit Code Group Chart.
3. Typical component names are defined in the Component Name Chart.
4. The $NAME record should be should one time for each component.

6. CTHREAT Input File

6.1 Description

The CTHREAT threat Database file is used by FASTGEN and COVART to define the threat characteristics necessary to properly vector and determine the damage associated with various threats through various targets.

The CTHREAT Threat Database format contains information on the threat geometry, polar zone geometry, and fragment fly out options available to the vulnerability analyst. Many of these features emulate some of the functions present in the SHAZAM end-game analysis code. CTHREAT is an ASCII file with record types ENDDATA, FRAGDEF, HECHAR, POLARZON, THRTSTAT, PROJLEN, PROJDIAM, and $COMMENT.

The following sections detail the record types contained in file CTHREAT that are used by FASTGEN. Please refer to the COVART 5.1 User's Manual. Listed below is the nested format the user must follow when specifying input records in CTHREAT. Note that multiple FRAGDEF records are allowed in each polar zone. ENDDATA is required in the threat file, and there must be at least one POLARZON and one FRAGDEF record, or an error will be generated.

Figure 6-1 CTHREAT Nested Format

- THRTSTAT
- PROJLEN
- PROJDIAM
- **POLARZON**
  - » **FRAGDEF**
  - » **FRAGDEF**
  - » **FRAGDEF**
  - » **…**
- **POLARZON**
  - » **FRAGDEF**
  - » **FRAGDEF**
  - » **FRAGDEF**
  - » **…**

6.2 FASTGEN Fragment Types

Fragment type codes are specified by the user in the threat file CTHREAT using the FRAGDEF record. Each fragment code corresponds to a fragment with a pre-defined shape. The different fragment types and their respective identification numbers are shown in Figure 6-2 and Table 6-1.

Figure 6-2 FASTGEN Fragment Types

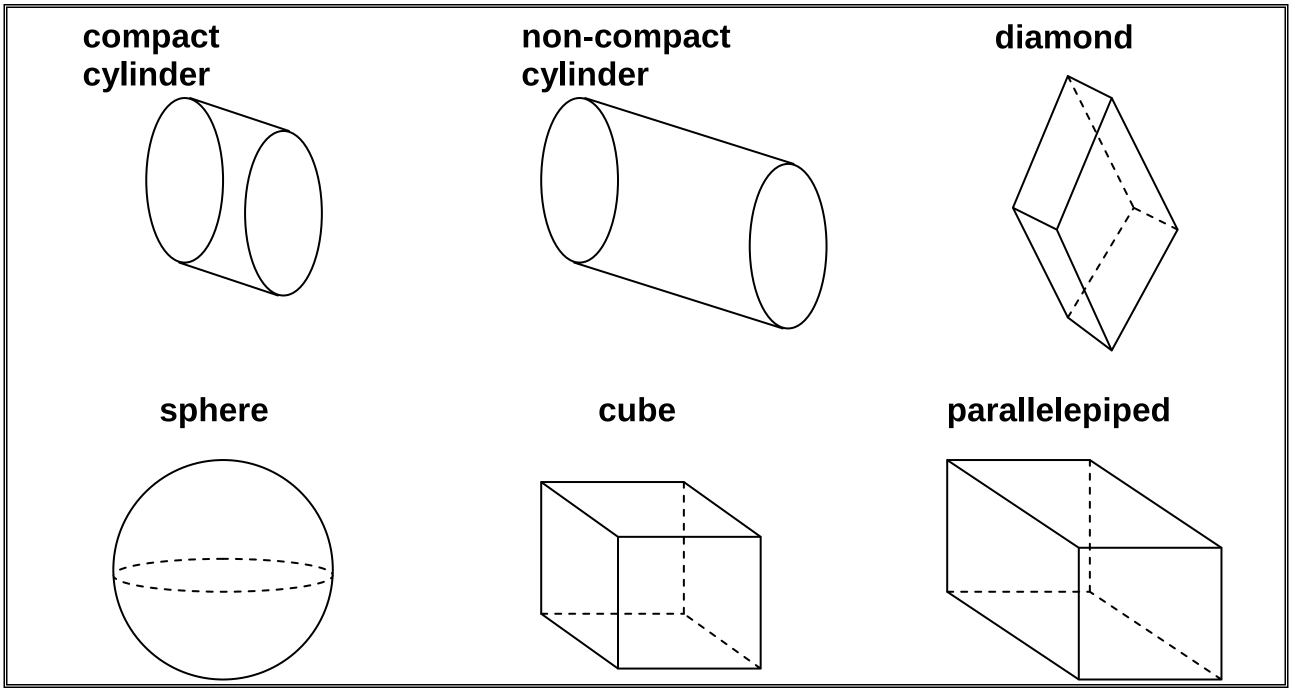


Table 6-1 FASTGEN Fragment Shape Codes

Fragment Type	Shape Code
Compact cylinder	1
Non-compact cylinder	2
Diamond	3
Sphere	4
Cube	5
Parallel piped	6

6.3 Sample CTHREAT File

Included below is a simplified CTHREAT file that illustrates a user's request for multiple burst rays per fragment. This simplified threat characterization contains two polar zones with four fragments each.

Before an analysis is run, the user must make a decision. They can run the fragments as single fragment rays (IMC = -1); they can let FASTGEN decide whether or not multiple burst rays are needed based on the FFCRIT standard deviation criteria (IMC = 0); or they can directly specify the number of burst rays per degree (IMC = 1). As an example, we assume that the user has decided that they want to bump up the number of burst rays in the first polar zone from 4 to 8, but want to use the single fragment ray assumption in the second polar zone. Each polar zone specified below is a ninety-degree zone. This represents an increase in the number of burst rays per degree from 0.044 (single fragment ray) to 0.088 in the first polar zone. The second polar zone is one burst ray per fragment. In the burst ray generation subroutines in FASTGEN, 8 burst rays are created and distributed in the first polar zone, and 4 burst rays are created and distributed in the second polar zone. Note that the parameter FFCRIT is not used if IMC = -1 or IMC = 1.

All of the variables highlighted in yellow are used by FASTGEN to process HE threats. The threat diameter is read from the PROJDIAM record. The threat length is read from the PROJLEN record. The threat center of detonation and charge length are read in through the HECHAR record. In the THRTSTAT record specified below, FFCRIT and NBRPD are global burst ray generation parameters. Whether or not these parameters are used locally in each polar zone is decided by the user using the IMC flag allocated for each POLARZON record. This allows the user to selectively apply burst ray generation criteria.

Table 6-2 Sample CTHREAT File

$COMMENT									
$COMMENT	TID	DIA1	DIA2	DIA3	DIA4				
PROJDIAM	1	0.25	0.25	0.25	0.25				
$COMMENT	TID	PROL1	PROL2	PROL3	PROL4				
PROJLEN	1	5	2.5	1.25	0.625				
$COMMENT	NOS	IX	IHALF	CHARGN	FUZTIM	FUZDIS	WARHDX	WARHDL	DSTMAX
HECHAR	2	2	0	208.0	0.00325	0.0	2.15	4.3	0
$COMMENT	FFCRIT	NBRPD							
THRTSTAT	0.0	0.088							
$COMMENT	PZ #1								
$COMMENT	PZID	LA	UA	LX	UX	IMC			
POLARZON	1	0.0	90.0	0.0	0.1	1			
$COMMENT	N	MASS	SC	L/D	IMAT	FSPD	FPAREA		
FRAGDEF	4	100.0	1	1.4	3	500.0	0.205		
$COMMENT	PZ #2								
POLARZON	2	90.0	180.0	0.1	0.2	-1			
FRAGDEF	4	100.0	1	1.4	3	500.0	0.205		
ENDDATA									

6.4 Input Data Records

6.4.1 $COMMENT

Description: Defines user comments.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
$COMMENT	Text								
$COMMENT	User defined text								
C	C								

Parameters	**Units**	**Description**
text		User defined text

REMARKS

1. The $COMMENT record may be used multiple times.
2. Heavy use of the $COMMENT record is recommended to give a description of the threat within the CTHREAT file.

6.4.2 FRAGDEF

Description: Define individual fragment or fragment group characteristics within static polar zones.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
FRAGDEF	nfrag	fragms	fragsh	fragld	fragmat	fragspd	fragpa		
FRAGDEF	3	500.0	1	1.4	5	500.0	0.025		
C	I	R	I	R	I	R	R		

Parameters	**Units**	**Description**
Nfrag		Number of fragments with specified characteristics.
Fragms		Fragment mass (grains)
Fragsh		Fragment shape code (See Table 6-1)
Fragld		Fragment length to diameter ratio (Not used by FASTGEN)
fragmat		Fragment material code (Not used by FASTGEN)
fragspd		Fragment speed (ft/s)
Fragpa		Fragment presented area (in^2)

REMARKS

1. The FRAGDEF input record will appear multiple times within a polar zone and the file CTHREAT.
2. FRAGMS must be greater than zero.
3. FRAGSH must be a valid FASTGEN fragment type.
4. FRAGSPD must be greater than zero.
5. FRAGPA is used by FASTGEN in its fragment drag calculations. FRAGPA must be greater than zero.
6. The FRAGDEF record allows the specification of fragments of identical mass type having different velocities.
7. The use of FRAGDEF records allows multiple fragment velocities in each polar zone.

6.4.3 HECHAR

Description: Defines threat weapon general characteristics and atmospheric conditions.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
HECHAR	NOS	IX	IHALF	CHARGN	FUZTIM	FUZDIS	WARHDX	WARHDL	DSTMAX
HECHAR	800.	0.0	0.303	14.69	1100.	1.0	10.1	2.5	0
C	R	R	R	R	R	R	R	R	I

Parameters	**Units**	**Description**
NOS	---	Number of side spray zones (Not used by FASTGEN)
IX	---	Code indication number of fragments or density (Not used by FASTGEN)
IHALF	---	Flag for subdivided in half side spray zones (Not used by FASTGEN)
CHARGN	grains	Charge mass (Not used by FASTGEN)
FUZTIM	Sec	Time Delay of round (Not used by FASTGEN)
FUZDIS	In	Distance projectile travels after first impact (Not used by FASTGEN)
WARHDX	in	Distance from nose to center of burst point
WARHDL	in	Length of projectile explosive charge
DSTMAX	---	Flag indicating that threat placement should be controlled by penetration (Not used by FASTGEN)

REMARKS

1. FASTGEN only uses the WARHDX and WARHDL parameters from this record. The remaining parameters are used by other models and need to be correctly set for those models to work properly.

6.4.4 POLARZON

Description: Define threat related static polar zones and local burst ray generation parameters.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
POLARZON	pzid	thl	thu	xl	xu	imc			
POLARZON	1	20.0	35.0	0.0	0.5	0			
C	I	R	R	R	R	I			

Parameters	**Units**	**Description**
pzid		Polar zone identification number
thl		Angle defining the lower polar zone boundary (deg)
thu		Angle defining the upper polar zone boundary (deg)
xl		Lower edge (position) of the polar zone (in)
xu		Upper edge (position) of the polar zone (in)
imc		Integer flag that controls the generation of burst rays within FASTGEN for BURST1 simulations.

imc = 0: FASTGEN uses an internal algorithm to decide if a polar zone population qualifies as “sparse” [DEFAULT]; this option uses the FFCRIT variable specified on the THRTSTAT record.

imc = -1: direct FASTGEN to assume that one fragment equals one burst ray; this is the single fragment ray approach.

imc = 1: allows the user to directly specify the number of burst rays per degree for all polar zones. All internal FASTGEN algorithms are bypassed. The fragments defined for the polar zone using FRAGDEF records are distributed in an integral fashion among all burst rays to avoid any mass or velocity bias.

REMARKS

1. The POLARZON input record may be used IMXPZ times. IMXPZ is the maximum number of allowed polar zones. IMXPZ is further described in the Software Description section of the user manual.

2. PZID specified for each polar zone must increase from zone to zone. Polar zones are specified sequentially from front to back along the warhead's longitudinal axis.

3. The upper polar zone angle must be greater than the lower polar zone angle. thl and thu are limited in range from 0 to 180 degrees. These angles are measured from the nose of the threat. (Figure 6-3)

4. The upper polar zone distance (xu) must be greater than the lower polar zone distance (xl). These absolute distances are measured from the leading edge of the first warhead polar zone. Multiple checks are in place to ensure that the warhead lies on the threat surface. (Figure 6-3)

5. IMC is interpreted as a burst ray density control flag. It is designed for use in polar zones where fragment information is sparse, or less than ideal. It is suggested that the default option of imc = 0 always be used for most FASTGEN simulations unless a single fragment simulation is justified. The imc = 1 option is primarily included for the case of very low fragment densities in a polar zone, but this feature is available on a per polar zone basis. Values that determine the calculation of additional rays in sparse zones is contained on the THRTSTAT record.

Figure 6-3 THREAT POLAR ZONE GEOMETRY

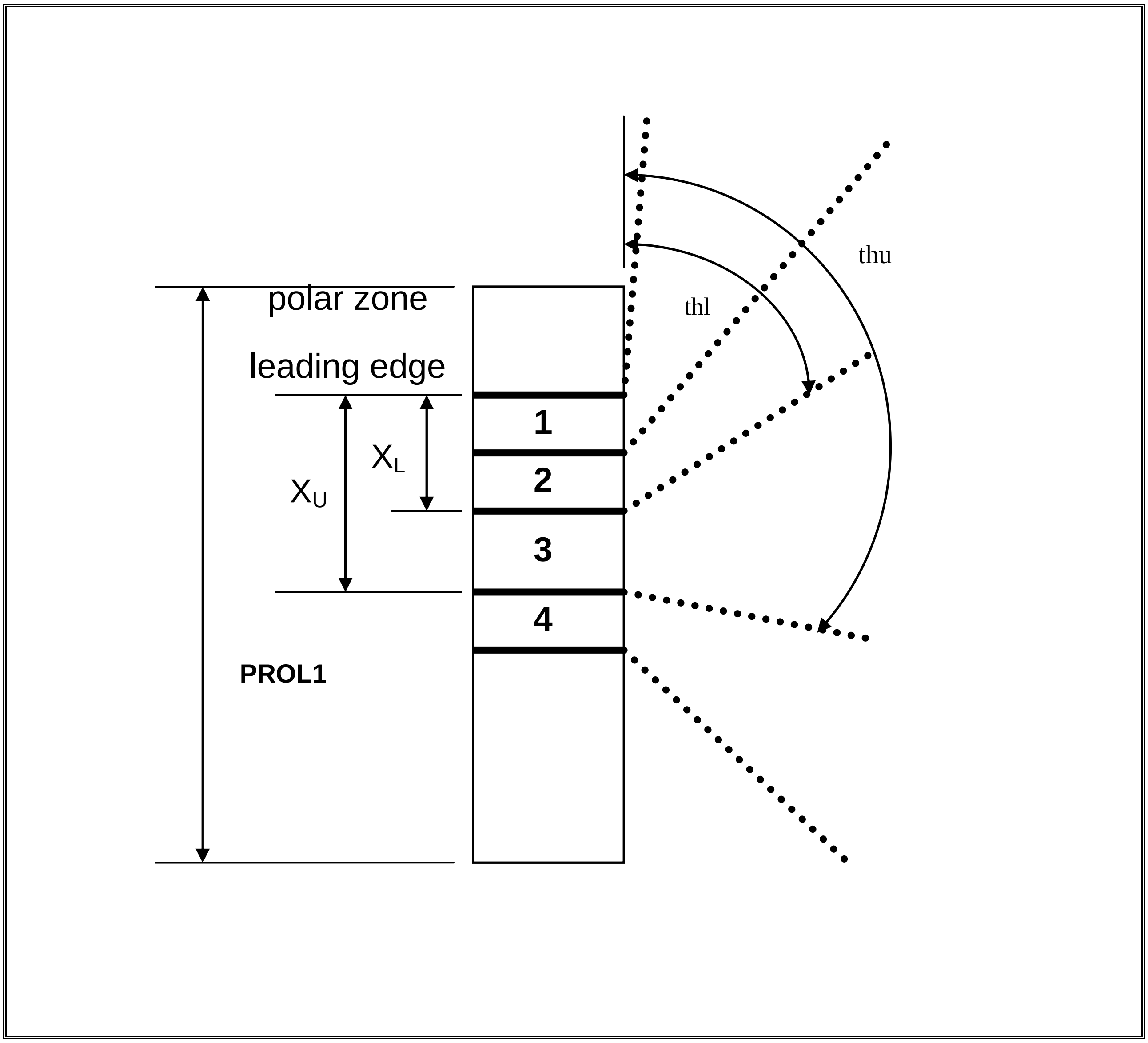
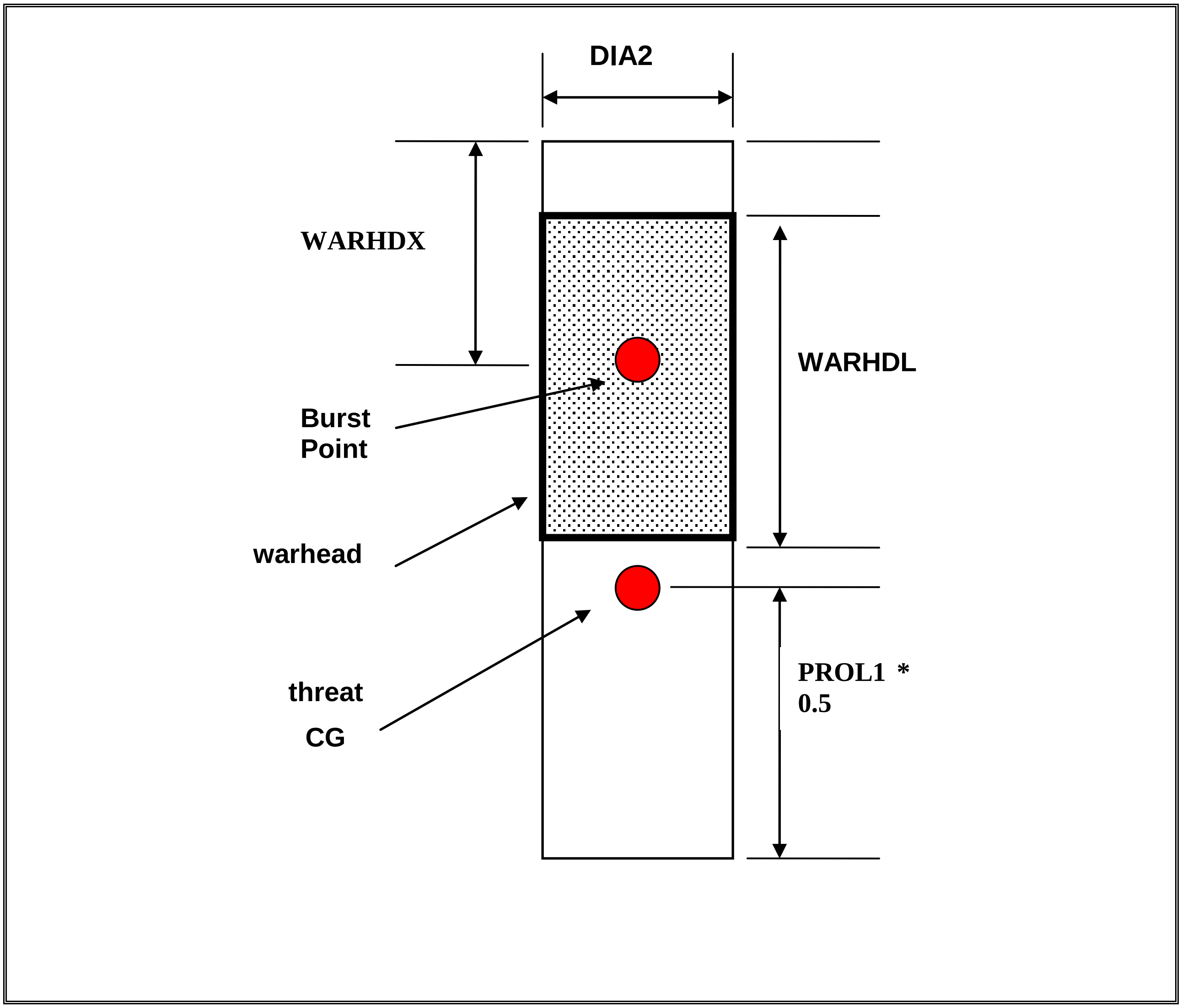


Figure 6-4 THREAT WARHEAD GEOMETRY



6.4.5 PROJDIAM

Description: PROJDIAM describes the projectile diameters.

Format, Example, and Data Type:

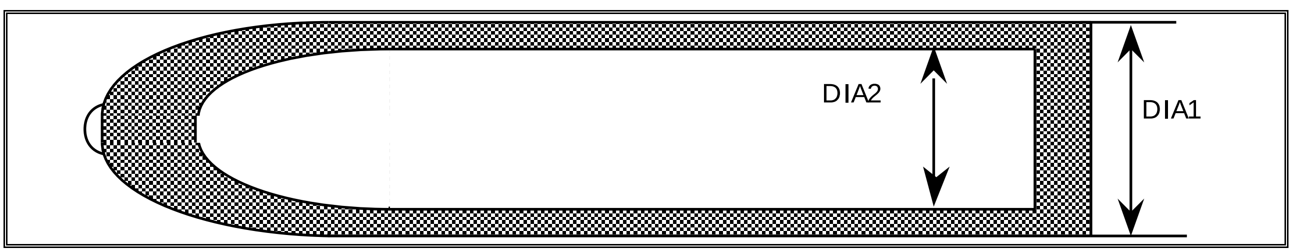
1	2	3	4	5	6	7	8	9	10
PROJDIAM	TID	DIA1	DIA2	DIA3	DIA4				
PROJDIAM	1	2.0	1.5	1.0	0.5				
C	I	R	R	R	R				

Parameters	**Units**	**Description**
TID	---	Projectile identification number (Not used by FASTGEN)
DIA1	inches	Projectile diameter (Not used by FASTGEN)
DIA2	inches	Projectile core diameter
DIA3	inches	Projectile broken core diameter (Not used by FASTGEN)
DIA4	inches	Projectile broken – broken core diameter (Not used by FASTGEN)

REMARKS

1. Fastgen only uses the DIA2 parameter from this record. The remaining parameters are used by other models and need to be correctly set for those models to work properly.

Figure 6-5 Projectile Diameters



6.4.6 PROJLEN

Description: PROJLEN describes the lengths of a projectile.

Format, Example, and Data Type:

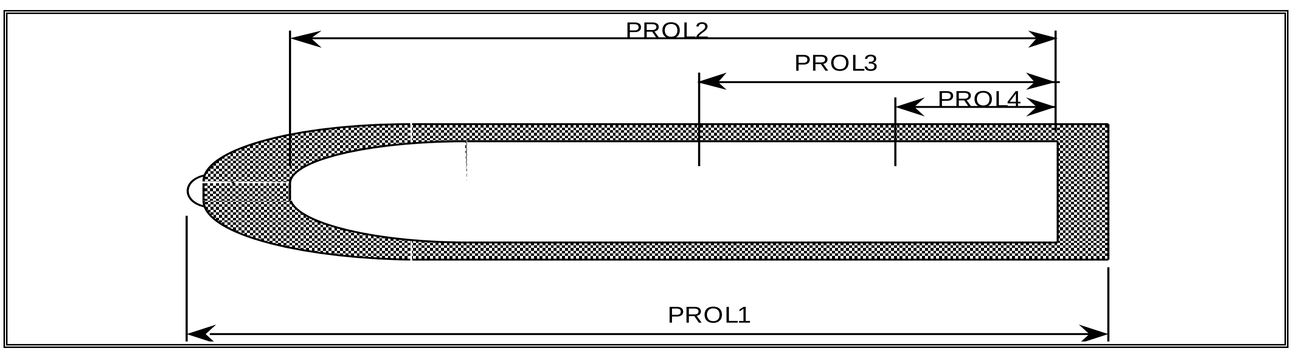
1	2	3	4	5	6	7	8	9	10
PROJLEN	TID	PROL1	PROL2	PROL3	PROL4				
PROJLEN	1	5.0	4.0	3.0	1.0				
C	I	R	R	R	R				

Parameters	**Units**	**Description**
TID	---	Projectile identification number (Not used by FASTGEN)
PROL1	inches	Projectile length
PROL2	inches	Projectile core length (Not used by FASTGEN)
PROL3	inches	Projectile broken core length (Not used by FASTGEN)
PROL4	inches	Projectile broken – broken core length (Not used by FASTGEN)

REMARKS

1. Fastgen only uses the PROL1 parameter from this record. The remaining parameters are used by other models and need to be correctly set for those models to work properly.

Figure 6-6 Projectile Lengths



6.4.7 THRTSTAT

Description: Define threat fragment and ray statistical parameters.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
THRTSTAT	FFCRIT	NBRPD							
THRTSTAT	1.0	0.25							
C	R	R							

Parameters	**Units**	**Description**
FFCRIT	---	Fractional fragment statistical criteria [DEFAULT = 1.0]
NRBPD	---	Number of burst rays per degree [DEFAULT = 20.0]

REMARKS

1. FFCRIT is a parameter that allows the user to associate a number of burst rays with a single fragment, which is useful for polar zones with small numbers of fragments. FASTGEN will perform a series of internal computations to decide if a fragment zone is sparse based on the FFCRIT value input by the user. It is a cutoff for the standard deviation of the number of fragments per degree for a given threat.

2. NBRPD is a burst ray density parameter that allows the user to directly specify the number of burst rays per degree for a single polar zone. It is only used if the parameter IMC is set equal to 1 on the relevant POLARZON record.

6.4.8 ENDDATA

Description: Defines the end of the CTHREAT file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ENDDATA									
ENDDATA									
C									

REMARKS

1. The ENDDATA record must appear at the end of the CTHREAT file.
2. Any data appearing after the ENDDATA record in the CTHREAT file is ignored by FASTGEN.

7. CCOVBP Input File

FASTGEN possesses the flexibility to accept output from other pieces of vulnerability simulation software as input. This flexibility allows the input of files generated by COVART.

The COVART data files are only used for burst point runs. The CCOVBP data file is created by running COVART, with the burst point location (BPLOC) option activated. See the COVART 5.1 Users Manual for additional details. The file contains burst point locations expressed in the shotline, or view coordinate system.

The burst point location file contains two types of records. The view header is written in FORTRAN (2I5,F8.4,5F8.3) format. The data on the view header are, in order, the azimuth, the elevation, the grid cell size, the maximum Y coordinate, the minimum Y coordinate, the maximum Z coordinate, the minimum Z coordinate, and the influence mode radius. The coordinates in the header record are in the shotline coordinate system, and represent the maximum and minimum limits of the target. They are copied from the shotline file header read in for the COVART burst point run.

The burst point data records are written in FORTRAN (5F10.4) format. They contain the X coordinate of the first intersection on the shotline, the Y coordinate of the shotline, the Z coordinate of the shotline, the distance from the first intersection to the burst point, and the burst point velocity. All coordinates are in the shotline system and the distance from the burst point to the first intersection is positive if the burst point is inside the target and negative if it is outside.

Table 7-1 CCOVBP File Data Types

Data Type	Description
header	Defines the view for the burst points
data	Defines the first intersection, distance, and velocity for each burst point

7.1 Input Data Records

7.1.1 View Header

Description: Defines the view for the burst points

Format, Example, and Data Type:

1 5	6 10	11 18	19 26	27 34	35 42	43 50	51 58
az	el	Grid	ymax	ymin	zmax	zmin	trad
45	45	2.0000	20.	-10.	300.	10.	1.25
I	I	R	R	R	R	R	R

Parameters	**Units**	**Description**
az	deg.	Azimuth angle.
el	deg.	Elevation angle.
grid	-----	Subgrid Ratio – This is the ratio of the grid/sub-grid from the shotline run.
ymax,ymin	Target	Maximum and minimum values of the target in shotline coordinate system.
zmax,zmin	Target	Maximum and minimum values of the target in shotline coordinate system.
trad	inches	Threat radius.

7.1.2 Burst Point Location

Description: Defines the burst point location along a shotline.

Format, Example, and Data Type:

1 10	11 20	21 30	31 40	41 50
sx	sy	sz	rdist	rvelocity
12.5000	21.0000	21.0000	0.0590	1800.2
R	R	R	R	R

Parameters	**Units**	**Description**
sx	Target	First interception X coordinate in shotline view
sy	Target	First interception Y coordinate in shotline view
sz	Target	First interception Z coordinate in shotline view
rdist	Target	Distance from the first interception point to the burst point.
rvelocity	fps	Velocity of the round at detonation.

8. OPKSA Output File

8.1 Description

The OPKSA file contains the ASCII shotline data. The OPKSA format consists of two records: a header record and a data record. The data format is a nested setup where each header record will likely have multiple data records. The data contained in each record is summarized in Table 8-1:

Table 8-1 OPKSA Data Types and Descriptions

Data Type	Description
header	Defines the view for this shotline
data	Defines the elements intercepted along a shotline.

8.2 Output Data Records

8.2.1 Header, Packed Format

Description: Defines the view for this shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11
az	el	grid	vc	ymax	ymin	zmax	zmin	trad		
45.	45.	2.	B-2	20.	-10.	300.	10.	1.25		
R	R	R	C	R	R	R	R	R		

Parameters	Units	Description
az	deg.	Azimuth angle.
el	deg.	Elevation angle.
grid	inches	Subgrid size.
vc	-----	Vehicle code.
ymax,ymin	inches	Maximum and minimum values of the target in translated coordinate system.
zmax,zmin	inches	Maximum and minimum values of the target in translated coordinate system.
trad	inches	Threat radius addition.

8.2.2 Line-Of-Sight Data, Packed Format

Description: Defines the elements intercepted along a shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11
sx	sy	sz	pl	p2	p3	s1	s2			
12.5.	21.	21.	059	1036	199	1000	1000			
R	R	R	I	I	I	I	I			

Parameters	**Units**	**Description**
sx	inches	Shotline coordinate
sy	inches	Shotline coordinate
sz	inches	Shotline coordinate
p1	-----	Packed word: XXXX X 1 2 1: Normal thickness (hundredths of an inch) of each element at shotline intercept. Normal thickness is set equal to 0.0 for all elements, except for CLINE, CTRI, CQUAD, and CHEX1 elements. Normal thickness for the CLINE element is set to the element diameter. 2: Space code of following component. Space code changed to 9 for last hit of each shotline.
p2	-----	Packed word: X XXX 1 2 1: Group identification number 2: Component identification number
p3	-----	Round off thickness to two digits; XXXX.XXXX 1: Line-of-sight thickness through component in 100ths (inches).
s1	-----	Secant of the obliquity angle times 1000 at the entrance of component encountered by shotline.

Parameters	Units	Description
s2	-----	Secant of the obliquity angle times 1000 at the exit of component encountered by shotline.

9. OPKSB Binary Output File

9.1 Description

The OPKSB file contains the binary shotline data. The OPKSB binary file format consists of two records a header record and a data record. The data format is a nested setup where each header record will likely have multiple data records. The data contained in each record is summarized in Table 9-1:

Table 9-1 OPKSB Data Types and Descriptions

Data Type	Description
header	Defines the view for this shotline
data	Defines the elements intercepted along a shotline.

9.2 Output Data Records

9.2.1 Header, Packed Format

Description: Defines the view for this shotline.

Format, Example, and Data Type:

Header Record for Each View

Parameters	**Units**	**Description**
az	deg.	Azimuth angle.
el	deg.	Elevation angle.
grid	inches	Subgrid size.
vc	-----	Vehicle code.
ymax,ymin	inches	Maximum and minimum values of the target in translated coordinate system.
zmax,zmin	inches	Maximum and minimum values of the target in translated coordinate system.
trad	inches	Threat radius addition.

REMARKS

1. These data use an unformatted binary format with content similar to the OPKSA data.

9.2.2 Line-Of-Sight Data, Packed Format

Description: Defines the elements intercepted along a shotline.

Format, Example, and Data Type:

Line-Of-Sight Data Record for Each View

Parameters	Units	Description
sx	inches	Shotline coordinate
sy	inches	Shotline coordinate
sz	inches	Shotline coordinate
p1	-----	Packed word: XXXX X 1 2 1: Normal thickness (hundredths of an inch) of each element at shotline intercept. Normal thickness is set equal to 0.0 for all elements, except for CLINE, CTRI, CQUAD, and CHEX1 elements. Normal thickness for the CLINE element is set to the element diameter. 2: Space code of following component. Space code changed to 9 for last hit of each shotline.
p2	-----	Packed word: X XXX 1 2 1: Group identification number 2: Component identification number
p3	-----	Round off thickness to two digits; XXXX.XXXX 1: Line-of-sight thickness through component in 100ths (inches).
s1	-----	Secant of the obliquity angle times 1000 at the entrance of component encountered by shotline.
s2	-----	Secant of the obliquity angle times 1000 at the exit of component encountered by shotline.

REMARKS

1. These data use an unformatted binary format with content similar to the OPKSA data.

10. OUNPKA Output File

10.1 Description

The OUNPKA file contains the unpacked ASCII shotline data. The OUNPKA format consists of two records: a header record and a data record. The data format is a nested setup where each header record will likely have multiple data records. The data contained in each record is summarized in Table 10-1:

Table 10-1 OUNPKA Data Types and Descriptions

Data Type	Description
header	Defines the view for this shotline
Line-of-sight data	Defines the elements intercepted along a shotline.

10.2 Output Data Records

10.2.1 Header, Unpacked Format

Description: Defines the view for this shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11	12
az	el	grid	vc	ymax	ymin	zmax	zmin	trad	vel	mass	mattyp
45.	45.	2.	B-2	20.	-10.	300.	10.	1.25	2000.	20.	5
R	R	R	C	R	R	R	R	R	R	R	I

Parameters	Units	Description
az	deg.	Azimuth angle.
el	deg.	Elevation angle.
grid	inches	Subgrid size.
vc	-----	Vehicle code.
ymax,ymin	inches	Maximum and minimum values of the target in translated coordinate system.
zmax,zmin	inches	Maximum and minimum values of the target in translated coordinate system.
trad	inches	Threat radius addition.
vel	fps	Threat velocity
mass	grains	Threat mass
mattyp	-----	Threat material type code

REMARKS

1. These data use an ASCII format similar to the input data.

2. Under circumstances where FOOTER1 and FOOTER2 records are used in the CONTROL file, those records will be printed in total before the header data is printed to the file.

10.2.2 Line-Of-Sight Data, Unpacked Format

Description: Defines the elements intercepted along a shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11
sx	sy	sz	los	th	s1	s2	co	sp	eid	mid
12.5.	21.	21.	1.99	0.05	1000	1000	1036	9	55	14
R	R	R	R	R	I	I	I	I	I	I

Parameters	**Units**	**Description**
sx	inches	Shotline coordinate
sy	inches	Shotline coordinate
sz	inches	Shotline coordinate
los	inches	Line-of-sight thickness through component.
th	inches	Normal thickness of component at shotline intercept. Normal thickness is set equal to 0.0 for all elements, except for CTRI, CQUAD, and CHEX1 elements. Normal thickness for the CLINE element is set to the element diameter.
s1	-----	Secant x 1000 of the obliquity angle at the entrance of component encountered by shotline.
s2	-----	Secant x 1000 of the obliquity angle at the exit of component encountered by shotline.
gr	-----	Group identification number
co	-----	Component identification number
sp	-----	Space Code of following component. Space code changed to 9 for last hit of each shotline.
eid	-----	Element identification number
mid	-----	Material identification number

REMARKS

1. These data use an ASCII format similar to the input data, except 88 columns are needed.

11. *OLOSV Output File*

11.1 Description

The OLOSV file contains the visualized LOS data. The OLOSV format consists of two records: a SECTION record and a line-of-sight (LOS) data record. The data format is a nested setup where each SECTION record will likely have multiple LOS data records. The LOS data is in an unpacked format in the target coordinate system. The data contained in each record is summarized in Table 11-1:

Table 11-1 OLOSV Data Types and Descriptions

Data Type	***Description***
SECTION	*Defines the view for this shotline*
Line-of-sight data	*Defines the elements intercepted along a shotline.*

11.2 Output Data Records

11.2.1 SECTION

Description: Defines the beginning of a new component.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
SECTION	*gr*	*co*	*mo*	*sp*					
SECTION	*10*	*173*	*2*	*5*					
C	*I*	*I*	*I*	*I*					

Parameters	**Units**	**Description**
gr	-----	*Group identification number. This value is preset to be 10.*
co	-----	*Component identification number. This value is incremented for each shotline output.*
mo	-----	*Always 2*
sp	-----	*Always 5*

11.2.2 *Line-Of-Sight Data, Unpacked Format*

Description: Defines the elements intercepted along a shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11
sx	sy	sz	los	th	s1	s2	co	sp	eid	mid
12.5.	21.	21.	1.99	0.05	1000	1000	1036	9	55	14
R	R	R	R	R	I	I	I	I	I	I

Parameters	Units	Description
sx	inches	Shotline coordinate in the target coordinate system
sy	inches	Shotline coordinate in the target coordinate system
sz	inches	Shotline coordinate in the target coordinate system
los	inches	Line-of-sight thickness through component.
th	inches	Normal thickness of component at shotline intercept. Normal thickness is set equal to 0.0 for all elements, except for CTRI, CQUAD, and CHEX1 elements. Normal thickness for the CLINE element is set to the element diameter.
s1	-----	Secant x 1000 of the obliquity angle at the entrance of component encountered by shotline.
s2	-----	Secant x 1000 of the obliquity angle at the exit of component encountered by shotline.
gr	-----	Group identification number
co	-----	Component identification number
sp	-----	Space Code of following component. Space code changed to 9 for last hit of each shotline.
eid	-----	Element identification number
mid	-----	Material identification number

REMARKS

1. *These data use an ASCII format similar to the input data, except 88 columns are needed.*

12. *OCHEM Output File*

12.1 Description

This file contains the first and last intersections on the shotline. The OCHEM format consists of two records: a SECTION record and a line-of-sight (LOS) data record. The data format is a nested setup where each SECTION record will have two LOS data records (one for the first intersection, and one for the last intersection on a shotline). The LOS data is in an unpacked format in the target coordinate system. The data contained in each record is summarized in Table 12-1:

Table 12-1 OCHEM Data Types and Descriptions

Data Type	***Description***
SECTION	*Defines the view for this shotline*
Line-of-sight data	*Defines the elements intercepted along a shotline.*

12.2 Output Data Records

12.2.1 *SECTION*

Description: Defines the beginning of a new component.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
SECTION	*gr*	*co*	*mo*	*sp*					
SECTION	*2*	*173*	*2*	*5*					
C	*I*	*I*	*I*	*I*					

Parameters	***Units***	***Description***
gr	-----	*Group identification number. This value is preset to be 10.*
co	-----	*Component identification number. This value is incremented for each shotline output.*
mo	-----	*Always 2*
sp	-----	*Always 5*

12.2.2 *Line-Of-Sight Data, Unpacked Format*

Description: Defines the elements intercepted along a shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11	12
sx	sy	sz	los	th	s1	s2	co	sp	eid	mid	stst
12.5.	21.	21.	1.99	0.05	1000	1000	1036	9	55	14	1
R	R	R	R	R	I	I	I	I	I	I	I

Parameters	***Units***	***Description***
sx	*inches*	*Shotline coordinate in the target coordinate system*
sy	*inches*	*Shotline coordinate in the target coordinate system*
sz	*inches*	*Shotline coordinate in the target coordinate system*
los	*inches*	*Line-of-sight thickness through component.*
th	*inches*	*Normal thickness of component at shotline intercept. Normal thickness is set equal to 0.0 for all elements, except for CTRI, CQUAD, and CHEX1 elements. Normal thickness for the CLINE element is set to the element diameter.*
s1	-----	*Secant x 1000 of the obliquity angle at the entrance of component encountered by shotline.*
s2	-----	*Secant x 1000 of the obliquity angle at the exit of component encountered by shotline.*
gr	-----	*Group identification number*
co	-----	*Component identification number*
sp	-----	*Space Code of following component. Space code changed to 9 for last hit of each shotline.*
eid	-----	*Element identification number*
mid	-----	*Material identification number*
stst	-----	*If stst = 1 then this is the first intersection on the shotline*
		If stst = 2 then this is the last intersection on the shotline

13. *OCDF Output File*

13.1 Description

This file contains visage color information used to identify interferences. The OCDF format, as it is output from FASTGEN, consists of three records a LIMITS record, a TMSTEPS record, and one or more CD records. The data contained in each record is summarized in Table 13-1. A more detailed description of the OCDF file format can be found in the VISAGE manual.

Table 13-1 OCDF Data Types and Descriptions

Data Type	***Description***
CD	*This card sets the color for the specified Component, at the specified time step*
LIMITS	*User defines the limits of magnitude for individual color bar values.*
TMSTEPS	*Provides the number of time steps in the CDF and sets the color bar title.*

13.2 Output Data Records

13.2.1 *CD*

Description: Contour data. This card sets the color for the specified Component, at the specified time step. The number of CD cards is limited by the number of Elements in the target description(s). CD cards can be used in conjunction with VIEW cards, or by themselves. If VIEW cards are used, the TIME value for the VIEW cards must correspond to those used in the CD cards.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
CD	gr	co		time	mag				
CD	0	1		1.00	0.24				
C	I	I		R	R				

Parameters	Units	Description
gr	-----	Group ID number (0 <= integer <= 11).
co	-----	Component ID number (integer > 0).
time	sec.	Time step value.
mag	-----	Magnitude value.

REMARKS

1. *All Elements with time steps must be defined for all time steps, otherwise the non-defined Elements will default to the last color specified.*
2. *The CD card has been revised from VISAGE 2.2. Individual Elements can no longer be specified. The COLORMAT and COLORTHK cards have been added to the GDF to allow for the specification of colors based on material or thickness. This effectively replaces the CD card for individual elements.*

13.2.2 *LIMITS*

Description: User defines the limits of magnitude for individual color bar values. (Maximum of 32 LIMITS cards.)

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
LIMITS	*cbid*	*max*	*min*						
LIMITS	*1*	*1.0*	*0.0*						
C	*I*	*R*	*R*						

Parameters	***Units***	***Description***
cbid	-----	*Color bar ID number (0 <= integer <= 31).*
max	-----	*Maximum magnitude value (real).*
min	-----	*Minimum magnitude value (real).*

REMARKS

1. *The following is a list of the approximate color ranges and the corresponding CBID's:*

Table 13-2 Color Values

Color Range	*CBID's*
Red (5 shades)	*0 - 4*
Orange (5 shades)	*5 - 9*
Yellow (5 shades)	*10 - 14*
Green (5 shades)	*15 - 19*
Blue (5 shades)	*20 - 24*
Purple (5 shades)	*25 - 29*
Invisible	*30*
Default Group Color	*31*

13.2.3 *TMSTEPS*

Description: Provides the number of time steps in the CDF and sets the color bar title. This card must be used if CD or VIEW cards are used.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
TMSTEPS	*num*	*text*							
TMSTEPS	*2*	*color*	*bar title*						
C	*I*	*C*	*C*						

Parameters	***Units***	***Description***
num	-----	*Number of time steps in CDF (1 <= integer <= 500).*
text	-----	*Title to be used for the color bar window (maximum 16 character string).*

14. *OCOEFA Output File*

14.1 Description

This file contains the ASCII cosine data for intersections on the shotline. The OCOEFA file format consists of two records a header record and a direction cosines data record. The data format is a nested setup where each header record will likely have multiple data records. The data contained in each record is summarized in Table 14-1.

Table 14-1 OCOEFA Data Types and Descriptions

Data Type	***Description***
header	*Defines the view for this shotline*
direction cosine data	*Defines the elements intercepted along a shotline.*

14.2 Output Data Records

14.2.1 *Header*

Description: Defines the view for this shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11
az	el	grid	vc	ymax	ymin	zmax	zmin	trad		
45.	45.	2.	B-2	20.	-10.	300.	10.	1.25		
R	R	R	C	R	R	R	R	R		

Parameters	Units	Description
az	deg.	Azimuth angle.
el	deg.	Elevation angle.
grid	inches	Subgrid size.
vc	-----	Vehicle code.
ymax,ymin	inches	Maximum and minimum values of the target in translated coordinate system.
zmax,zmin	inches	Maximum and minimum values of the target in translated coordinate system.
trad	inches	Threat radius addition (inches).

14.2.2 *Direction Cosine Data*

Description: Defines the direction cosine, entrance and exit, of each hit along the shotline.

Format, Example, and Data Type:

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
icox	*icoy*	*icoz*	*ocox*	*ocoy*	*ocoz*					
1000.	*10.*	*21.*	*1000.*	*21.*	*10.*					
R	*R*	*R*	*R*	*R*	*R*					

Parameters	***Units***	***Description***
icox,icoy,icoz	-----	*Direction cosines for entrance intercept.*
ocox,ocoy,ocoz	-----	*Direction cosines for exit intercept.*

15. *OCOEFB Binary Output File*

15.1 Description

This file contains the binary cosine data for intersections on the shotline. The OCOEFB binary file format consists of two records: a header record and a direction cosines data record. The data format is a nested setup where each header record will likely have multiple data records. The data contained in each record is summarized in Table 15-1.

Table 15-1 OCOEFB Data Types and Descriptions

Data Type	***Description***
header	*Defines the view for this shotline*
direction cosine data	*Defines the elements intercepted along a shotline.*

15.2 Output Data Records

15.2.1 *Header*

Description: Defines the view for this shotline.

Format, Example, and Data Type:

Header Record for Each View

Parameters	***Units***	***Description***
az	*deg.*	*Azimuth angle.*
el	*deg.*	*Elevation angle.*
grid	*inches*	*Subgrid size.*
vc	*-----*	*Vehicle code.*
ymax,ymin	*inches*	*Maximum and minimum values of the target in translated coordinate system.*
zmax,zmin	*inches*	*Maximum and minimum values of the target in translated coordinate system.*
trad	*inches*	*Threat radius addition.*

REMARKS

1. *These data use an unformatted binary format with content similar to the OPKSA data.*

15.2.2 *Direction Cosine Data*

Description: Defines the direction cosine, entrance and exit, of each hit along the shotline.

Format, Example, and Data Type:

Direction Cosine Data

Parameters	***Units***	***Description***
icox,icoy,icoz	-----	*Direction cosines for entrance intercept.*
ocox,ocoy,ocoz	-----	*Direction cosines for exit intercept.*

16. OCOVART Binary Output File

16.1 PGEN Format

The OCOVART binary file is produced for PGEN replacement mode and Multi-Hit mode. This section describes the PGEN replacement mode format.

16.1.1 Description

This file contains the binary PGEN replacement data. The OCOVART binary file format consists of six records listed in Table 16-1. The data format is a nested setup where each view header record will likely have multiple shotline header records, which will in turn have multiple shotline intersection records and ray header records, which will in turn have multiple ray intersection records. The end-of-burst indicator record specifies the end of the current burst/shotline.

Table 16-1 OCOVART Data Types and Descriptions

Data Type	Description
View Header	Defines the current view
Shotline Header	Defines the current shotline
Shotline Intersection Data	Defines an intersection along the current shotline
Ray Header	Defines the current ray
Ray Intersection Data	Defines an intersection along the current ray
End-of-Burst Indicator	Defines the end of the current burst/shotline

16.1.2 Output Data Records

16.1.2.1 View Header

Description: Defines COVART 4.2 line-of-sight output data tape.

Header Record for Each View

Parameters	**Units**	**Format**	**Description**
a	degrees	R	View azimuth angle (Figure 4-6)
el	degrees	R	View elevation angle (Figure 4-6)
grid	Target	R	View grid cell size
ll	--------	I	Vehicle code number
ymax	Target	R	Maximum horizontal coordinate
ymin	Target	R	Minimum horizontal coordinate
zmax	Target	R	Maximum vertical coordinate
zmin	Target	R	Minimum vertical coordinate
r	Target	R	Influence mode radius addition

REMARKS

1. If a=999.0, this is an end-of-data flag.

16.1.2.2 Shotline Header

Description: Defines COVART 4.2 line-of-sight output data tape.

Header Data for shotline

Parameters	**Units**	**Format**	**Description**
ieco	------	I	Number of components on the shotline
isri	Target	I	Variable grid factor for KE shotline; Fuse distance (in .01") for HE shotline.
cth	Target	R	x-distance from the grid plane to the component intersect along shotline
ath	Target	R	Shotline y-coordinate (in view coordinate system)
enob	Target	R	Shotline z-coordinate (in view coordinate system)
exob	------	R	Blank for KE shotline; Area (sq. ft.) association with HE shotline.

REMARKS

1. If ieco=0, this is an end-of-view flag.

16.1.2.3 Shotline Intersection Data

Description: Defines COVART 4.2 line-of-sight output data tape.

Component Data

Parameters	**Units**	**Format**	**Description**
ieco	------	I	Component number
isri		I	Packed word: XXXX (1) X (2)
	Target		1 - Normal thickness x 100 of component at shotline intercept. If rod mode, entry is radius of rod x 100.
	------		2 - Space code of space following component
cth	Target	R	Line-of-sight thickness through the component
ath	Target	R	Line-of-sight thickness through the air space following the component
enob	------	R	Cosine of the obliquity angle at entrance surface of component encountered by shotline
exob	------	R	Cosine of the obliquity angle at exit surface of component encountered by shotline

16.1.2.4 Ray Header

Description: Defines COVART 4.2 line-of-sight output data tape.

Header Data for ray

Parameters	**Units**	**Format**	**Description**
ieco	-----	I	Number of components on the ray.
isri	-----	I	Unused by COVART, set to -2.
cth	in	R	Distance from the burst point to the first component along ray.
ath	-----	R	Ray Azimuth
enob	-----	R	Sine of ray elevation.
exob	Steradians	R	Solid angle associated with ray.

16.1.2.5 Ray Intersection Data

Description: Defines COVART 4.2 line-of-sight output data tape.

Component Data for ray

Parameters	**Units**	**Format**	**Description**
ieco	-----	I	Component number.
isri	-----	I	Normal thickness and space code. (NNNNSS).
cth	in.	R	Component line-of-sight thickness.
ath	in.	R	Air gap line-of-sight thickness.
enob	-----	R	Cosine of entrance obliquity.
exob	Steradians	R	Solid angle associated with component.

16.1.2.6 End-of-Burst Indicator

Description: Defines COVART 4.2 line-of-sight output data tape.

End of burst flag

Parameters	**Units**	**Format**	**Description**
ieco	------	I	-999
isri		I	Blank
cth		R	Blank
ath		R	Blank
enob		R	Blank
exob	------	R	Blank

16.2 Multi-Hit Format

The OCOVART binary file is produced for PGEN replacement mode and Multi-Hit mode. This section describes the Multi-Hit mode format.

16.2.1 Description

The Multi-Hit format contains records that are similar to the PGEN replacement format. This similarity allows COVART to easily read both formats. The view header is the same for both modes. The reference header is similar to the shotline header, except there is no main shotline in Multi-Hit mode. As a result, there are no shotline intersection records in the Multi-Hit mode. Each aim-point for a Multi-Hit run is processed as parallel rays. These rays are described as shotlines, but internal to FASTGEN are processed as if they were diverging rays originating from different locations.

Table 16-2 OCOVART Multi-Hit Data Types and Descriptions

Data Type	Description
View Header	Defines the properties of a particular view
Reference Point Header	Defines the properties of the Multi-hit reference point
Multi-hit Ray Header	Defines the properties of a particular Multi-hit shotline (Ray)
Multi-hit Ray LOS Data	Defines the elements intercepted along a particular Multi-hit shotline (Ray)
End-of-Ref point	Signals the end of a particular reference point
End-of-View	Signals the end of a particular view
End-of-Data	Signals the end of the data

16.2.1.1 Multi-hit OCOVART Output File Format

The Multi-hit OCOVART file is formatted similar to the legacy PGEN replacement mode OCOVART output file. This consists of a view header record followed by one or more records of packed data. The records of packed data contain the remaining data types packed in groups of 170 entries. These packed records are zero padded to maintain a consistent record size of 170 entries.

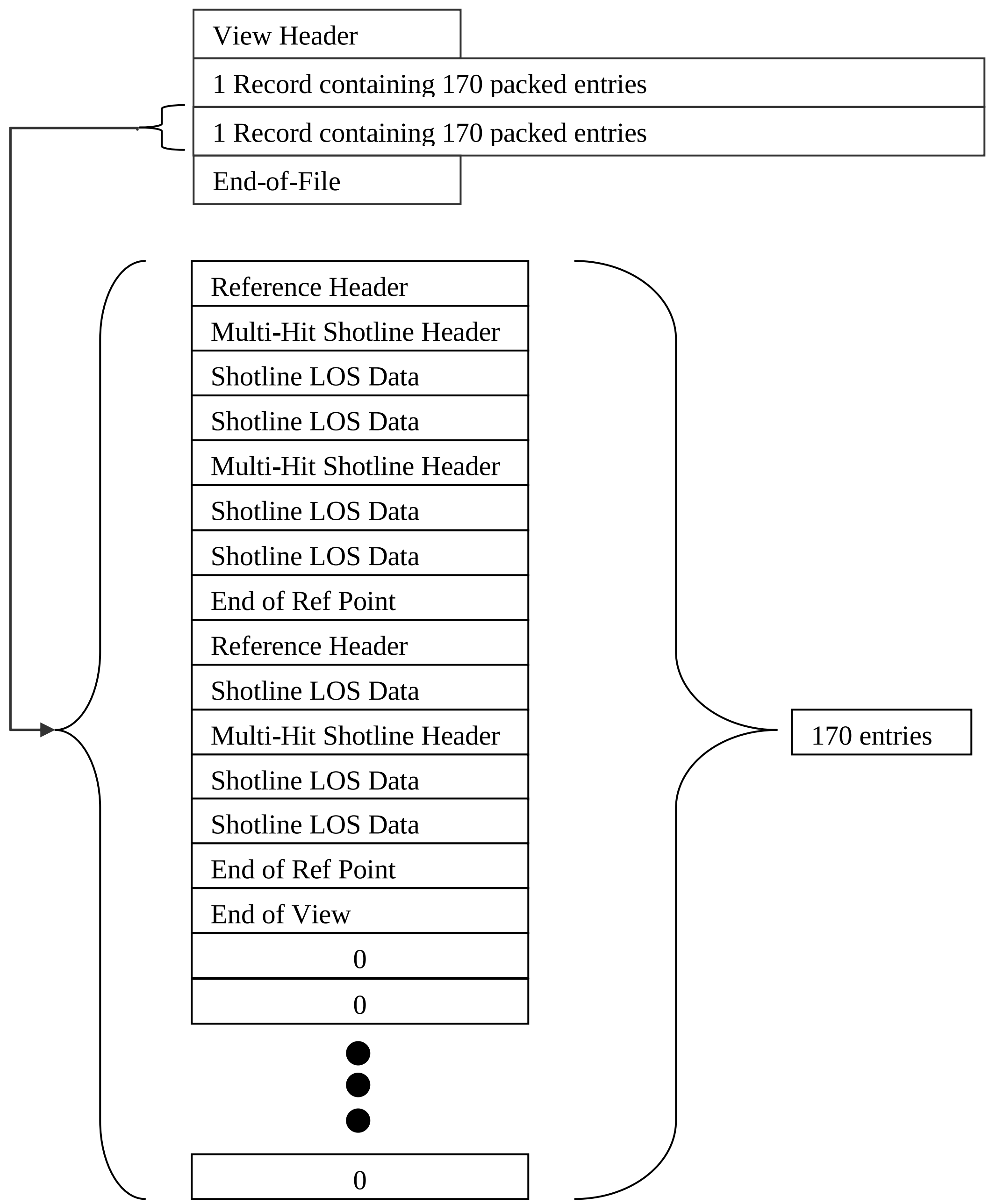
Multi-hit runs may have more than one view associated with each run. This format is shown in Figure 16-1 below.

Figure 16-1 OCOVART Multi-Hit File Layout

View Header
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
View Header
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
End-of-File

16.2.1.2 Detailed Multi-hit OCOVART Output

Figure 16-2 OCOVART Multi-Hit Sample File Layout



16.2.2 Output Data Records

16.2.2.1 View Header, Multi-hit OCOVART Format

Description: Defines variables that appear in the view header.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad
90.00	0.00	0.0	1	1.0	-1.0	1.0	-1.0	1.0
R	R	R	I	R	R	R	R	R

Parameters	**Units**	**Description**
taz	deg.	Threat azimuth angle (deg)
tel	deg.	Threat elevation angle (deg)
grid	-----	Unused
iveh	-----	Vehicle code
rymax	inches	Maximum y-coordinate of the target in the threat coordinate system (inches)
rymin	inches	Minimum y-coordinate of the target in the threat coordinate system (inches)
rzmax	inches	Maximum z-coordinate of the target in the threat coordinate system (inches)
rzmin	inches	Minimum z-coordinate of the target in the threat coordinate system (inches)
rad	inches	Influence mode radius addition

16.2.2.2 Reference Point Header, Multi-hit OCOVART Format

Description: Defines the parameters associated with a proximity burst point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
0	4	39.14	2.0	5.5	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always 0
isri	-----	Always 4
cth	Target	Reference Point y-coordinate in the target coordinate system
ath	Target	Reference Point y-coordinate in the target coordinate system
enob	Target	Reference Point z-coordinate in the target coordinate system
exob	-----	Always 0

16.2.2.3 Multi-Hit Shotline Header, Multi-hit OCOVART Format

Description: Defines the parameters associated with a Multi-hit shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	isri	cth	ath	enob	Exob			
1	2	1800.0	2.0	5.5	1.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Number of components on the shotline
isri	-----	Threat ID associated with this Multi-hit shotline.
cth	fps	Threat velocity associated with this Multi-hit shotline.
ath	Target	Shotline y-coordinate in the threat coordinate system
enob	Target	Shotline z-coordinate in the threat coordinate system
exob	-----	Relative position of the MULTIHT1/2 record in the CONTROL file.

16.2.2.4 Shotline Line-of-Sight Data, Multi-hit OCOVART Format

Description: Defines the parameters associated with a Multi-hit shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	isri	cth	ath	enob	exob			
500	00101	0.01	0.01	1.0	1.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Component number
isri	-----	Packed word: XXXXY XXXX: normal thickness x 100 of component at shot line intercept. If rod mode, entry is radius of rod x 100. Y : space code of space following component
cth	inches	Line-of-sight thickness through the component
ath	inches	Line-of-sight thickness through the air space following the component
enob	-----	Cosine of the obliquity angle at entrance surface of component encountered by shotline
exob	-----	Cosine of the obliquity angle at exit surface of component encountered by shotline

16.2.2.5 End-of-Ref Point, Multi-hit OCOVART Format

Description: Defines the parameters associated with a Multi-hit reference point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
-999	0	0.0	0.0	0.0	0.0			
I	I	R	R	R	R			

Parameters	Units	Description
ieco	-----	Always -999
isri	-----	Always 0
cth	-----	Always 0.0
ath	-----	Always 0.0
enob	-----	Always 0.0
exob	-----	Always 0.0

16.2.2.6 End-of-View, Multi-hit OCOVART Format

Description: Defines the parameters associated with a Multi-hit view.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
0	0	0.0	0.0	0.0	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always 0
isri	-----	Always 0
cth	-----	Always 0.0
ath	-----	Always 0.0
enob	-----	Always 0.0
exob	-----	Always 0.0

16.2.2.7 End of File Header, Multi-hit OCOVART Format

Description: Defines variables that appear at the end of the file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad
999.0	0.00	0.0	0	0.0	0.0	0.0	0.0	0.0
R	R	R	I	R	R	R	R	R

Parameters	**Units**	**Description**
taz	-----	Always 999
tel	-----	Always 0.0
grid	-----	Always 0.0
iveh	-----	Always 0
rymax	-----	Always 0.0
rymin	-----	Always 0.0
rzmax	-----	Always 0.0
rzmin	-----	Always 0.0
rad	-----	Always 0.0

17. OCOVARTA Output File

17.1 Description

The OCOVARTA format is the ASCII equivalent of the Multi-hit OCOVART file.

Table 17-1 OCOVARTA Multi-Hit Data Types and Descriptions

Data Type	Description
View Header	Defines the properties of a particular view
Reference Point Header	Defines the properties of the Multi-hit reference point
Multi-hit Shotline Header	Defines the properties of a particular Multi-hit shotline
Multi-hit Shotline LOS Data	Defines the elements intercepted along a particular Multi-hit shotline
End-of-Ref point	Signals the end of a particular reference point
End-of-View	Signals the end of a particular view
End-of-Data	Signals the end of the data

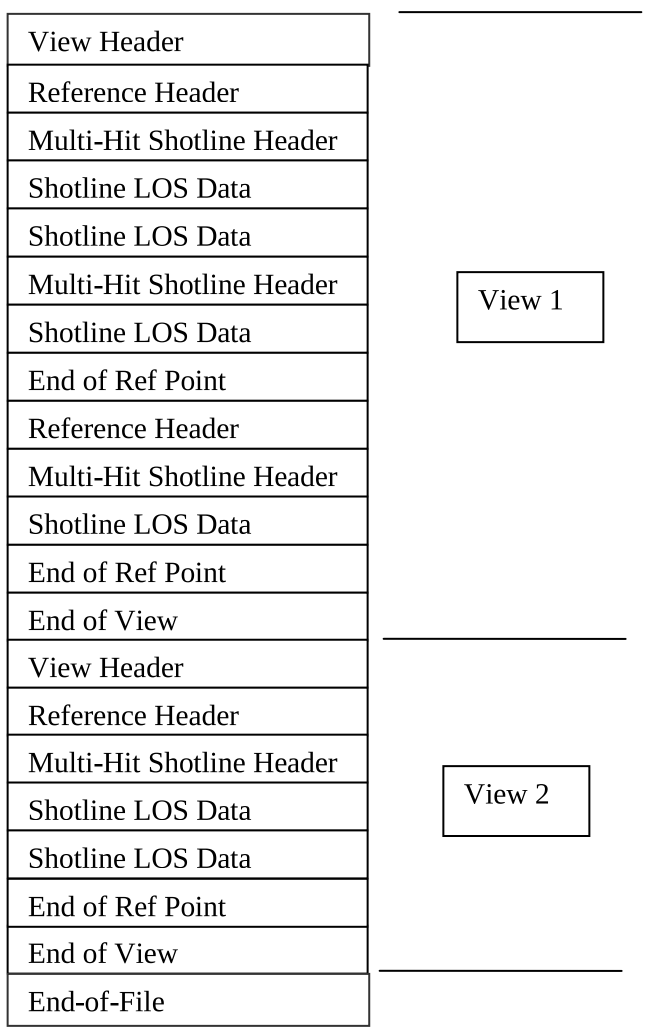
17.1.1 Multi-hit OCOVARTA Output File Format

The Multi-hit OCOVARTA file is formatted similar to the legacy PGEN replacement mode OCOVART output file. This consists of a view header record followed by one or more records of packed data. The records of packed data contain the remaining data types packed in groups of 170 entries. These packed records are zero padded to maintain a consistent record size of 170 entries.

Multi-hit runs may have more than one view associated with each run. This format is shown in Figure 17-1 below.

17.1.2 Detailed Multi-hit OCOVART Output

Figure 17-1 OCOVARTA Multi-Hit Sample File Layout



17.2 Output Data Records

17.2.1 View Header, Multi-hit OCOVARTA Format

Description: Defines variables that appear in the view header.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad
90.00	0.00	0.0	NAME	1.0	-1.0	1.0	-1.0	1.0
R	R	R	C	R	R	R	R	R

Parameters	Units	Description
taz	deg.	Threat azimuth angle
tel	deg.	Threat elevation angle
grid	-----	Unused
iveh	-----	Vehicle Name
rymax	inches	Maximum y-coordinate of the target in the threat coordinate system
rymin	inches	Minimum y-coordinate of the target in the threat coordinate system
rzmax	inches	Maximum z-coordinate of the target in the threat coordinate system
rzmin	inches	Minimum z-coordinate of the target in the threat coordinate system
rad	inches	Influence mode radius addition

17.2.2 Reference Point Header, Multi-hit OCOVARTA Format

Description: Defines the parameters associated with a proximity burst point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
0	4	39.14	2.0	5.5	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always 0
isri	-----	Always 4
cth	Target	Reference Point y-coordinate in the target coordinate system
ath	Target	Reference Point y-coordinate in the target coordinate system
enob	Target	Reference Point z-coordinate in the target coordinate system
exob	-----	Always 0

17.2.3 Multi-Hit Shotline Header, Multi-hit OCOVARTA Format

Description: Defines the parameters associated with a Multi-hit shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	isri	cth	ath	enob	Exob			
1	2	1800.0	2.0	5.5	1.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Number of components on the shotline
isri	-----	Threat ID associated with this Multi-hit shotline.
cth	fps	Threat velocity associated with this Multi-hit shotline.
ath	inches	Shotline y-coordinate in the threat coordinate system
enob	inches	Shotline z-coordinate in the threat coordinate system
exob	-----	Relative position of the MULTIHT1/2 record in the CONTROL file.

17.2.4 Shotline Line-of-Sight Data, Multi-hit OCOVARTA Format

Description: Defines the parameters associated with a Multi-hit shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	isri	cth	ath	enob	exob			
500	00101	0.01	0.01	1.0	1.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Component number
isri	-----	Packed word: XXXXY XXXX: normal thickness x 100 of component at shot line intercept. If rod mode, entry is radius of rod x 100. Y : space code of space following component
cth	inches	Line-of-sight thickness through the component
ath	inches	Line-of-sight thickness through the air space following the component
enob	-----	Cosine of the obliquity angle at entrance surface of component encountered by shotline
exob	-----	Cosine of the obliquity angle at exit surface of component encountered by shotline

17.2.5 End-of-Ref Point, Multi-hit OCOVARTA Format

Description: Defines the parameters associated with a Multi-hit reference point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
-999	0	0.0	0.0	0.0	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always -999
isri	-----	Always 0
cth	-----	Always 0.0
ath	-----	Always 0.0
enob	-----	Always 0.0
exob	-----	Always 0.0

17.2.6 End-of-View, Multi-hit OCOVARTA Format

Description: Defines the parameters associated with a Multi-hit view.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
0	0	0.0	0.0	0.0	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always 0
isri	-----	Always 0
cth	-----	Always 0.0
ath	-----	Always 0.0
enob	-----	Always 0.0
exob	-----	Always 0.0

17.2.7 End of File Header, Multi-hit OCOVARTA Format

Description: Defines variables that appear at the end of the file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad
999.0	0.00	0.0	NAME	0.0	0.0	0.0	0.0	0.0
R	R	R	C	R	R	R	R	R

Parameters	**Units**	**Description**
taz	-----	Always 999
tel	-----	Always 0.0
grid	-----	Always 0.0
iveh	-----	Vehicle Name
rymax	-----	Always 0.0
rymin	-----	Always 0.0
rzmax	-----	Always 0.0
rzmin	-----	Always 0.0
rad	-----	Always 0.0

18. *OBURST Output File*

18.1 Description

The OBURST file format is in the BRL-CAD burst point file format and consists of six records listed in Table 18-1. The data format is a nested setup where each run header record will likely have multiple shotline header records, which will in turn have multiple shotline intersection records and ray header records, which will in turn have multiple ray intersection records.

Table 18-1 OBURST Data Types and Descriptions

Data Type	***Description***
Run Header	*Describes the current run*
Shotline Header	*Describes the current shotline*
Shotline Intersections	*Describes a shotline intersection on the current shotline*
Ray Header	*Describes the current ray*
Ray Intersections	*Describes a ray intersection on the current ray*

18.2 Output Data Records

18.2.1 *Run Header*

Description: Run header for burst point file from BRL-CAD burst.

01	*03 11*	*13 21*	*23 26*	*28 37*	*39 44*	*46 54*
IR	*AZ*	*EL*	*FUZDIS*	*BPAREA*	*UNITS*	*SOLANG*
I						
I	*R*	*R*	*R*	*R*	*C*	*R*

Parameters	***Units***	***Description***
IR	-----	*Record type indicator. 1 indicates run header in a BRL-CAD burst point file.*
AZ	*Degrees*	*Attack Azimuth.*
EL	*Degrees*	*Attack elevation in degrees.*
FUZDIS	*See Remarks*	*Burst distance from first component on shotline. Negative inside aircraft, positive if before first component.*
UNITS	-----	*Unit of length: mm, cm, inches, feet, or meters.*
SOLANG	*Steradions*	*Solid angle associated with each ray.*

REMARKS

1. *The units used for length measurements in the shotline file are indicated in the run header record.*

18.2.2 *Shotline Header*

Description: Shotline header for BRL-CAD burst point file.

01	03 10	12 19
IR	*YSL*	*ZSL*
2		
I	*R*	*R*

Parameters	***Units***	***Description***
IR	-----	*Record type indicator. 2 Indicates shotline header in a BRL-CAD burst point file.*
YSL	*See Remark*	*Y' Coordinate of the shotline.*
ZSL	*See Remark*	*Z' Coordinate of the shotline.*

REMARKS

1. The units used for length measurements in the shotline file are indicated in the run header record.

18.2.3 *Shotline Intersections*

Description: Shotline intersections for BRL-CAD burst point file.

01	03 10	12 19	21 24	26 27	29 35	37 43	45 51	53
IR	DIRX	TLOS	ICNO	ISP	SFAEN	RAEN	COSOBL	ICB
3								
I	R	R	I	I	R	R	R	I

Parameters	***Units***	***Description***
IR	-----	*Record type indicator. 3 Indicates shotline intersections in a BRL-CAD burst point file.*
DIRX	*See Remarks*	*X' Coordinate of component intersection.*
TLOS	*See Remarks*	*Component line-of-sight thickness.*
ICNO	-----	*Component number.*
ISP	-----	*Space Code.*
SFAEN	-----	*Sine of fallback angle of entry normal.*
RAEN	*Degrees*	*Rotation angle of entry normal.*
COSOBL	-----	*Cosine of entrance obliquity.*
ICB	-----	*Indicates whether component triggered burst (0 = no, 1 = yes)*

REMARKS

1. *The units used for length measurements in the shotline file are indicated in the run header record.*

18.2.4 *Burst-Format Ray Header*

Description: Ray header for BRL-CAD burst point file.

01 – 03	03 – 08	10 – 15	17 – 22
IR	*AZRAY*	*SELRAY*	*IRAY*
4			
I	*R*	*R*	*R*

Parameters	**Units**	**Description**
IR	-----	*Record type indicator. 4 Indicates a ray header for a BRL-CAD burst point file.*
AZRAY	*Radians*	*Azimuth angle with respect to shotline.*
SELRAY	-----	*Sine of elevation angle with respect to shotline.*
IRAY	-----	*Sequential number of ray.*

18.2.5 *Burst-Format Ray Intersections*

Description: Ray intersections for BRL-CAD burst point file.

01	*03 12*	*14 22*	*24 32*	*34 37*	*39 42*	*44 49*
IR	*DIRX*	*TLOS*	*TN*	*ISC*	*ICNO*	*COSOBL*
5						
I	*R*	*R*	*R*	*I*	*I*	*R*

Parameters	***Units***	***Description***
IR	--	*Record type indicator. 5 Indicates ray intersections in a BRL-CAD burst point file.*
DIRX	*See Remarks*	*Distance from burst point to first component.*
TLOS	*See Remarks*	*Line-of-sight thickness of component.*
ISL	--	*Space Code.*
ICNO	--	*Component number.*
COSOBL	--	*Cosine of entrance obliquity angle.*

REMARKS

1. *The units used for length measurements in the shotline file are indicated in the run header record.*

19. OFRAGB Output File

19.1 Overview

There are two additional simulation options for handling multiple burst points within FASTGEN. The first option is a gridded burst option, and is treated very much in the same way as a FASTGEN 5.1 BURST2 simulation with a single view orientation. The second option was implemented in FASTGEN 5.3, and gives the user the ability to space multiple bursts at user-specified coordinates. The burst points can be distributed irregularly around the target, exterior to or interior to the target, with a separate view orientation for each burst point.

FASTGEN will potentially generate two output files as a result of these additional simulation options, one for use by COVART and the other for debugging purposes. The first file, OFRAGB, represents a binary multi-burst format and contains all threat related information needed by COVART. This includes burst ray definition information as well as burst ray line-of-sight data. The second file, OFRAGA, is an ASCII representation of the OFRAGB file. Only burst rays that hit the target are output to OFRAGB and OFRAGA files.

Traditional FASTGEN/COVART interactions have involved large quantities of data when multiple burst points that generate large number of fragments are simulated. For each burst ray that intersected the target, fragment mass, impact velocity, shape code, length-to-diameter ratio, and other parameters were passed. In order to minimize the amount of information that must be passed between FASTGEN and COVART, a special polar zone/fragment ID key combination is output to the OFRAGB and OFRAGA files, which COVART can use to lookup original fragment information in the threat file, CTHREAT. Since there can be multiple burst rays per fragment as a result of user-specified burst ray generation parameters, the parameter NBRPD specified on each POLARZON record also comes into play in identifying original fragment information.

19.1.1 Gridded Burst Option

The gridded burst capability provided with the BURST1 input record is very similar to the capability provided by the BURST2 record, and an effort has been made to keep many of the inputs identical in terms of location on the input record itself. In addition, a BURST1 simulation that makes use of CCOVBP information can only be used in conjunction with a single VIEW input record to specify the attack aspect of the threat.

When FASTGEN is executed in PGEN replacement mode, several passes through FASTGEN and COVART are required. In the first FASTGEN pass, a shotline or series of shotlines are passed through the target, and this information is passed to COVART. COVART's role at this point is to estimate the coordinates of each burst point composing the grid in the shotline coordinate system. This information is output to the file CCOVBP and is read back into FASTGEN using the BURST2 record. The aim of the second FASTGEN pass is to generate the burst rays emanating from the burst point and to output line-of-sight information for each of these burst rays in a format that COVART can accept. The second COVART pass then performs its usual function of assessing the vulnerability of a target to the threat's burst rays.

A similar approach is adopted for the gridded burst option available with the BURST1 card. FASTGEN will expect burst point information to be located in the file CCOVBP which is output from COVART.

Both BURST1 and BURST2 simulations make use of identical burst point information provided by COVART. The difference between the two methods is that the BURST1 uses a more robust methodology for characterizing the threat in terms of how fragments are specified in polar zones, how the fragments are allowed to fly off the warhead, and offers the user additional control over burst ray generation in polar zones where fragment information is sparse. In addition, burst rays generated using BURST1 are vectored explicitly by FASTGEN before they are flown to the target. Burst rays generated by BURST2 are flown to the target without being vectored by the threat velocity. The vectoring of the burst rays is handled in COVART using its threat file. This discrepancy results in inaccuracies in fragment hit locations on the target when a BURST2 simulation is performed.

19.1.2 Proximity Burst Option

The proximity burst point option provided by the BURST4 input record is an attempt to replicate some of the capability of the SHAZAM end game code in terms of an exterior burst point. The primary difference between the gridded burst option and the proximity burst option is that the coordinates of each burst point must be specified manually by the user in the target coordinate system on the BURST4 record. For the irregular burst option, a separate VIEW1 card must be specified for each BURST4 record that occurs in the CONTROL file.

19.2 Description

The OFRAGB file is a multi-burst point binary file generated by FASTGEN. The information contained in the OFRAGB file is required by COVART to perform its analysis. The OFRAGB file is only generated when the OFRAGB flag is set in an OUTPUT1 record, and a BURST1, BURST4, or BURST5 record is specified in the CONTROL file. Due to the capability upgrade represented by FASTGEN, there is no longer a requirement that multiple burst points occur in a gridded framework. The OFRAGB file only contains information on burst rays that successfully strike the target. For each burst ray, additional line-of-sight information is also output if the ray hits the target.

Output types required by COVART involve burst ray header information that is generated as a part of the FASTGEN shotline process. Fragment properties that are defined in the CTHREAT file are not output to the OFRAGB file. Instead, the variables RATIO, IPZID, and FROFFSET are passed to COVART and it is COVART's responsibility to use these variables to extract needed fragment property information from the CTHREAT file. The type of data contained in the OFRAGB file is summarized in Table 19-1. Table 19-1There are differences in the content of the header records between the uniformly distributed gridded burst option and the user-specified multiple burst point option. For a gridded burst, the area of a sub-grid cell size is well defined in the context of the source grid. However, for a user-specified multiple burst, there is no aligned grid, and the required area is no longer defined. The only recourse is for COVART to compute the P_k associated with this user-specified burst point internally. FASTGEN's role in this case is to signal COVART via its output that the burst point information it needs to calculate is for a single burst, as opposed to a burst that is part of a grid.

Multiple burst simulations are controlled within FASTGEN using the BURST1, BURST4, and BURST5 records, which replaces the BURST1 input card available in FASTGEN 5.1. While retaining many of the features of the BURST2 card, it also introduced several significant features.

Table 19-1 OFRAGB Data Types and Descriptions

Data Type	Description
View Header	Defines the properties of a particular view
Burst Point Header	Defines the properties of a particular burst point
Shotline Header	Defines the properties of the shotline
Shotline LOS Data	Defines the elements intercepted along the shotline
Burst Ray Header	Defines the properties of a particular burst ray
Burst Ray LOS Data	Defines the elements intercepted along a particular burst ray
End-of-Burst point	Signals the end of a particular burst point
End-of-View	Signals the end of a particular view
End-of-Data	Signals the end of the data

19.2.1 OFRAGB Output File Format

The OFRAGB file is formatted similar to the OCOVART output file. This consists of a view header record followed by one or more records of packed data. The records of packed data contain the remaining data types packed in groups of 170 entries. These packed records are zero padded to maintain a consistent record size of 170 entries.

Gridded burst runs and single proximity burst runs will only have one view associated with each run. This format is shown in Figure 19-1 below.

Figure 19-1 OFRAGB Gridded and Single Proximity Burst File Layout

View Header
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries

Multiple proximity burst points may have more than one view associated with each run.. This format is shown in Figure 19-2 below.

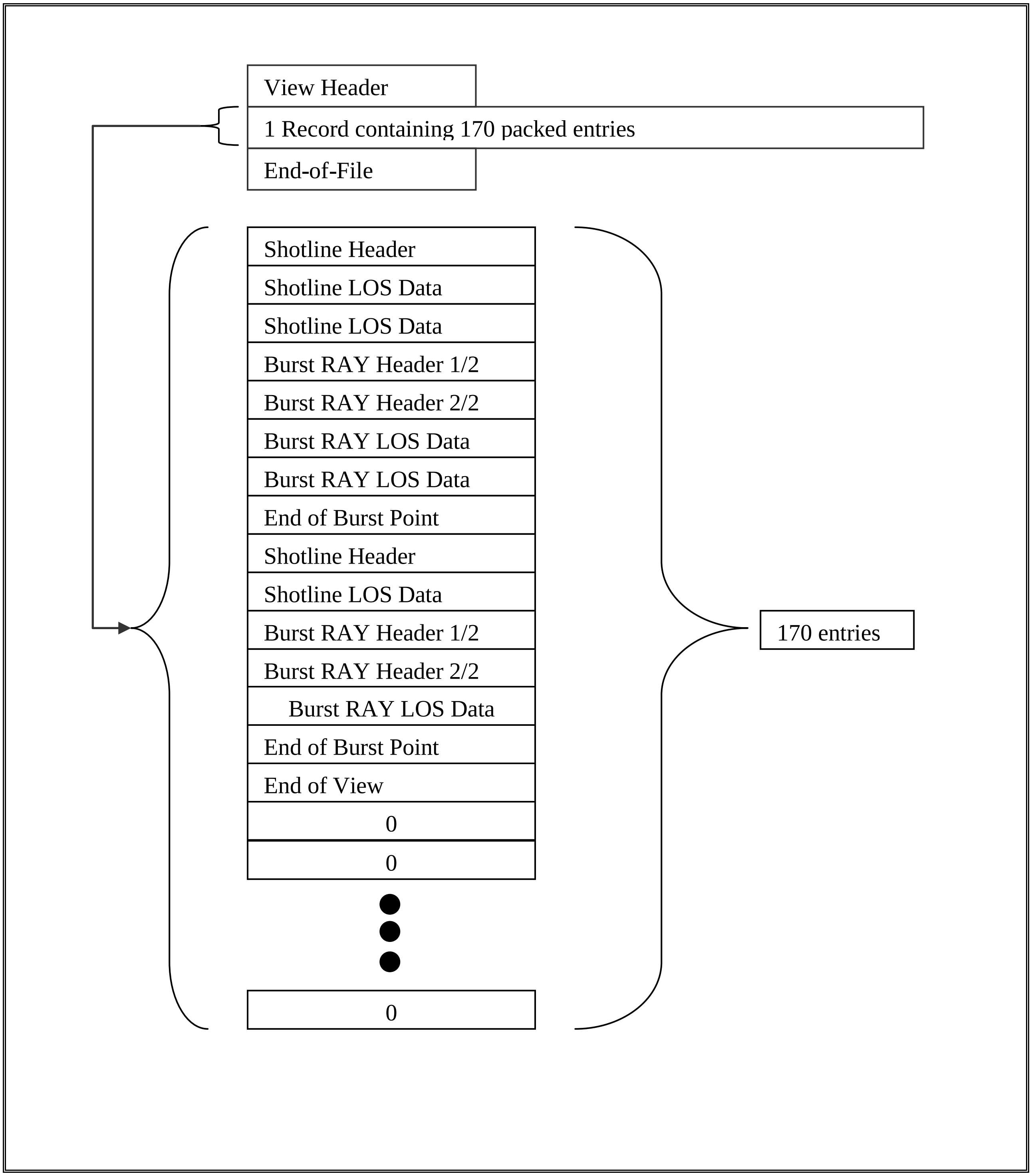
Figure 19-2 OFRAGB Multiple Proximity Burst File Layout

View Header
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
View Header
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
1 Record containing 170 packed entries
End-of-File

19.2.2 OFRAGB Gridded Burst Output

The gridded burst OFRAGB output file contains specific data types in a specific order, and this order is different from the proximity burst output. The OFRAGB file begins with a single record containing the view header. The records of packed data contain the following data records: Shotline Header, Shotline LOS data, Burst Ray Header, Burst Ray LOS data, End-of-Burst, End-of-View, End-of-File. One or more Shotline LOS data records will follow the Shotline Header. One or more groupings of the Burst Header record followed by one or more Burst Ray LOS data records will be next. An End-of-Burst record will complete one of the gridded burst points. The pattern of shotline data followed by burst data will repeat for every burst point in the gridded run. After the last End-of-Burst record, an End-of-View record will occur, followed by an End-of-File record. See Figure 19-3 below for a sample of this format.

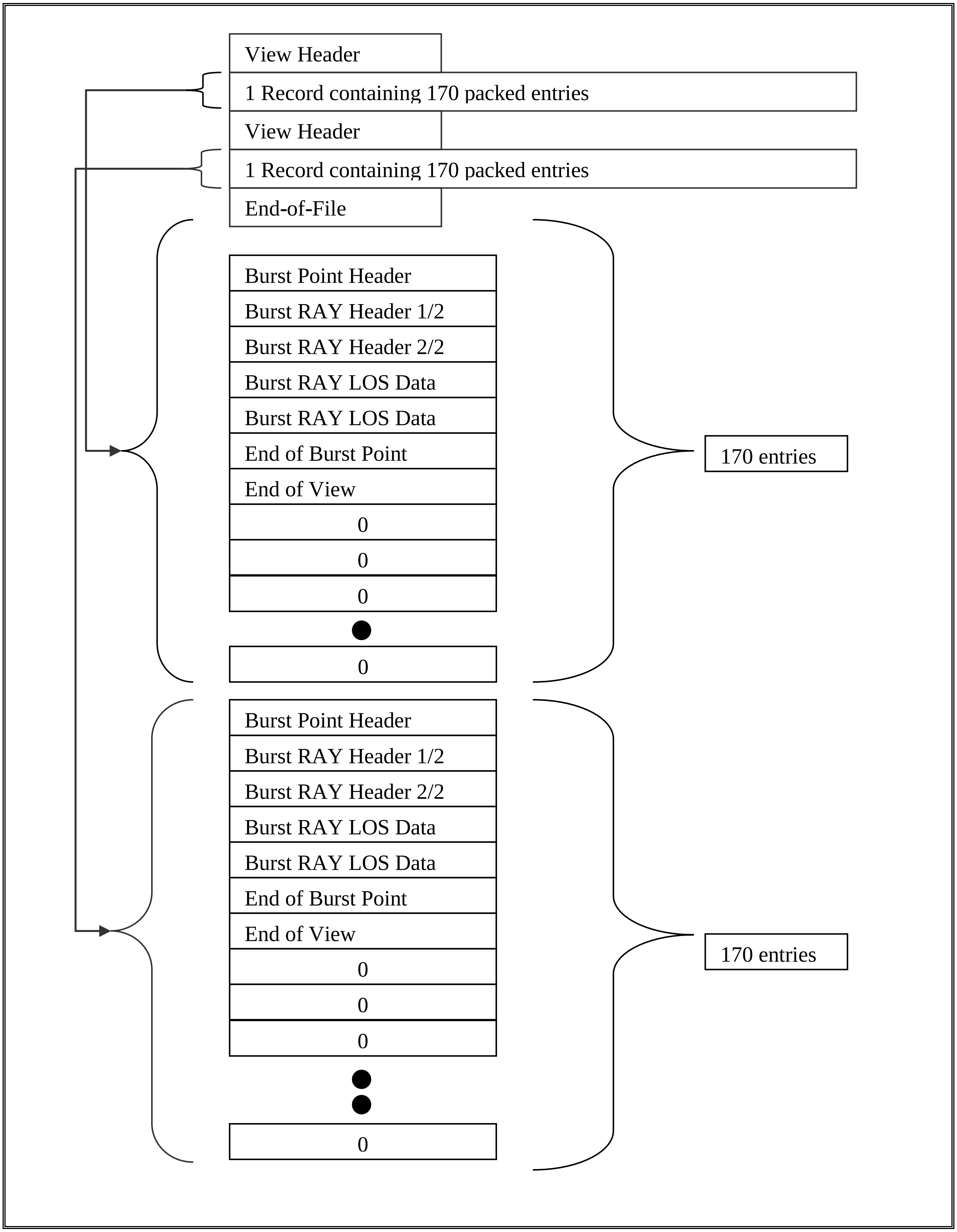
Figure 19-3 OFRAGB Gridded Burst Sample File Layout



19.2.3 OFRAGB Proximity Burst Output

The proximity burst OFRAGB output file contains specific data types in a specific order, and this order is different from the gridded burst output. The OFRAGB file begins with a single record containing the view header. The records of packed data contain the following data records: Shotline Header, Shotline LOS data, Burst Ray Header, Burst Ray LOS data, End-of-Burst, End-of-View, End-of-File. A single Burst Point Header will be followed by one or more groupings of the Burst Header record followed by one or more Burst Ray LOS data records. An End-of-Burst record will complete one of the gridded burst points. Each burst point will have a view header followed by one or more packed groups of 170 entries. After the last burst point record is an End-of-File record. See Figure 19-4 below for a sample of this format.

Figure 19-4 Proximity Burst Sample File Format



19.3 Output Data Records

19.3.1 View Header, OFRAGB Format

Description: Defines variables that appear in the view header.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad
90.00	0.00	2.0	1	1.0	-1.0	1.0	-1.0	1.0
R	R	R	I	R	R	R	R	R

Parameters	**Units**	**Description**
taz	deg.	Threat azimuth angle
tel	deg.	Threat elevation angle
grid	-----	View grid cell size grid > 0 => GRIDDED BURST POINT (use grid cell size for vulnerable area calc) [DEFAULT = 1.0] grid < 0 => IRREGULAR BURST POINT (COVART internally generates a Pk for a stand-alone burst point)
iveh	-----	Vehicle code
rymax	inches	Maximum y-coordinate of the target in the threat coordinate system
rymin	inches	Minimum y-coordinate of the target in the threat coordinate system
rzmax	inches	Maximum z-coordinate of the target in the threat coordinate system
rzmin	inches	Minimum z-coordinate of the target in the threat coordinate system
rad	inches	Influence mode radius addition

REMARKS

1. If taz=999.0, this record is an end-of-burst point flag.

2. Variables iveh and rad have no meaning in the context of FASTGEN and are included for consistency.

3. For a gridded burst point, the minimum and maximum coordinates are defined by the surrounding grid cell boundaries.

4. For a non-gridded burst point, the minimum and maximum coordinates are defined by the entire target.

19.3.2 Burst Point Header, OFRAGB Format

Description: Defines the parameters associated with a proximity burst point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
1	0	39.14	2.0	5.5	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always 1
isri	-----	Always 0
cth	inches	Burst Point y-coordinate in the target coordinate system
ath	inches	Burst Point y-coordinate in the target coordinate system
enob	inches	Burst Point z-coordinate in the target coordinate system
exob	-----	Always 1.0

19.3.3 Shotline Header, OFRAGB Format

Description: Defines the parameters associated with a gridded burst shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	isri	cth	ath	enob	Exob			
1	-999	39.14	2.0	5.5	1.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Number of components on the shotline
isri	-----	Variable grid factor for KE shotline; Fuse distance (in 0.01") for HE shotline
cth	inches	x-distance from the grid plane to the component intersect along shotline
ath	inches	Shotline y-coordinate in the threat coordinate system
enob	inches	Shotline z-coordinate in the threat coordinate system
exob	-----	Blank for KE shotline; Area (ft^2) associated with HE shotline.

19.3.4 Shotline Line-of-Sight Data, OFRAGB Format

Description: Defines the parameters associated with a gridded burst shotline.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	isri	cth	ath	enob	exob			
500	00101	0.01	0.01	1.0	1.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Component number
isri	-----	Packed word: XXXXY XXXX: normal thickness x 100 of component at shot line intercept. If rod mode, entry is radius of rod x 100. Y : space code of space following component
cth	inches	Line-of-sight thickness through the component
ath	inches	Line-of-sight thickness through the air space following the component
enob	-----	Cosine of the obliquity angle at entrance surface of component encountered by shotline
exob	-----	Cosine of the obliquity angle at exit surface of component encountered by shotline

19.3.5 Burst Ray Header, OFRAGB Format

Description: Defines the view of a particular burst ray.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco1	isri1	cth	ath	enob	exob			
5	1	3.5	135.0	-60.0	250.0			
I	I	R	R	R	R			

1	2	3	4	5	6	7	8	9
ieco2	isri2							
1	4							
I	I							

Parameters	**Units**	**Description**
ieco1	-----	Number of components on the ray
isri1	-----	Number of burst rays per fragment
cth	inches	Distance from the burst ray's initial location to the first component along ray
ath	deg.	Ray azimuth
enob	deg.	Ray elevation
exob	fps	Fragment impact velocity; this is less than the initial velocity due to drag effects
ieco2	-----	Polar zone ID key within file CTHREAT
isri2	-----	INDEX of the FRAGDEF record within the POLARZON in the file CTHREAT

REMARKS

1. COVART will use the parameters isri1, ieco2, and isri2 to extract needed fragment information such as mass, shape code, or material type from the FASTGEN threat file CTHREAT.

19.3.6 Burst Ray Line-of-Sight Data, OFRAGB Format

Description: Defines the components intercepted along a particular burst ray.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10	11
ieco	isri	cth	ath	enob	exob					
34	001503	0.05	0.02	0.707	1.0					
I	I	R	R	R	R					

Parameters	**Units**	**Description**
ieco	-----	Component number
isri	-----	Normal thickness and space code (NNNNSS)
cth	inches	Component line-of-sight thickness (inches)
ath	inches	Air gap line-of-sight thickness
enob	-----	Cosine of entrance obliquity angle
exob	-----	Solid angle associated with component

REMARKS

1. The variable exob representing the solid angle is always set equal to 1.0.

19.3.7 End-of-Burst, OFRAGB Format

Description: Defines the parameters associated with a proximity burst point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
-999	0	39.14	2.0	5.5	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always -999
isri	-----	Always 0
cth	inches	Burst Point y-coordinate in the target coordinate system
ath	inches	Burst Point y-coordinate in the target coordinate system
enob	inches	Burst Point z-coordinate in the target coordinate system
exob	-----	Always 0

19.3.8 End-of-View, OFRAGB Format

Description: Defines the parameters associated with a proximity burst point.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
ieco	Isri	cth	ath	enob	Exob			
0	0	0.0	0.0	0.0	0.0			
I	I	R	R	R	R			

Parameters	**Units**	**Description**
ieco	-----	Always 0
isri	-----	Always 0
cth	-----	Always 0
ath	-----	Always 0
enob	-----	Always 0
exob	-----	Always 0

19.3.9 End of File Header, OFRAGB Format

Description: Defines variables that appear at the end of the file.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad
999.0	0.00	0.0	0	0.0	0.0	0.0	0.0	0.0
R	R	R	I	R	R	R	R	R

Parameters	**Units**	**Description**
taz	-----	Always 999
tel	-----	Always 0
grid	-----	Always 0
iveh	-----	Always 0
rymax	-----	Always 0
rymin	-----	Always 0
rzmax	-----	Always 0
rzmin	-----	Always 0
rad	-----	Always 0

20. OFRAGA Output File

20.1 Description

The OFRAGA format is the ASCII equivalent of OFRAGB. The data format is nested, where each burst point, or view header will have multiple burst rays and relevant line-of-sight data records. The OFRAGA file will contain burst ray headers for all fragments that hit the target. If a burst ray assigned to a fragment strikes the target, additional line-of-sight information is also output. If the burst ray assigned to a fragment misses the target, no LOS information is generated. It is emphasized that OFRAGA is an ASCII file which can be activated by the user using appropriate input, and does not interact with COVART. Its primary use is as a debugging aid, and is off by default.

20.2 Output Data Records

20.2.1 Burst Point Header, OFRAGA Format

Description: Defines variables that appear in the view header.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
taz	tel	grid	iveh	rymax	rymin	rzmax	rzmin	rad	
90.00	0.00	2.0	1	1.0	-1.0	1.0	-1.0	1.0	
R	R	R	I	R	R	R	R	R	

Parameters	**Units**	**Description**
taz	deg.	Threat azimuth angle
tel	deg.	Threat elevation angle
grid	-----	View grid cell size grid > 0 => GRIDDED BURST POINT (use grid cell size for vulnerable area calc) [DEFAULT = 1.0] grid < 0 => IRREGULAR BURST POINT (COVART internally generates a Pk for a stand-alone burst point)
iveh	-----	Vehicle code
rymax	inches	Maximum y-coordinate of the target in the threat coordinate system
rymin	inches	Minimum y-coordinate of the target in the threat coordinate system
rzmax	inches	Maximum z-coordinate of the target in the threat coordinate system
rzmin	inches	Minimum z-coordinate of the target in the threat coordinate system
rad	inches	Influence mode radius addition

REMARKS

1. If taz=999.0, this record is an end-of-burst point flag.
2. Variables iveh and rad have no meaning in the context of FASTGEN and are included for consistency.
3. For a gridded burst point, the minimum and maximum coordinates are defined by the surrounding grid cell boundaries.

4. For a non-gridded burst point, the minimum and maximum coordinates are defined by the entire target.

20.2.2 Shotline Header, OFRAGA Format

Description: Defines the parameters associated with a shotline in OCOVART format.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ieco	isri	cth	ath	enob	exob				
1	-999	39.14	2.0	5.5	1.0				
I	I	R	R	R	R				

Parameters	**Units**	**Description**
ieco	-----	Number of components on the shotline
isri	-----	Variable grid factor for KE shotline; Fuse distance (in 0.01") for HE shotline
cth	inches	x-distance from the grid plane to the component intersect along shotline
ath	inches	Shotline y-coordinate in the threat coordinate system
enob	inches	Shotline z-coordinate in the threat coordinate system
exob	-----	Blank for KE shotline; Area (ft^2) associated with HE shotline.

REMARKS

1. If ieco = 0, this is an end-of-view flag.

20.2.3 Shotline Intersection Data, OFRAGA Format

Description: Defines the parameters associated with a shotline in OCOVART format.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ieco	isri	cth	ath	enob	exob				
500	00101	0.01	0.01	1.0	1.0				
I	I	R	R	R	R				

Parameters	**Units**	**Description**
ieco	-----	Component number
isri	-----	Packed word: XXXXY XXXX: normal thickness x 100 of component at shot line intercept. If rod mode, entry is radius of rod x 100. Y : space code of space following component
cth	inches	Line-of-sight thickness through the component
ath	inches	Line-of-sight thickness through the air space following the component
enob	-----	Cosine of the obliquity angle at entrance surface of component encountered by shotline
exob	-----	Cosine of the obliquity angle at exit surface of component encountered by shotline

REMARKS

1. This record serves no purpose in the context of FASTGEN, and is included to remain consistent with the COVART binary format.

20.2.4 Burst Ray Header, OFRAGA Format

Description: Defines the view of a particular burst ray.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ieco1	isri1	cth	ath	enob	exob				
5	1	3.5	135.0	-60.0	250.0				
I	I	R	R	R	R				

1	2	3	4	5	6	7	8	9	10
ieco2	isri2								
1	4								
I	I								

Parameters	**Units**	**Description**
ieco1	-----	Number of components on the ray
isri1	-----	Number of burst rays per fragment
cth	inches	Distance from the burst ray's initial location to the first component along ray
ath	deg.	Ray azimuth
enob	deg.	Ray elevation
exob	fps	Fragment impact velocity; this is less than the initial velocity due to drag effects
ieco2	-----	Polar zone ID key within file CTHREAT
isri2	-----	INDEX of the FRAGDEF record within the POLARZON in the file CTHREAT

REMARKS

1. COVART will use the parameters isri1, ieco2, and isri2 to extract needed fragment information such as mass, shape code, or material type from the FASTGEN threat file CTHREAT.

20.2.5 Burst Ray Line-of-Sight Data, OFRAGA Format

Description: Defines the components intercepted along a particular burst ray.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
ieco	isri	cth	ath	enob	exob				
34	001503	0.05	0.02	0.707	1.0				
I	I	R	R	R	R				

Parameters	**Units**	**Description**
ieco	-----	Component number
isri	-----	Normal thickness and space code (NNNNSS)
cth	inches	Component line-of-sight thickness
ath	inches	Air gap line-of-sight thickness
enob	-----	Cosine of entrance obliquity angle
exob	-----	Solid angle associated with component

REMARKS

1. The variable exob representing the solid angle is always set equal to 1.0.

21. ODISPLAY_THREAT Output File

21.1 Description

The OUTPUT3 input record allows a user to activate a flag which will generate an ASCII file that contains standard FASTGEN geometric elements to represent threats, their burst points, and the burst rays that emanate from the burst point. Any visualization package that can view a standard FASTGEN CBULK file can also visualize the contents of this file.

File ODISPLAY_THREAT follows a very specific format. All threat information is output to group 31, and different classes of objects are assigned component numbers. These different classes use CCONE2 elements to represent the threat and its polar zones, CSPHERE elements to highlight the threat's burst point and its center of gravity, and CLINE elements to represent the threat shot line and the threat's burst rays.

A multiple burst visualization capability is implemented by serially outputting bursts into a single group and incrementing the FASTGEN component number. Thus, individual bursts will occur in batches of components whose sizes are primarily dictated by the number of polar zones defined for the threat. Multiple burst points associated with a FASTGEN BURST1, BURST4, and BURST5 simulation reference a single CTHREAT file.

There is an option in FASTGEN to simulate multiple burst points within a gridded framework. As discussed elsewhere in this user manual, FASTGEN will read information from the burst point file CCOVBP, which is generated by COVART. When these burst points are returned in the view coordinate system, the ODISPLAY_THREAT file will reconstruct a graphical representation of this original grid upstream of the target at the specified view angle.

The variable INPZ in Table 21-1 represent the number of user-defined polar zones in the CTHREAT file. Note that there are INPZ + 1 boundaries visualized for the INPZ polar zones. In general, the minimum number of components created in file ODISPLAY_THREAT is governed by the minimum number of polar zones in the threat file.

Table 21-1 ODISPLAY_THREAT Output Format

Burst Point No.	Component No.	Element Type	Description
1	1	CCONE2	Threat cylinder
	2	CCONE2	Warhead cylinder
	3	CSPHERE	Threat Burst Point
	4	CSPHERE	Threat Center of Gravity
	5	CLINE	…..
	6	CCONE2	Polar Zone Boundary No. 1
	…..	CCONE2	…..
	6 + INPZ	CCONE2	Polar Zone Boundary INPZ + 1
	6 + INPZ + 1	CLINE	Burst Rays in Polar Zone No. 1
	…..	CLINE	…..
	6 + 2 * INPZ	CLINE	Burst Rays in Polar Zone INPZ
2	6 + 2 * INPZ + 1	CCONE2	Threat cylinder
	6 + 2 * INPZ + 2	CCONE2	Warhead cylinder
	6 + 2 * INPZ + 3	CSPHERE	Threat burst point
	6 + 2 * INPZ + 4	CSPHERE	Threat center of gravity
	6 + 2 * INPZ + 5	CLINE	…..
	6 + 2 * INPZ + 6	CCONE2	Polar Zone Boundary No. 1
	…..	CCONE2	…..
	6 + 3 * INPZ	CCONE2	Polar Zone Boundary INPZ + 1
	6 + 3 * INPZ + 1	CLINE	Burst Rays in Polar Zone No. 1
	6 + 3 * INPZ + 2	CLINE	.....
	6 + 3 * INPZ + 3	CLINE	Burst Rays in Polar Zone INPZ

22. OERROR Output File

22.1 Description

FASTGEN uses the OERROR file to record run time status and error messages. OERROR also contains a copy of the CONTROL input file used in the run to identify it at a later time. FASTGEN messages have been changed starting with version 5.4. These messages fall into several categories:

- Fatal Errors – Errors that cause FASTGEN to stop
- Non-Fatal Errors – Errors that do not cause FASTGEN to stop
- Warnings – Warning Messages
- Information – Informational messages

Fatal error messages are reported when events occur while running FASTGEN that require FASTGEN to stop executing. Fatal error messages are echoed to the command line as well as included in the OERROR file. This was provided so that any fatal errors would be reported even if the OERROR file was turned off.

Non-Fatal error messages are reported when serious errors are identified by FASTGEN that do not require FASTGEN to stop execution. Non-Fatal error messages are written to the OERROR file, but cannot be suppressed.

Warning messages are reported when events occur while running FASTGEN that can have an effect on the output results. These messages are designed to allow the user to investigate the source of the message and determine if additional action is required. Warning messages are written to the OERROR file and can be suppressed by setting the warn flag in the OUTPUT2 record.

All other messages are written to the OERROR file.

The general format for Fatal Errors, Non-Fatal Errors, and Warnings are:

1. Message Type;
2. Message Number
3. Location of Message
4. Message
5. Additional Information

Figure 22-1 Example Error Message

```
NON-FATAL ERROR 127 in Module  BULK3D
  HEX1 ELEMENT FOUND IN A VOLUME MODE COMPONENT.
Group =      1 Component =      2 Element =     31 DROPPED
```

Figure 22-2 Example informational messages

```
    AZIMUTH     0.000     ELEVATION   0.000
PROJECTED AREA (UNIT**2) FOR THIS VIEW
 0.000
NUMBER OF SHOTLINES FOR THIS VIEW
         0
END OF EXECUTION IN SUBROUTINE RUN
================================================
============        FASTGEN 5       ============
============  SIMULATION COMPLETED  ============
================================================
```

NOTE: All FASTGEN error, warning and other diagnostic messages are written to the OERROR output file. It is recommended that the user manually check the contents of this file after a FASTGEN simulation is executed.

22.2 FASTGEN Messages

FASTGEN has 130 messages that can be reported to the user. These messages can appear as Fatal Error, Non-Fatal Error, or Warning messages. The complete lest of messages is contained in Table 22-1.

Table 22-1 FASTGEN MESSAGES

ID	FASTGEN Message
1	INDEX LARGER THAN PARAMETER ILOS
2	ORIENTATION IS WITHIN 0.01 DEGREES OF RAY
3	TRIANGLE WITH 2-D AREA LESS THAN 0.00001
4	CONE WITH 2-D LENGTH LESS THAN 0.01
5	INDEX LARGER THAN PARAMETER ICOGR
6	INDEX LARGER THAN PARAMETER IHW
7	LINE WITH 2-D LENGTH LESS THAN 0.01
8	CONE CARD DOES NOT HAVE A CONTINUATION CARD
9	CHEX CARD DOES NOT HAVE A CONTINUATION CARD
10	SEE ERROR MESSAGE
11	CQUAD ELEMENT HAS OVER 30 DEGREES WARP
12	ENDDATA RECORD NOT FOUND
13	FIRST GRID ID NUMBER MUST BE SMALLEST
14	GRID INDEX TOO SMALL
15	TRIANGLE DEGENERATES, ELEMENT DROPPED.
16	SUB GRID LARGER THAN GRID, TERMS SWITCHED
17	INDEX LARGER THAN PARAMETER IENV
18	NO INTERSECTION OF TARGET AND ENVELOPE NUMBER
19	INDEX LARGER THAN PARAMETER IRAN
20	INDEX LARGER THAN PARAMETER ISECTH
21	INDEX LARGER THAN PARAMETER ING
22	INTERCEPT FAILED TESTS, INTERCEPT IS NOT USED
23	NO INTERFERENCE RECORDS
24	INTERFERENCE FOUND WITH NO HOLE OR WALL RECORDS
25	CALL SUBROUTINE BULK
26	CALL SUBROUTINE GPLANA
27	CALL SUBROUTINE GPLANB
28	END EXECUTION IN SUBROUTINE RUN
29	END EXECUTION IN SUBROUTINE BULK

ID	FASTGEN Message
30	END EXECUTION IN SUBROUTINE GPLANA
31	END EXECUTION IN SUBROUTINE GPLANB
32	END EXECUTION IN SUBROUTINE SOL
33	END EXECUTION IN SUBROUTINE SHOTDT
34	CBULK DATA FILE DOES NOT EXIST
35	CONTROL DATA FILE DOES NOT EXIST
36	CCOVBP DATA FILE DOES NOT EXIST
37	CZONES DATA FILE DOES NOT EXIST
38	COVBPX DATA FILE DOES NOT EXIST
39	CTHREAT INPUT FILE DOES NOT EXIST
40	CTRI ELEMENT SET TO FRONT FACE
41	CQUAD ELEMENT SET TO FRONT FACE
42	CONE LENGTH EQUAL TO ZERO - ELEMENT DROPPED
43	WALL HEIGHT GREATER THAN CONE RADII - ELEMENT DROPPED
44	INNER CONE RADIUS GREATER THAN OUTER RADIUS - ELEMENT DROPPED
45	CHEX ELEMENT SET TO FRONT FACE
46	MAXIMUM SHIELD PRESSURE EQUAL TO ZERO OR NOT DEFINED
47	VEHICLE INFORMATION
48	END OF FILE OCCURED WHILE READING CCONE DATA
49	THE NUMBER OF GRIDS IS LARGER THAN PARAMETER ING
50	INVALID THREAT RADIUS VALUE
51	INVALID GRID BLOCK SIZE
52	MIXED BURST DATA TYPES
53	EXTRA BURST2 DATA TYPE
54	INVALID DRAG OPTION ON BURST4. DRAG SET
55	INVALID DISTRIBUTION OPTION ON BURST4. UNIFORM DISTRIBUTION SET
56	MAXIMUM PROXIMITY BURST POINTS SPECIFIED
57	TARGET SPEED LESS THAN ZERO
58	THREAT SPEED LESS THAN ZERO
59	MAXIMUM DEL RECORDS EXCEEDED
60	MAXIMUM CRIT RECORDS EXCEEDED
61	MAXIMUM VIEW RECORDS EXCEEDED
62	BLAST RADIUS MUST BE GREATER THAN ZERO
63	NUMBER OF BLAST REFLECTIONS GREATER THAN 6
64	MINIMUM GRID ELEMENT SIZE IS LESS THAN OR EQUAL TO ZERO

ID	FASTGEN Message
65	BLAST GRID SIZE IS LESS THAN OR EQUAL ZERO
66	BLAST GRID SIZE GREATER THAN MINIMUM GRID ELEMENT SIZE
67	RMINANG LESS THAN ZERO OR RMINANG GREATER THAN NINETY DEGREES
68	BURST RAY DENSITY MIN IS GREATER THAN DENSITY MAX
69	BLAST1 AND BLAST2 CARDS FOUND IN CONTROL FILE
70	PARAMETER IOSTORE EXCEEDED
71	GRIDS COINCIDE - CCONE3 ELEMENT DROPPED
72	CCONE3 GRIDS OUT OF LINE
73	CCONE3 RADII UNDEFINED - CCONE3 ELEMENT DROPPED
74	CCONE3 3 POINTS DEGENERATE
75	CCONE3 BAD OUTER RADIUS
76	CCONE3 BAD INNER RADIUS
77	END OF FILE OCCURED WHILE READING CCONE3 DATA
78	INCORRECT SHOTLINE INTERCEPT COMPUTED FOR OUTER CONE
79	INCORRECT SHOTLINE INTERCEPT COMPUTED FOR INNER CONE
80	ODD NUMBER OF HITS ON
81	HIGH ASPECT RATIO CONE
82	THIN CONE
83	CURRENT GROUP/COMPONENT OVERLAP GROUP/COMPONENT
84	IBRSTLM PARAMETER EXCEEDED -- BURST DATA DROPPED.
85	RANDOM FRAGMENT SELECTION FAILED
86	COULDNT FIND A POLAR FRAGMENT
87	HEX2 HAS ONLY ONE INTERSECTION -- INTERSECTION DROPPED
88	COULDNT FIND A FRAGMENT
89	D-THETA LESS THAN ZERO
90	D-THETA COMPLEX
91	TWO VOLUME MODE ELEMENTS BEGIN AT THE SAME LOCATION
92	VOLUME MODE COMPONENT OPEN -- INTERSECTION DROPPED.
93	CONCAVE QUAD IN COMPONENT -- REIDENTIFYING GRIDS:
94	NO VALID SHOTLINE OPTION CHOSEN
95	VIEW1/BURST1 MISMATCH
96	AZ/EL MISMATCH IN CCOVBP INPUT FILE
97	ERROR WRITING TO FILE OCOVART
98	ERROR WRITING TO FILE OFRAGB
99	CBLAST FILE NOT FOUND - SHIELD PRESSURE LIMIT IGNORED

ID	FASTGEN Message
100	NUMBER OF COMPONENTS IN BLAST RADIUS GREATER THAN IMXCMP
101	NUMBER OF COMPONENTS EXCEED IMXC
102	NUMBER OF ELEMENTS EXCEED IMXE
103	NUMBER OF POINTS EXCEED IMXPT
104	IMXAR ARRAY BOUNDS EXCEEDED
105	THE NUMBER OF BLAST RAYS HAS EXCEEDED PARAMETER IMXRY.
106	OCOMPLIST WRITE ERROR - UNKNOWN DATA TYPE
107	END OF LINE DURING READ OF DATA STRING
108	ERROR DURING READ OF DATA STRING
109	Error Opening File - Aborting calculation.
110	NOT ALL RAYS DISTRIBUTED
111	ILLEGAL FRAGMENT TYPE
112	INVALID POLAR ZONE ORIGIN IN FILE CTHREAT
113	MAXIMUM NUMBER OF BURST RAYS EXCEEDED
114	NO POLARZON RECORD FOUND IN FILE CTHREAT
115	POLAR ZONE ANGLES MUST BE GE 0.0 DEGREES
116	POLAR ZONE UPPER ANGLE MUST BE GE LOWER ANGLE IN FILE CTHREAT
117	POLAR ZONES MUST INCREASE IN LENGTH ALONG THE WARHEAD
118	POLAR ZONE OVERLAP NOT ALLOWED
119	MAXIMUM NUMBER OF POLAR ZONES EXCEEDED
120	POLAR ZONE ID MISMATCH
121	INVALID PROJECTILE DIAMETER IN FILE CTHREAT
122	INVALID PROJECTILE LENGTH
123	INVALID ALTITUDE SPECIFIED ON BURST1 CARD
124	MEMORY ALLOCATION ERROR.
125	BLAST1 AND BURST3 RECORDS FOUND IN THE CONTROL FILE.
126	ELEMENT WITH ZERO THICKNESS FOUND IN PLATE MODE COMPONENT.
127	HEX1 ELEMENT FOUND IN A VOLUME MODE COMPONENT.
128	HEX2 ELEMENT FOUND IN PLATE MODE COMPONENT.
129	QUAD DEGENERATES, ELEMENT DROPPED.
130	HEX DEGENERATES, ELEMENT DROPPED.
131	ILLEGAL CONE DEFINITION.
132	THE GRID TO SUBGRID RATIO MUST BE 20 OR LESS.
133	PLATE MODE OBLIQUITY ANGLE TOO HIGH. INTERSECTION DROPPED.
134	HIGH OBLIQUITY ANGLE (RCOSB1 & RCOSB2 < 1.0E-06) SECANT=1E+09

22.3 Fatal Error Messages

22.3.1 Input File Fatal Error Messages

These messages occur when required inputs are missing:

- `CBULK DATA FILE DOES NOT EXIST`
- `CONTROL DATA FILE DOES NOT EXIST`
- `CCOVBP DATA FILE DOES NOT EXIST`
- `CZONES DATA FILE DOES NOT EXIST`
- `COVBPX DATA FILE DOES NOT EXIST`
- `CTHREAT INPUT FILE DOES NOT EXIST`

22.3.2 CBULK File Fatal Error Messages

These messages occur when problems exist in the CBULK target file:

- `INDEX LARGER THAN PARAMETER ICOGR`
- `SEE ERROR MESSAGE (detailed message included in OERROR FILE)`
- `ENDDATA RECORD NOT FOUND`
- `FIRST GRID ID NUMBER MUST BE SMALLEST`
- `END OF FILE OCCURED WHILE READING CCONE DATA`
- `PARAMETER IOSTORE EXCEEDED`

22.3.3 CONTROL File Fatal Error Messages

These messages occur when problems exist in the CONTROL file:

- `INDEX LARGER THAN PARAMETER IRAN`
- `THE NUMBER OF GRIDS IS LARGER THAN PARAMETER ING`
- `INVALID THREAT RADIUS VALUE`
- `INVALID GRID BLOCK SIZE`
- `MIXED BURST DATA TYPES`
- `EXTRA BURST2 DATA TYPE`

- BLAST RADIUS MUST BE GREATER THAN ZERO
- NUMBER OF BLAST REFLECTIONS GREATER THAN 6
- MINIMUM GRID ELEMENT SIZE IS LESS THAN OR EQUAL TO ZERO
- BLAST GRID SIZE IS LESS THAN OR EQUAL ZERO
- BLAST GRID SIZE GREATER THAN MINIMUM GRID ELEMENT SIZE
- RMINANG LESS THAN ZERO OR RMINANG GREATER THAN NINETY DEGREES
- BURST RAY DENSITY MIN IS GREATER THAN DENSITY MAX
- BLAST1 AND BLAST2 CARDS FOUND IN CONTROL FILE
- BLAST1 AND BURST3 RECORDS FOUND IN THE CONTROL FILE.

22.3.4 CTHREAT File Fatal Error Messages

These messages occur when problems exist in the CTHREAT file:

- MAXIMUM NUMBER OF BURST RAYS EXCEEDED
- NO POLARZON RECORD FOUND IN FILE CTHREAT
- POLAR ZONE ANGLES MUST BE GE 0.0 DEGREES
- POLAR ZONE UPPER ANGLE MUST BE GE LOWER ANGLE IN FILE CTHREAT
- POLAR ZONES MUST INCREASE IN LENGTH ALONG THE WARHEAD
- POLAR ZONE OVERLAP NOT ALLOWED
- MAXIMUM NUMBER OF POLAR ZONES EXCEEDED
- POLAR ZONE ID MISMATCH
- INVALID PROJECTILE DIAMETER IN FILE CTHREAT

22.3.5 Initial Run Condition Fatal Error Messages

These messages occur when problems exist in the initial run conditions:

- INDEX LARGER THAN PARAMETER IENV
- NO VALID SHOTLINE OPTION CHOSEN
- AZ/EL MISMATCH IN CCOVBP INPUT FILE

22.3.6 ADRaM mode Runtime Fatal Error Messages

These messages occur when problems arise during ADRaM mode execution:

- `COULDNT FIND A POLAR FRAGMENT`
- `VIEW1/BURST1 MISMATCH`
- `NOT ALL RAYS DISTRIBUTED`
- `ILLEGAL FRAGMENT TYPE`
- `INVALID POLAR ZONE ORIGIN IN FILE CTHREAT`
- `MAXIMUM NUMBER OF BURST RAYS EXCEEDED`
- `INVALID ALTITUDE SPECIFIED ON BURST1 CARD`

22.4 Non-Fatal Error Messages

22.4.1 CBULK File Non-Fatal Error Messages

These messages occur when problems exist in the CBULK input file:

- TRIANGLE DEGENERATES, ELEMENT DROPPED.
- ELEMENT WITH ZERO THICKNESS FOUND IN PLATE MODE COMPONENT.
- HEX1 ELEMENT FOUND IN A VOLUME MODE COMPONENT.
- HEX2 ELEMENT FOUND IN PLATE MODE COMPONENT.
- QUAD DEGENERATES, ELEMENT DROPPED.
- HEX DEGENERATES, ELEMENT DROPPED.

22.4.2 Runtime Volume Component Non-Fatal Error Messages

These messages occur when volume mode component problems are discovered during execution:

- TWO VOLUME MODE ELEMENTS BEGIN AT THE SAME LOCATION
- VOLUME MODE COMPONENT OPEN -- INTERSECTION DROPPED.

22.5 Warning Messages

22.5.1 CBULK File Warning Messages

These messages occur when problems exist in the CBULK input file:

- INDEX LARGER THAN PARAMETER ILOS
- INDEX LARGER THAN PARAMETER IHW
- LINE WITH 2-D LENGTH LESS THAN 0.01
- CONE CARD DOES NOT HAVE A CONTINUATION CARD
- CHEX CARD DOES NOT HAVE A CONTINUATION CARD
- CQUAD ELEMENT HAS OVER 30 DEGREES WARP
- GRID INDEX TOO SMALL
- CONE LENGTH EQUAL TO ZERO - ELEMENT DROPPED
- WALL HEIGHT GREATER THAN CONE RADII - ELEMENT DROPPED

- INNER CONE RADIUS GREATER THAN OUTER RADIUS - ELEMENT DROPPED
- CHEX ELEMENT SET TO FRONT FACE
- CCONE3 GRIDS OUT OF LINE
- CCONE3 RADII UNDEFINED - CCONE3 ELEMENT DROPPED
- CCONE3 3 POINTS DEGENERATE
- CCONE3 BAD OUTER RADIUS
- CCONE3 BAD INNER RADIUS
- END OF FILE OCCURED WHILE READING CCONE3 DATA
- ELEMENT WITH ZERO THICKNESS FOUND IN PLATE MODE COMPONENT.
- HEX1 ELEMENT FOUND IN A VOLUME MODE COMPONENT.
- HEX2 ELEMENT FOUND IN PLATE MODE COMPONENT.

22.5.2 CONTROL File Warning Messages

These messages occur when problems exist in the CONTROL input file:

- INVALID DRAG OPTION ON BURST4. DRAG SET
- INVALID DISTRIBUTION OPTION ON BURST4. UNIFORM DISTRIBUTION SET
- MAXIMUM PROXIMITY BURST POINTS SPECIFIED
- TARGET SPEED LESS THAN ZERO
- THREAT SPEED LESS THAN ZERO
- MAXIMUM DEL RECORDS EXCEEDED
- MAXIMUM CRIT RECORDS EXCEEDED
- MAXIMUM VIEW RECORDS EXCEEDED

22.5.3 Runtime File Warning Messages

These messages occur when data handling in or out of a file occurs during execution:

- IBRSTLM PARAMETER EXCEEDED -- BURST DATA DROPPED.
- ERROR WRITING TO FILE OCOVART
- ERROR WRITING TO FILE OFRAGB

22.5.4 Component interference Warning Messages

These messages occur when component interference occurs during execution:

- `NO INTERFERENCE RECORDS`
- `INTERFERENCE FOUND WITH NO HOLE OR WALL RECORDS`

22.5.5 Element-Based Warnings

These messages occur when possible issues with elements are discovered during execution:

- `ORIENTATION IS WITHIN 0.01 DEGREES OF RAY`
- `TRIANGLE WITH 2-D AREA LESS THAN 0.00001`
- `INCORRECT SHOTLINE INTERCEPT COMPUTED FOR OUTER CONE`
- `INCORRECT SHOTLINE INTERCEPT COMPUTED FOR INNER CONE`
- `ODD NUMBER OF HITS ON`
- `HIGH ASPECT RATIO CONE`
- `THIN CONE`
- `HEX2 HAS ONLY ONE INTERSECTION -- INTERSECTION DROPPED`
- `CONCAVE QUAD IN COMPONENT -- REIDENTIFYING GRIDS`

22.5.6 ADRaM mode execution Warning Messages

These messages occur when ADRaM mode issues are identified during program execution:

- `RANDOM FRAGMENT SELECTION FAILED`

23. RBURST Output File

23.1 Description

The RBURST file is an optional ASCII file generated by FASTGEN to support the Combat Assessment Tool (CAT). This file contains information about components intersected along a shotline or fragment ray. The output is a sequential listing of records that represent each intersection encountered by the shotline or fragment ray. The synchronization of this output file to the primary LOS data file is maintained by FASTGEN such that no header records are required.

COVART can optionally read this file and add penetration information for each intersection. The combined data is written into the original file that is used by the CAT tool for display purposes.

23.2 Output Data Records

23.2.1 Component Data Record

Description: Defines the components and elements intercepted along a particular shotline or fragment ray.

Format, Example, and Data Type:

1	2	3	4	5	6	7	8	9	10
RAYID	DIST	CTH	COMP	EID					
35	37.465	0.211	121	277					
I	R	R	I	I					

Parameters	**Units**	**Description**
RAYID	-----	Ray index.
DIST	inches	Distance from burst point to face of element.
CTH	inches	Component line-of-sight thickness
COMP	-----	Component number.
EID	-----	Element number.

REMARKS

1. The ray index is the i^{th} shotline or fragment ray that impacts the target.

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