BENCHMARK FOR THE ASALT PROGRAM: ASSESSMENT OF SURVIVABILITY AGAINST LASER THREATS

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September 1981

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FOREWORD

This report presents the results of research performed under Naval Weapons Center, China Lake, California Contract N00123-80-D-0033.

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The benchmark run of the ASALT Computer Program using data for an F-18 aircraft target is documented in this report. Also described in this report, are several other computer programs that are useful in assembling data for input to the ASALT Program. Copies of the input and output files from the benchmark process are included, so that the report serves as an example of the execution of the ASALT Program and the programs which precede it.
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Due to improvements in laser and tracking technology, high-energy lasers have become a potential threat to the survivability of combat aircraft. A method for evaluating the effectiveness of a ground-based laser weapon system against an aircraft is provided by the computer program, ASALT, Assessment of Survivability Against Laser Threats (Reference 1). This report is the documentation for a benchmark run of the ASALT Program which has been completed using data for a typical fighter aircraft. In order to assemble realistic data, the benchmark process utilized a sequence of several other computer programs also described in this report.

ASALT DESCRIPTION

The ASALT Program is used to evaluate the effectiveness of a high-energy laser against an aircraft. The laser weapon system is located in a fixed position and is described by a flux emission function, aiming errors caused by jitter, and slewing limits for the tracking mechanism. The target aircraft is comprised of components which are linked using fault tree structures. Each component is characterized by a set of presented areas which vary with different aspect angles, and a Pk function which increases with rising levels of accumulated irradiation. The aircraft flies a path with designated
"can engage" and "cannot engage" intervals determined by using the Engagement Model (Reference 2). The ASALT Program also has an atmospheric model used to determine the power degradation of the laser beam due to interaction with molecules in the air, or with an optional smoke corridor.

Damage to each component is dependent on the total amount of energy that can be expected to accumulate on the component. The probability of hitting a component is computed by determining the rectangular presented area of the component, computing the total standard deviations caused by aiming errors and jitter, and integrating a Gaussian probability density function, centered at the user-defined aim point, over the component presented area. The probability of hit multiplied by the time interval between program iterations results in the expected time duration that the laser beam center is focused on the component. The expected time multiplied by the attenuated beam power results in the amount of energy expected to reach the component during the time interval. The total energy reaching each component is summed over all time intervals to obtain the total expected energy on each component. The component Pk is then computed using the user-defined Pk functions with the total expected energy as the argument. Subgroup and total target Pk's are computed using the target fault tree description to determine the component interrelationships.
The ASALT Program line printer output includes a description of the input parameters, an optional time trace showing the total target Pk's at regular time intervals, and an end-of-run damage summary which contains the final Pk's for the components, subgroups, and the total target. The ASALT Program requires approximately $140,000_8$ (4915210) words of addressable memory (HP 3000 Computer), and makes use of two input files and two output files.

ASALT INPUT REQUIREMENTS

The ASALT Program requires two input files as shown in Figure 1-1, a Flight Path File and an ASALT Data Deck. A detailed description of both input files is given in Section III of the ASALT documentation (Reference 1). Sections II and III of this report are used to describe a sequence of several other computer programs which can be used to assist in assembling these data.

The tape symbol on the left side of Figure 1-1 represents the Flight Path File, which is a binary sequential file that contains data describing the aircraft position and attitude as it moves through the scenario. Each record in this file contains a flag used to indicate whether or not the aircraft may be engaged during that time step. The ASALT Program will not simulate laser firing unless the flag permits engagement. In this way such factors as clear line-of-sight or acquisition envelopes can directly affect the results
FIGURE 1-1. ASALT Input Requirements.

from the ASALT Program. Section II of this report is used to describe the techniques employed to generate the Flight Path File.

The card shaped box in Figure 1-1 represents the ASALT Data Deck which contains the values necessary to describe the laser weapon system, the target aircraft, and the atmosphere around the laser. Since some parameters in the ASALT Data Deck can be assembled only by users, this file is in an easily modified card image format. Section II of this report is used to describe the method for assembling these data.

REPORT ORGANIZATION

This report is used to document the procedure utilized for the ASALT benchmark run and serves as an example of an ASALT execution. Copies of several input and output files from the benchmark run described in this report are included.
in Appendix A. Section II, Flight Path File Assembly, contains a description of the method for creating the Flight Path File and is used to describe Figure A-1, a copy of the output from the Engagement Model run used in the benchmark procedure. The sequence used to assemble the ASALT Data Deck is described in Section III, ASALT Data Deck Assembly. Listings in the Appendix referenced in Section III include a copy of the final ASALT Data Deck used for the benchmark run as well as listings of other programs employed in the data deck assembly procedure. Section IV is used to describe a copy of the line printer output from the ASALT benchmark run and a discussion of that run. Appendix A also contains a copy of the source code for the VAMERGE Program which is the only undocumented program in the sequence utilized in this benchmark procedure. Following the appendix, is a page of references for the other programs used in the benchmark procedure.

Input files are described as being either binary tape files which consist of records, or card decks which consist of formatted cards. All of these input files are read sequentially. The distinction between tape files and card decks is used to emphasize whether files are read by executing unformatted or formatted READ statements, respectively. The words "card" and "tape" do not imply any specific device type restrictions.
STRENGTHS AND WEAKNESSES

The benchmark exercise revealed a few weak areas that were corrected with minor programming changes. These problems and their corrections follow:

1. The QKLOOK programs as documented in Reference 4 are limited to a maximum of 498 components in the aircraft model. This limit had to be increased to 1398 components for the fighter aircraft model used in this report. The procedure for increasing this limit is clearly outlined in Appendix B of the QKLOOK documentation (Reference 4).

2. The QKLOOK program, QKPK, could abort on some computers with a small word size, especially with a large target such as the F-18. By making the variables, TNOW and TUSED, double precision the problem can be prevented.

One of the strongest points of the ASALT benchmark procedure is that a fairly complex network of programs fit together very well. Only one final step requires manual modification of a file produced by one program before being used by the next. Other strong points are the readable line printer output from the programs, and the thorough set of documentation that exists for the programs used here.
SECTION II

FLIGHT PATH FILE ASSEMBLY

The Flight Path File contains data used to describe the position and attitude of the aircraft as it moves through the scenario. Each record on this file contains a flag which indicates whether or not the aircraft can be engaged. One way of generating this input file is to use the FLYGEN Program (Reference 3) to build a flight path and then use the ENGAGEMENT Model (Reference 2) to determine the engagement intervals. Figure 2-1 is used to depict the addition of these programs to the diagram depicted in Figure 1-1.

The Engagement Model is used to evaluate any combination of eight different engagement conditions which influence a ground weapon attempting to engage an aircraft. The eight engagement conditions are presented in Table 2-1. The engagement conditions selected by the user are specified in the formatted input for the Engagement Model, represented in Figure 2-1 by the card shaped box labeled "ENGAGEMENT CONDITIONS". The two tape symbols in Figure 2-1 represent the binary Flight Path File before and after the Engagement Model has been used to determine the intervals for engagement. The exact format and contents of both input files for the Engagement Model are presented in Section V of Reference 2.
The Engagement Model can use any flight path file in the proper format. Program FLYGEN produces a file in the correct format but almost any flight path generating program could be modified to perform this task. If a flight path
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<td>1. FIELD OF FIRE</td>
</tr>
<tr>
<td>This test compares the weapon-to-target azimuth angle with user specified limits. A 360-degree field of fire is allowed.</td>
</tr>
<tr>
<td>2. MINIMUM RANGE</td>
</tr>
<tr>
<td>The range from the weapon to the aircraft is compared with the minimum range specified by the user.</td>
</tr>
<tr>
<td>3. MAXIMUM RANGE</td>
</tr>
<tr>
<td>The range from the weapon to the aircraft is compared with the maximum range defined by the user.</td>
</tr>
<tr>
<td>4. ACQUISITION ENVELOPE</td>
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<tr>
<td>An acquisition envelope may be defined for the weapon in a tabular form. The table contains maximum acquisition ranges as a function of azimuth and elevation from the weapon location. The model is used to perform a double interpolation of values from the table and compare the interpolated maximum range with the weapon-to-aircraft range.</td>
</tr>
<tr>
<td>5. STATISTICAL TERRAIN PROBABILITY OF CLEAR LINE-OF-SIGHT</td>
</tr>
<tr>
<td>A probability of clear line-of-sight may be computed in one of two ways:</td>
</tr>
<tr>
<td>a. A probability of clear line-of-sight can be interpolated from values in a table containing probabilities as a function of range and altitude from the weapon location.</td>
</tr>
<tr>
<td>b. A table listing boundary ranges and altitudes as a function of azimuth may be used. In this method the weapon-to-target azimuth is used to interpolate the boundary range and altitude values from the table. The probability of clear line-of-sight is 1.0 if the actual range is less than the boundary range, or if the actual elevation is greater than the minimum elevation computed from the boundary range and altitude.</td>
</tr>
<tr>
<td>The probability of clear line-of-sight is compared with a user-specified minimum to determine when this engagement condition is satisfied.</td>
</tr>
<tr>
<td>6. DIGITAL TERRAIN CLEAR LINE-OF-SIGHT</td>
</tr>
<tr>
<td>A direct access input file containing terrain altitudes at a user-specified grid interval may be used to test for terrain masking. The weapon-to-target line-of-sight altitude is compared with the terrain altitude at every horizontal and vertical grid line intersection. A clear line-of-sight exists if the terrain altitude is less than the line-of-sight altitude at every intersection.</td>
</tr>
<tr>
<td>7. RADAR ACQUISITION AND COUNTERMEASURES</td>
</tr>
<tr>
<td>An acquisition radar for the ground weapon may be defined with radar parameters and a target radar cross section array which varies with azimuth and elevation look-angles. Additionally, jamming and/or chaff countermeasures may be employed to nullify the radar acquisition capability.</td>
</tr>
<tr>
<td>8. IR LOCK-ON</td>
</tr>
<tr>
<td>An IR lock-on range equation may be used to test the lock-on capabilities of such a device. This test allows the user to make use of a large set of atmospheric transmission factors derived by previous study, or to define a unique set of transmission factors.</td>
</tr>
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</table>
file which bypasses the Engagement Model is used as input for the ASALT Program the results will be based upon the assumption that the laser beam is able to engage the aircraft during the entire flight path.

The execution of the Engagement Model used for this benchmark is the same as part of the sample problem described in the ENGAGE documentation (Reference 2). Figure 2-2 is a contour map which shows the terrain for the scenario, the laser location, and the aircraft flight path. The solid lines on the flight path represent intervals during which the aircraft can be engaged and the dashed lines represent intervals during which the aircraft cannot be engaged by the laser weapon system. The line printer output for that execution of the Engagement Model is shown in Figure A-1.
FIGURE 2-2. Engaged Flight Path Intervals for ASALT Benchmark.
SECTION III
ASALT DATA DECK ASSEMBLY

The ASALT Data Deck contains the values necessary to describe the laser weapon system, the target aircraft, and the atmosphere around the laser. A major portion of this input is the set of cards used to specify the name, location, presented areas, and Pk functions for each aircraft component. A sequence of four steps which can be used to assemble this component information into the ASALT Data Deck is presented in Table 3-1. Figure 3-1 is used to show this sequence of steps added to the diagram from Figure 2-1. The sequence added in Figure 3-1 includes a shot line generating program such as FASTGEN (Reference 5), followed by several executions of the QKLOOK Programs (Reference 4), and finally the VAMERGE Program which is used to combine the QKLOOK output into the ASALT Data Deck. The dashed line between the VAMERGE PROGRAM box and the ASALT DATA DECK box in Figure 3-1 is used to indicate that the ASALT Data Deck must be completed manually by the user. This completion step includes specifying the laser weapon location and the aircraft fault tree structure. The next four subsections are used to discuss the four steps in assembling the ASALT Data Deck.
TABLE 3-1. Steps for Assembling the ASALT Data Deck

1. Generate target shot line descriptions at 13 views.
2. Generate target vulnerable area tables at 26 views.
3. Merge the 26 vulnerable area tables.
4. Manually complete the ASALT Data Deck

GENERATE TARGET SHOT LINE DESCRIPTIONS AT 13 VIEWS

The QKLOOK Programs require a target shot line description as input. The format and contents of this file are described in Section V of the QKLOOK documentation (Reference 4) under the subheading, QKPK Binary Input File. Figure 3-1 depicts this file as the output from the FASTGEN Program (Reference 5). Other possibilities for this step include Program SHOTGEN or Program MAGIC (Reference 6) followed by Program CONMAG from the QKLOOK set of programs. The final ASALT Data Deck requires data from 26 aspect angles around the aircraft but the reverse option in the QKLOOK Programs can be used so that shot line descriptions at only 13 views are required for this step.

GENERATE TARGET VULNERABLE AREAS AT 26 VIEWS

This is the longest step in preparing input data for an ASALT run because it involves the repeated execution of the QKLOOK Programs. These programs are used to evaluate the vulnerability of a target to high-energy laser irradiation at one constant aspect angle. Before this step could be started
FIGURE 3-1. ASALT Data Deck Assembly
for the fighter aircraft model used in this benchmark problem, two changes were required in the QKLOOK Programs: the maximum number of components was increased from 498 to 1398 using the code changes outlined in Appendix B of the QKLOOK documentation (Reference 4), and Program PEAKAY was modified so that PEAKAY Binary Output FILE 3 was kept separately from the other output files which were not needed.

The QKLOOK Programs require as input, a formatted data deck which contains the component characteristics for the target aircraft, and a binary target shot line description file. The card shaped box in Figure 3-1 labeled "COMPONENT CHARACTERISTICS" represents the QKLOOK formatted input deck. A copy of this input file for the benchmark problem is presented in Figure A-2. Since the component characteristics do not change with different aspect angles, the same input deck is used for the different views for each execution of the QKLOOK Programs. The QKLOOK Program, PRERD, should be executed once to check for possible errors in the QKLOOK formatted input deck. The binary shot line description files are the 13 files produced by executing the FASTGEN Program in the preceding step. Notice that QKLOOK Program, CONMAG, is not needed in this case because the shot lines files from FASTGEN are in the proper format for QKLOOK. Each target shot line file is used twice as QKLOOK input, once without the reverse flag set as shown in Figure A-2, and once with
the reverse flag set on Card QK2. Since each of the 13 target shot line files is used twice as input for QKLOOK Program, QKPK, a total of 26 target vulnerable area files are produced.

Only data for critical components are contained in the vulnerable area files even though the entire target model is considered when computing the burn-through times. Therefore the vulnerable areas for the critical components are numbers which reflect the shielding effects of all other components. The ASALT Program does not need to handle the large complete target model but rather only the smaller set of critical components.

An alternative in this step is that the vulnerable areas for the systems of components computed by the QKLOOK Program PEAKAY and written on PEAKAY Binary Output, File 4, could be used for the vulnerable area files. This alternative would require some changes in Program VAMERGE and provide a different level of answers in the ASALT output.

MERGE THE 26 VULNERABLE AREA TABLES

Program VAMERGE was written for the benchmark procedure due to the need for a method to quickly and accurately combine the data from several QKLOOK runs. Appendix A of this manual contains a copy of the VAMERGE source code (Figure A-7). The current version of this program requires 31 different input files. The input files read from Logical Units #1,
#2, and #3 are three target shot line files from Program FASTGEN at three orthogonal views, and are used in Subroutine GETXYZ to determine the locations of the critical components in the Aircraft Coordinate System. The number of critical components is read from Logical #5. This value is necessary to properly read the target vulnerable area files as well as the component name file, and can easily be found in the output from the QKLOOK Program PEAKAY. The input file read from Logical Unit #7 is used in Subroutine NAMES to assign an eight character name for each critical component. The 26 target vulnerable area files from the QKLOOK run are read from Logical Units #11 through #36.

Two output files are produced by executing the VAMERGE Program. A lot of useful information is presented in the standard line printer output from Logical Unit #6. The output file that can be modified to be used as the ASALT Data Deck is written on Logical Unit #4. Figure A-3 is a copy of the VAMERGE output written on Logical Unit #6 for the benchmark problem. The first 52 pages of Figure A-3 are an echo of the vulnerable areas at each of the 26 views computed by executing the QKLOOK programs.

Pages 53 and 54 of Figure A-3 contain the coordinates of the critical components in the Aircraft Coordinate System as computed in Subroutine GETXYZ. Note that components with coordinate values of .00 and the value "0" in the sample
column are components not intersected in any of the three shot line files. The user must manually provide accurate coordinates for those components before running ASALT.

Pages 55 through 69 of Figure A-3 contain the values for the component presented areas and widths at the 26 look-angles in a readable form. These values were read from the 26 target vulnerable area files in square feet and feet and converted to square meters and meters before being printed during execution of the VAMERGE program. The last two pages, 70 and 71, of Figure A-3 contain the component Pk functions computed during execution of Program VAMERGE. The component Pk functions were computed by dividing the vulnerable area at each time increment by the presented area from the target vulnerable area files, and averaging the Pk's computed at each of the 26 views. The output shown in Figure A-3 is intended to be readable and useful to analysts. The same values are written in the format required for the ASALT Data Deck on Logical Unit #4. Figure A-4 is a copy of this output which requires a few changes before it can be used as the ASALT Data Deck.

MANUALLY COMPLETE THE ASALT DATA DECK

The final step required before running the ASALT Program is to finish the ASALT Data Deck. Most of this file has been completed by executing Program VAMERGE. Figure A-5 is a copy of the final corrected ASALT Data Deck. One method of doing
this task is to look at the ASALT Data Deck Setup in Figure 3-1 of Reference 1 and the card description forms in Section III of Reference 1 to verify the validity of the values provided by the VAMERGE program. Normally, Card Types 3, 4, 5, 13, 14, and 15 are correct. The rest of the cards must reflect values the user wants in the scenario. The weapon location and coordinate system reference point on Card 2 should be copied from the Engagement Model output (see Figure A-1). Any components with invalid coordinates on Cards 13 can be found by scanning the critical component coordinates in the VAMERGE line printer output (see Figure A-3). For some of the other cards, reasonable values are provided by the VAMERGE Program and may not require changes. The last several cards required in the ASALT Data Deck are Card Type 17, and are used to define the aircraft fault tree structures. These cards must be added by the user as indicated by the note printed at the end of the VAMERGE output in Figure A-4. Table 3-1 of Reference 1 contains a set of helpful rules for assembling the fault tree descriptions.
SECTION IV
ASALT BENCHMARK RUN

After the Flight Path File has been built as described in Section II, and the ASALT Data Deck assembled as described in Section III, the ASALT Program can be executed. The Flight Path File is read from Logical Unit #10 and the ASALT Data Deck is read from Logical Unit #5. Figure A-5 is a copy of the ASALT Data Deck used for the benchmark run. The ASALT line printer output from the benchmark run is shown in Figure A-6. Section IV in the ASALT Documentation (Reference 1) contains a description of this output.

Aircraft fault trees were defined for two kill categories, K-KILL and M ABORT for the benchmark run. The K-KILL fault tree consists of a few subgroups with redundant components with the majority of the fault tree containing singly vulnerable components. For the M ABORT fault tree, the aircraft model consists of all critical components in one singly vulnerable arrangement. Pages 3 through 15 of Figure A-6 contain these fault tree diagrams. Seven aim points are used in the benchmark run with each aim point designated to be near a particular set of components. Aim points 5 and 6 are associated with the highest Pk values in this benchmark run.

Users can spend a substantial amount of time and effort in preparing for one ASALT run. However, after the initial
set of input is assembled, a lot of variables can be evaluated without repeating the complete procedure again. For example, different aircraft fault tree structures can be compared by simply rerunning the ASALT Program with the modified fault tree input. A new set of engagement conditions can easily be specified for another execution of the Engagement Model, providing a different scenario for analysis by running ASALT. Different aim points are easily specified in the ASALT Data Deck, and may reveal more sensitive spots in the aircraft design. All of these can be evaluated with small changes to the input files and rerunning only one or two programs in the sequence.
APPENDIX A

COMPUTER PRINTOUTS

In order to provide continuity in the documentation of the ASALT benchmark, copies of all referenced computer printouts are presented in this appendix. Each printout is identified by a distinct figure number and is preceded by a short paragraph used to describe its contents and length. The seven figures in this appendix are:

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<td>Line Printer Output for ASALT Benchmark</td>
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<td>A-7</td>
<td>VAMERGE Source Code</td>
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Figure A-1. Engagement Model Output for ASALT Benchmark

This figure consists of six pages (A-3 through A-8) and is a copy of the output from the Engagement Model Computer Program. The values for the flight path coordinates and the "can" or "cannot" engage status associated with each point are used in another format, as input for the ASALT Program.
**Flight Main File: Airplane: B-17, Weapon-20mm, Flight Angle = 15 degrees, Track Time = 50 seconds.**

**Aircraft Characteristics:**
- **Location:**
- **Range:**
- **Flare:**
- **Fuel:**

**Acquisition Envelope:**
- **Arrival:**
- **Departure:**
- **Left to Right:**

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**Radar Minimum Signal-To-Noise Ratio for Detection:**
- **Signal-to-Noise Ratio:**
- **Equation:**
- **Constant:**

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<td>100 dB</td>
<td>.79695E+15</td>
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**Radar Gain:**
- **Gain:**
- **Effective:**
- **Gain:**

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- **Cross Section:**

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**In-Lockout Minimum Signal-To-Noise Ratio:**
- **Ratio:**
- **Sensitivity:**

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- **Factors:**

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**Target Characteristics:**
- **Closest Approach:**
- **Probability:**

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**Clean Flight Characteristics:**
- **Flight Angle:**
- **Probability:**

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Figure A-2. QKLOOK Formatted Input for ASALT Benchmark

The data on the 23 pages (A-10 through A-32) of this figure must be assembled manually. They consist primarily of component characteristics for the aircraft model, and are used as input for Program QKP from the set of QKLOOK Programs.
Figure A-3. VAMERGE Line Printer Output for ASALT Benchmark

There are 71 pages (A-34 through A-104) in this copy of line printer output from the execution of Program VAMERGE for the ASALT Benchmark.
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The presented areas are the component vulnerable areas (swage feet) per time increment.
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**PRESENTED AREAS AND TRUE COMPONENT VULNERABLE AREAS (SQUARE FEET) PER TIME INCREMENT**

**TIME (SEC.)** **FLUX (W/SQ. CM.)**

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- **TIME INCREMENTS**
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**Index 3**
Figure A-4. VAMERGE Output for ASALT Data Deck

These ten pages (A-106 through A-115) are a copy of the output written on Logical Unit #4 by executing Program VAMERGE. It represents the computer generated portion of the ASALT Data Deck which requires a few manual modifications before it can be used as input for the ASALT Program.
Figure A-5. Final ASALT Data Deck for Benchmark

These ten pages (A-117 through A-126) are a copy of the final ASALT Data Deck used for the benchmark run. Most of the data is the output from Program VAMERGE, but the pages also include several additional items required as input for the ASALT Program.
Figure A-6. Line Printer Output for ASALT Benchmark

These 20 pages (A-128 through A-147) are a copy of the line printer output generated during execution of Program ASALT using the input data assembled for the benchmark run.
**AIRCRAFT FLIGHT PATHS**

**FLIGHT PATH FILE**

**SAMPLE FLIGHT PATH FILE FOR ASSESSMENT CALCULATION**

**TRANSFORMATION**

\[(x', y', z') = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 40 & 0 & 0 \end{pmatrix} \] **IN FLIGHT PATH COORDINATE SYSTEM IS EQUAL TO**

\[(x, y, z) = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} **IN GENERAL COORDINATE SYSTEM WITH 0 DEGREES ROLL, TUM, ANGLE**

**LASER EMITTED LOCATION**

**DENOTES**

\[(x, y, z) = \begin{pmatrix} -150,000 \\ 700,000 \\ 2952 \end{pmatrix} **IN FLIGHT PATH COORDINATE SYSTEM DUE TO JITTER SIGMA** = 0.04 MILES SIGMA = 0.5 MILES

**FLUX EMISSION IN KILOWATTS/ST.CK.** 10.00

**AT TIMES 10 SECONDS**

**TRACKING**

**MAXIMUM SLEW RATES IN DEGREES PER SECOND**

AZIMUTH = 65.00 ELEVATION = 10.00

**MINIMUM TRACKING TIME** = 1.00 SECONDS

**ATMOSPHERE**

**ATTENUATION FACTORS 1,000**

\[ \text{AT DANGES (METERS):} 10,000, 20,000, 40,000, 60,000, 80,000, 100,000, 150,000, 200,000 \]

**SMOKE ATTENUATION**

\[ \text{FROM COORDINATES} (0, 0) \text{TO} (5000, 0) \text{IN THE X-PLANE} \]

**ATTENUATION FACTORS**

\[ \text{THROUGH SMOKE} = 10,000 \]

**AIRCRAFT CUMULATIVES**

<table>
<thead>
<tr>
<th>LOCATION IN AIRCRAFT (C.S.)</th>
<th>DAMAGE ENERGY LEVELS IN KILOJOULES/ST.CK.</th>
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**ASSessed: IF SURVIVABILITY AGAINST LASER TREAT**
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Figure A-7. VAMERGE Source Code

These 11 pages (A-149 through A-159) contain a copy of the source code for program VAMERGE which is the only undocumented program used in the ASALT benchmark sequence.
PROGRAM VAMERGE

*** PROGRAM VAMERGE IS USED TO READ THE VULNERABLE AREA FILES
*** CREATED BY GALLOK PROGRAM REASAY, AVERAGE THE COMPONENT PA'S,
*** AND PRINT THEM IN THE ASALT INPUT FORMAT (LOGICAL UNIT 4) AS
*** WELL AS IN READABLE FORM ON THE LINE PRINTER (LOGICAL UNIT, 6)

1/5 LOGICAL UNIT TABLE FOR PROGRAM VAMERGE
FORTRAN LOGICAL UNIT NUMBER

1, 2, 3

TARGET SHOT LINE DESCRIPTIONS
FOR THE FRONT, LEFT, AND
BUTT OF VIEWS

4

FILL TO BE USED FOR ASALT INPUT

5

INPUT FOR VAMERGE, NUMBER OF
CRITICAL COMPONENTS IN GALLOOK
FILES

6

READABLE LINE PRINTER FILE
PRINTED BY EXECUTING VAMERGE

7

COMPONENT NAME FILE (OPTIONAL)

8, 9, 10

NOT USED

11 THROUGH 36

2nd VULNERABLE AREA FILES FROM
GALLOOK PROGRAM REASAY

DIMENSION F1M(25), FICX(25), TIMES(10), ENERGY(10)
DIMENSION F1M2(25), FICM2(25), TIMES2(10)
DIMENSION ICOMP(100), PARA(100), COMPA(100,10)
DIMENSION CLMP(3,100), AP(100,20), WIDTH(100,20), PK(10,100)
CHARACTER*8 NAME(100), BLANK
CHARACTER*7 YOR(2)
DATA YOR/*NO */ "YES */
DATA AP/2600=1.0/ PK/100=0.0/
DATA ENERGY/10=0.0/ DATA COMP/300=0.0/
DATA BLANK/"

ASALT CARD 1 = TCEL1, IPRINT, LINLIN

WHITE (0,0,0) 0.5, 2, 6.0

ASALT CARD 2 = WEAPON LOCATION, AND C.S. REFERENCE

WHITE (0,0,0) (0,0, 141,9)

IIN = 11
READ (5,110) MCRT

READ THE FIRST VULNERABLE AREA FILE FROM LOGICAL UNIT 11

READ (11,ENDB=900) AZ,EL,IFXX,(FT1+1),IFXX+1),IFXX+2),RVHS,
1

NCOMP, NTIME, (TIMES(I), I=1, NTIME)

INVS = RNU * 1.

WRITE (6,111) (TIME(I), I=1, NTIME), NCOMP, NCRIT,

IWRITE (6,112) (TIMES(I), I=1, NTIME)

C***

C*** WRITE LASER FLUX EMISSION RATES, ASALT CARDS 3, 4, AND 5

C***

WRITE (4,101) IFMAX, 1
WRITE (4,102) (FXCM(I), I = 1, IFMAX)
FTIM(IFMAX) = 1.0 + 30
WRITE (4,102) (FTIM(I), I = 1, IFMAX)

C*** ASALT CARDS 6 AND 7 -- JITTER AND TRACKING

C***

WRITE (4,102) 1.0, 1.0
WRITE (4,102) W0, 45., 0.

C*** ASALT CARDS 8 AND 9 -- ATMOSPHERIC ATTENUATION

C***

WRITE (4,102) 1.0
WRITE (4,102) 1.0 + 30

C*** ASALT CARD 10 -- NO SMOKE CORRIDOR

C***

WRITE (4,12)

C*** ASALT CARD 11 -- NUMBER OF COMPONENTS AND AIR POINTS

C***

WRITE (4,101) NCRIT, 1

C*** ASALT CARD 12 -- ENERGY ARGUMENTS, compute using FXCM and

FTIM ARRAYS FROM ORNLOCK FILE

C***

ENERGY(I) = 0.0
LIM = NTIME
IF (NTIME,E6, 10) LIM = 9
DO 20 I = 1, LIM
TI = 0.0
FLUX = 0.0
DO 15 J = 1, IFMAX
IF (FTIM(J) .GE. TIMES(I)) GC TO 16
DELT = FTIM(J) - TI
FLUX = FLUX + (FXCM(J) * DELT)
TI = FTIM(J)
CONTINUE
15 J = J + IFMAX
16 DELT = TIMES(I) - TI
FLUX = FLUX + (FXCM(J) * DELT)

C***

C *** CONVERT FROM JOULES/3G,CP, TO KILJOULES/3G,CP.

C***

ENERGY(I+1) = FLUX = 0.001
20 CONTINUE
LIM = LIM + 1
IWRITE (4,102) (ENERGY(I), I = 1, LIM)
HEADING COMPONENT NAMES IF PROVIDED, AND CONVERT TO DEGREES TO

ASALT INDEX

CALL NAMES(NAME, ACRT, HLA)=

CALL ASPECT(AZ, EL, ILOOK)

REAL PRESENTED AND VULNERABLE AREAS FOR EACH CRITICAL COMPONENT

DU 200 J = 1,ACRT

HEAD(I,J,ENDCOMP) ICOMP(J),PAREA(J),C(COMP(J,J),KE1,NTIME)

IF (NAME(J) = '0', BLANK) WRITE (NAME(J), 195) ICOMP(J)

195 FORMAT (A,COMP,J)

WRITE (NAME(J),ICOMP(J),PAREA(J),COMP(J,J),KE1,NTIME)

CONTINUE

USE THE PRESENTED AND VULNERABLE AREAS IN SQ, FEET

TO COMPUTE PRESENTED AREA AND WIDTH IN SQ, METERS

ASSUME SQUARE PRESENTED AREA

DU 280 J = 1,ACRT

AP(J,ILOOK) = PAREA(J) / 0.029030

WIDTH(J,ILOOK) = SQRT (AP(J,ILOOK))

PK(J,J) = 0.0

IF (PAREA(J) < .01, 1,0.05) GC TO 280

SUM PK'S OVER ALL VIEWS

DU 280 I = 2,1

PK(J,J) = PK(J,J) + COMP(A,J,J) / PAREA(J)

CONTINUE

HEAD NEXT VULNERABLE AREA FILE FROM LOGICAL UNIT 11N

IIH = IIIH + 1

IF (IIA, GRT, 36) GC TO 900

HEAD(III,END=GO) AZ, EL, ICOMP2, (FTIMZ(I), FXCM2(I), IM1, IFMAX2), RVRS, 0.049000

NGCOMP1, NCOMP2, ACRT, NCR1, NCR2

WRITE (NAME(J),IIH=10), AZ, EL, YRN(1, RVRS), NCOMP2, NCR1, ACRT

WRITE (1,1) (FTIMZ(I), FXCM2(I), IM1, IFMAX2)

WRITE (NAME(J),11H=10), AZ, EL, TIMES(I)

CONTINUE

TEST TO BE SURE NEW VA DATA FILE IS COMPATIBLE

FTIMZ(IFMAX2) = 1,0.0

IF (IFMAX2 NE, IFMAX1) GC TO 950

IF (NGCOMP1 NE, NCOMP2) GC TO 950

IF (ACRT NE, NCR2) GC TO 950

DO 300 I = 1,1,IFMAX2

IF (FTIMZ(I) NE, FTIMZ(I)) .GR., FXCM1(I), NE, FXCM1(I)) GC TO 950

CONTINUE

DO 320 I = 1,NTIME

IF (TIMES(I) NE, TIMES(I)) GC TO 950

CONTINUE
ALL TESTS OK, READY ITS VULNERABLE AREAS AS DONE FOR PRECEDING FILE.

GO TO 190

AVERAGE THE PK'S FROM ALL 26 VIEWS

DO 400 J = 2, 26
   DO 410 I = 1, NCRTIT
     PK(I, J) = PK(I, J) / 26.0
   410 CONTINUE

DETERMINE THE COMPONENT CENTRIP LOCATIONS

CALL GETXY(IICUMP, COMP, NCRTIT, NAME)
WRITE (6, 121)

ASALT CARDS 13, 14, AND 15 FOR EACH CRITICAL COMPONENT

DO 450 I = 1, NCRTIT
   WRITE (6, 100) NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
   WRITE (6, 102) (AP(I, J), WIDTH(I, J), J = 1, 26)
   WRITE (6, 122) I, NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
   WRITE (6, 126) I, NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
   WRITE (6, 127) I, NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
   WRITE (6, 125) STOP

PRINT COMPONENT PK FUNCTION ON THE LINE PRINTER TOO

WRITE (6, 123) I, NAME(I), (PK(I, J), J = 1, 26)
WRITE (6, 128) I, NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
WRITE (6, 126) I, NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
WRITE (6, 127) I, NAME(I), ICOMP(I), (PK(I, J), J = 1, 26)
WRITE (6, 125) STOP

ALL DONE -- FORMAT 125 IS A REPEATER TO FINISH THE ASALT INPUT

WRITE (6, 125) STOP

FATAL ERRORS DETECTED

STOP

WRITE (6, 126) I, NAME(I), STOP

STOP

WRITE (6, 127) I, NAME(I), STOP

STOP

FORMATS

101 FORMAT (10I6)
102 FORMAT (106I6)
103 FORMAT (66I6)
104 FORMAT (I6)
111 FORMAT (200I15, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0)
200I7, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0)
200I15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0)
112 FORMAT (NO, 4X, 4X, PRESENTED AREAS AND THEIR COMPONENT VULNERABLE, 00284100)
  N 39H AREAS (SQUARE FEET) PER TIME INCREMENT / 00284100
  35HC ++ COMPONENT ++ PRESENTED, 39H, 00286000
  35H TIME INCREMENTS / 00286000
  35H INDEX NAME NUMBER AREAS, 7X, 10F4.2) 00286000
113 FORMAT (1X, 14, 3X, 10, 16, F13.5, 2X, 10F9.6) 00284000
121 FORMAT (1H1) 00284000
122 FORMAT (22H0 + COMPONENT ++ / 22H INDEX NAME NUMBER, 00231000
  3(37H LOOKING PRESENTED AREA WIDTH )/ 00232000
  3X, 13, 3X, 10, 16, 1X, 00233000
  3(5X) 32HINDEX (SO, PETERS) (PETERS) )/ 00234000
  19X, 3(112, 1X, 2F12.2 ) ) 00235000
123 FORMAT (1H1) 1X, 34H + COMPONENT PK, 00236000
  45FUNCTIONS FOR ASALT ++ / 00237000
  45X, 43-DAMAGING ENERGY LEVELS IN KILOJOULES/50.CM. / 00238000
  3X, 24H + COMPONENT ++ 1, 7X, 9F8.2 / 00239000
  3X, 26HINDEX NAME NUMBER 1, 7G(1X=) 00240000
124 FORMAT (1X, 15, 3X, 10, 16, 4H 1, 10(F7.2,1X)) 00241000
125 FORMAT (25H ALL DONE = ADD THE AIR POINTS AND FALLT THEE) 00242000
126 FORMAT (23H UNEXPECTED EOF = LINE, 13, 11H COMPONENT=, 13) 00243000
127 FORMAT (31H VS FILE DOES NOT MATCH -- LINE, 13) 00244000
END 00245000
SUBROUTINE ASPTJAL(AZ, EL, ILUGA)

CONVERT FASTGEN LOCUR AZIMUTH AND LOCUG ELEVATION TO THE
SAME INDEX FOR THE SAME LOCUG ANGLES.

FASTGEN  ASALT
AZ EL AZ EL IDX
180. 0.03 45. 0. 4
225. 45. 0. 45. 4 5
270. 45. 0. 45. 4 6
315. 45. 0. 45. 4 7
180. 0. 45. 0. 4 8
225. 0. 45. 0. 4 9
270. 0. 45. 0. 4 10
315. 0. 45. 0. 4 11
0. 135. 0. 45. 12
45. 0. 135. 0. 13
90. 270. 0. 45. 14
135. 315. 0. 45. 15
180. 0. 0. 45. 16
225. 0. 0. 45. 17
270. 0. 0. 45. 18
315. 0. 0. 45. 19
0. 45. 135. 0. 20
45. 45. 135. 0. 21
90. 225. 0. 45. 22
135. 270. 0. 45. 23
180. 315. 0. 45. 24
225. 0. 135. 0. 25
180. 0. 135. 0. 26

ILUGA = 0
IF (ABS(EL-90.), LE, 1.E-05) ILLUGA = 26
IF (ABS(EL+90.), LE, 1.E-05) ILLUGA = 1
IF (ILUGA = 61) O RETURN

WHICH ELEVATION?

CHK = 45.
DU 10 1 = 0.2
IF (ABS(EL=CHK), LE, 1.E-05) GO TO 12
CHK = CHK + 45.
CONTINUE
GL TO 900

WHICH AZIMUTH?

12 142 = a
IF (AZ, LT, 180.,) GO TO 20
142 = 0
AZ = 2 = 180.
142 = 0
CHK = 0.0
DC 30 J = 1.4
IF (ABS(A-Z-CHR.) .LE. 1.E-05) GO TO 32
CHR = CHR + 45.
30 CONTINUE
GO TO 900

C*** THE INDEX IS ***
C***
32 ILOOK = I08 + 1 + IA2 + J
RETURN

C*** ENNH
C***
900 WRITE (8,901) A2, EL
901 FORMAT (' *** ERROR *** CANNOT CLASSIFY LOCANNULES A2, EL',/
* 15X, 2F10,2)
CALL EXIT
STOP
END
SUBROUTINE FINDCOMP(IPT, IC, ICNK)
DIMENSION ICNK(100)
C
C ** SEARCH FOR COMPONENT NUMBER, IC, IN ARRAY ICNK WHICH CONTAINS
C MEKTK COMPONENT NUMBERS. RETURN THE ARRAY POSITION IN IPT OR
C THE VALUE 0 IF THE COMPONENT IS NOT THERE.
C
IPT = 0
DO 100 J = 1,ICNK
IF (ICNK(J)) .EQ. IC GO TO 110
100 CONTINUE
RETURN
110 IPT = 1
RETURN
END
SUBROUTINE GETOYZ(IComp, CName, NAME)
DIMENSION ICOMP(100), CNAME(3,100)
CHARACTER NAME(100)
DIMENSION SM(2,170), JM(5,170), AZY(3), ELV(3)
DIMENSION X(100), Y(100), Z(100)
DIMENSION NX(100), NY(100), NZ(100)

C***
DATA AZV/0.0, 90.0, 90.0, ELV/0.0, 0.0, -90.0/
DATA X/100=10.0, Y/0.0, Z/100=1.0/
DATA NX/100=0.0, NY/100=0.0, NZ/10=1.0/

C***
READ THE FRONT, LEFT SIDE, AND BOTTOM LINE OF SIGHT SHOT LINE
OF EACH CRITICAL COMPONENT
C***
ILOS = 1
10 READ (ILOS) AZ, EL
IF (AZ .EQ. AZV(ILOS)) GO TO 20
WRITE (6,11) ILOS, AZ, EL
11 FORMAT (1MU, '***ERROR*** INCORRECT LOS FILE FOR VIEW', 13,
+ 'AZ=', 'FB.1, ' EL=', 'FB.1)
CALL EXIT

C***
20 READ (ILOS, END=150) (S(M(1,J), J=1,170)
UU 100 J = 1,170

C***
END OF VIEW?
C***
IF (JMH(2,J) .EQ. 0) GO TO 150
SY = SH(1,J)
SZ = SH(2,J)
IC = JM(2,J)
CALL FINCCOMP(IPT, ICOMP, IC, NAME)
C***
IPT0 FOR NONCRITICAL COMPONENTS (NOT IN ARAY ICOMP)
C***
10 (IPT, EQ. 0) GC TO 160
C***
STORE SHOT LINE COORDINATES -- DEPENDENT ON THE CURRENT VIEW
C***
GO TO (50, 60, 70), ILOS
C***
FRONT VIEW -- COORDINATES ARE Y AND Z AIRCRAFT COORDINATES
C***
50 Y(IPT) = Y(IPT) + SY
NY(1,T) = NY(IPT) + 1
Z(IPT) = Z(IPT) + SZ
NZ(IPT) = NZ(IPT) + 1
GO TO 100
C***
SIDE VIEW -- COORDINATES ARE X AND Z AIRCRAFT COORDINATES
C***
60 X(IPT) = X(IPT) + SX
NX(IPT) = NX(IPT) + 1
Z(IPT) = Z(IPT) + SZ
GO TO 160

\[ \text{AZ(IPT)} = \text{AZ(IPT)} + 1 \]

\[ \text{GO TO 160} \]

**CASE**

**BOTTOM VIEW**

**COORDINATES ARE \( X \) AND \( Y \) AIRCRAFT COORDINATES**

\[ X(IPT) = X(IPT) + 5 \]

\[ Y(IPT) = Y(IPT) + 1 \]

\[ \text{GO TO 20} \]

**CASE**

**END OF VIEW**

**CASE**

\[ \text{ILOS} = \text{ILCS} + 1 \]

**IF** \((\text{ILOS} \leq 3) \text{ GO TO 10} \)

**CASE**

**COMPUTE COMPONENT LOCATIONS IN THE ASSAY AIRCRAFT COORDINATE SYSTEM, USE THE AVERAGE OF THE SHOT LINE COORDINATES THAT INTERSECTED THEM IN THESE THREE VIEWS**

**CASE**

**ALSO CONVERT COORDINATES FROM INCHES TO METERS**

**WRITE** \((6,301)\) **NCRIT**

**DO** 300 \(I = 1, NCRIT \)

**IF** \((\text{AZ}(I), \text{NE}, 0) \text{ COMP}(1,I) = X(I) / \text{FLOAT}(\text{AX}(I)) + 0.0254 \)

**IF** \((\text{NY}(I), \text{NE}, 0) \text{ COMP}(2,I) = Y(I) / \text{FLOAT}(\text{AY}(I)) + 0.0254 \)

**WRITE** \((6,302)\) **NAME(1),ICOMP(I),COMP(1,I),AZ(1),COMP(2,I),NY(1),COMP(3,I),NZ(1),**

**STOP**

**FORMAT** \((1X,14, 3X, 1S, 1X, 1X, 1X, 1X, 3F12.2, 17, 2X)\)

**RETURN**

**END**
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