IN-18
4783
P-206

NASA
Technical
Memorandum

NASA TM - 108452

VULNERABILITY OF MANNED SPACECRAFT TO CREW LOSS FROM ORBITAL DEBRIS PENETRATION

By J.E. Williamsen

Structures and Dynamics Laboratory
Science and Engineering Directorate

April 1994

NASA
National Aeronautics and
Space Administration
George C. Marshall Space Flight Center

MSFC - Form 3190 (Rev. May 1983)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
April 1994

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Vulnerability of Manned Spacecraft to Crew Loss From Orbital Debris Penetration

5. FUNDING NUMBERS

6. AUTHOR(S)
J.E. Williamsen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM - 108452

11. SUPPLEMENTARY NOTES
Prepared by Structures and Dynamics Laboratory, Science and Engineering Directorate.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified—Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Orbital debris growth threatens the survival of spacecraft systems from impact-induced failures. Whereas the probability of debris impact and spacecraft penetration may currently be calculated, another parameter of great interest to safety engineers is the probability that debris penetration will cause actual spacecraft or crew loss. Quantifying the likelihood of crew loss following a penetration allows spacecraft designers to identify those design features and crew operational protocols that offer the highest improvement in crew safety for available resources.

Within this study, a Manned Spacecraft Crew Survivability (MSCSurv) computer model is developed that quantifies the conditional probability of losing one or more crew members, $P_{loss/pen}$, following the remote likelihood of an orbital debris penetration into an eight module space station. Contributions to $P_{loss/pen}$ are quantified from three significant penetration-induced hazards: pressure wall rupture (explosive decompression), fragment-induced injury and "slow" depressurization. Sensitivity analyses are performed using alternate assumptions for hazard-generating functions, crew vulnerability thresholds, and selected spacecraft design and crew operations parameters. These results are then used to recommend modifications to the spacecraft design and expected crew operations that quantitatively increase crew safety from orbital debris impacts.

14. SUBJECT TERMS
orbital debris, vulnerability, system survivability, manned spacecraft, astronaut safety, spacecraft safety, Monte Carlo analysis

15. NUMBER OF PAGES
231

16. PRICE CODE
NTIS

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

LIST OF TA

TECHNICAL MEMORANDUM

VULNERABILITY OF MANNED SPACECRAFT TO CREW LOSS FROM ORBITAL DEBRIS PENETRATION

I. INTRODUCTION

A. Background

For much of its history, the National Aeronautics and Space Administration (NASA) has employed a qualitative approach utilizing failure modes and effects analysis (FMEA) as the principal building block of their risk analysis program. One area of exception has been the design of spacecraft meteoroid protection systems. Since the 1960's, NASA managers have established a strong structural design requirement for preventing meteoroid penetration into inhabited spacecraft. Since the meteoroid environment was considered to be well understood, this requirement was probabilistic in nature. For example, the structural design requirement for space shuttle cabin walls and windows was a 0.95 probability of no penetration by a meteoroid in 500 "typical" missions.

Inherent to the establishment of this type of requirement was the conservative assumption that any penetration of these small manned volumes would cause a loss of the spacecraft and its crew. Thus, the probability of crew loss from meteoroid impact was considered roughly equal to the probability of spacecraft penetration, and a meteoroid "safety" analysis amounted to a structural and statistical analysis of the probability of no penetration. In general, these "probabilistic" meteoroid protection requirements were easy to meet, since the probability of impact by meteoroids on a small, short-lived spacecraft was very low.

In the late 1970's, NASA began to detect a new threat to manned space operations in the form of impact with orbital debris—small particles from the breakup of satellites in low Earth orbit (LEO). Recognizing this threat, NASA space station managers included orbital debris when formulating meteoroid penetration protection requirements for initial space station elements. However, because of the proliferation of orbital debris (space junk) in LEO, danger of spacecraft collision with orbital debris particles now far surpasses the danger from meteoroids. It is a serious, growing threat to the survivability of human operations in an Earth-orbiting space station over its long (as much as 30 years) design life.

B. Research Statement

The sudden and dramatic growth of orbital debris in LEO places many spacecraft designers in a difficult position. Resource (time, cost, and weight) constraints on the design and placement of manned spacecraft in orbit are often critical. There is an obvious limit to the amount of initial orbital debris shielding that can be offered to human inhabitants of a space station module. The preliminary (conservative) assumption that loss of a spacecraft "always" occurs following a meteoroid/orbital debris penetration drives the spacecraft designer to choose shielding designs that may be over-designed for preventing actual catastrophic failure (crew or spacecraft loss).

However, today's large manned spacecraft, such as Space Station *Freedom* (S.S. *Freedom*), are being designed as compartmented vehicles consisting of separated manned modules, with heavy internal structure, connected by independent hatches. This construction challenges the assumption of "automatic" spacecraft (or crew) loss given a penetration. In reality, the probability of spacecraft or crew loss from meteoroid/debris (M/D) penetration is not only due to the probability of penetration, but also depends upon the magnitude and internal effects of that penetration. It can be thought of as the product of (1) the probability of penetration and (2) the conditional probability that this penetration causes a loss of the spacecraft or crew, as suggested by the second term of the following equation:

$$P \text{ [spacecraft or crew loss due to M/D penetration]} = P \text{ [penetration]} \times P \text{ [loss/penetration]} \ ,$$

or,

$$P_{\text{M/D loss}} = P_{\text{pen}} \times P_{\text{loss/pen}} \ . \tag{1}$$

One can further define station or crew "safety" as:

$$\text{“Safety”} = 1 - P_{\text{M/D loss}} \ . \tag{2}$$

To restate, the second term on the right side of equation (1), $P_{\text{loss/pen}}$, was conservatively assumed to be equal to unity for small spacecraft. However, this term can be quantified through additional analyses of actual penetration effects on spacecraft survivability. A lower "second term" indicates a lower probability of overall crew or spacecraft loss, and a higher overall spacecraft "safety" for a particular shield design.

To the spacecraft designer, quantifying the $P_{\text{loss/pen}}$ allows a lower expenditure of resources for orbital debris shielding to provide required safety levels to the spacecraft and crew. This expanded probabilistic analysis can also be used to identify internal design configurations that further increase spacecraft and crew safety from the damaging effects of M/D impacts. Further, quantifying this "second term" opens the option of improving orbital debris safety for existing spacecraft through adding internal (rather than external) shielding. Because internal shielding may often be placed on existing spacecraft without costly extravehicular activity (EVA), quantifying the probability of spacecraft loss following an orbital debris penetration may be used to lengthen the orbital "life" of existing spacecraft at lower cost than augmenting external orbital debris shields.

Thus, quantifying actual crew safety from meteoroid and orbital debris penetration is important not only to determine whether existing spacecraft shielding is sufficient, but also to determine the extent to which future shielding should be added, and where. For these reasons, it is the general objective of this report to quantify crew safety from "significant" orbital debris penetration effects into large manned spacecraft, and discuss how this procedure could be extended to other penetration effects and spacecraft types. The next sections detail the objectives and approach of this report.

C. Research Objectives and Novelty of the Approach

The objectives of this report are to:

(1) Conduct research into methods for estimating quantitative risk that are applicable to the manned spacecraft orbital debris impact problem.

(2) Identify penetration-induced failure modes that induce spacecraft or crew loss and those internal design and/or operational factors that most affect these failure modes (hazard sensitivity factors).

(3) Summarize baseline assumptions from above studies and develop a detailed probabilistic model and simulation tool for computing loss of crew from "significant" orbital debris penetration failure modes considering a significant number of operational/design variables.

(4) Perform baseline and sensitivity studies on probability of crew loss from orbital debris penetration for spacecraft manned modules. Perform validation and verification of developed simulation tool. Identify operational modes and design alternatives that increase crew safety and possible roadblocks to their implementation.

(5) Outline how this detailed model for spacecraft manned modules might be expanded to a general probabilistic model for loss of spacecraft or crew from orbital debris impacts, considering all failure modes and operational factors described in (2).

This report is the first application of a quantitative, "military-style" survivability/vulnerability analysis technique to the civil space program. It differs from other past/proposed analyses by its use of the orbital debris environment as the primary random variable for Monte Carlo "probability of crew loss" analyses, using S.S. *Freedom* program inputs of expected crew position as secondary random input variables where necessary. It develops a model for oblique hole size and initial crack size based on limited penetration data. It quantifies baseline input values for operational factors (crew escape time, sleep position, etc.) and phenomenological factors (depressurization through a hole, internal equipment resistance, etc.) that affect the probability of crew loss, quoting values where available, and generating them where information is unavailable. It includes a sensitivity analysis for the effects of alternative input assumptions where baseline input assumptions are uncertain. Finally, it identifies quantitative increases in crew safety possible through implementing design changes and operational protocols.

II. QUANTITATIVE RISK ESTIMATION METHODS

This section of the report reviews how quantitative "probability of penetration" analyses are performed at NASA, and gives a short summary of quantitative meteoroid/orbital debris performance requirements for various space projects. It also describes quantitative risk analysis procedures used within government and industry for estimating system safety. This discussion concentrates primarily on military system survivability analysis procedures as outlined by the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) that are applicable to this problem.

A. Orbital Debris Environment

In the late 1970's, NASA began to detect a new threat to manned space operations in the form of potential impact with orbital debris—small particles from the breakup of satellites in Earth orbit. The first models of the orbital debris population were developed by Donald Kessler of NASA'S Johnson Space Center, still one of the world's foremost experts in the study of the orbital debris population. In 1978, Kessler and Cour-Palais published their first article on orbital debris entitled "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt."[1] Since that time, Kessler has produced increasingly more detailed descriptions of the orbital debris environment using sophisticated optical and radar systems to gather supporting data.[2 3]

The orbital debris environment is similar to the meteoroid environment in that the probability density functions for particle velocity and particle diameter are independent of one another. Both models contain equations describing the flux (number) of particles of a particular diameter or larger that are expected to impact a square meter of randomly tumbling spacecraft surface in a year's time (fig. 1).

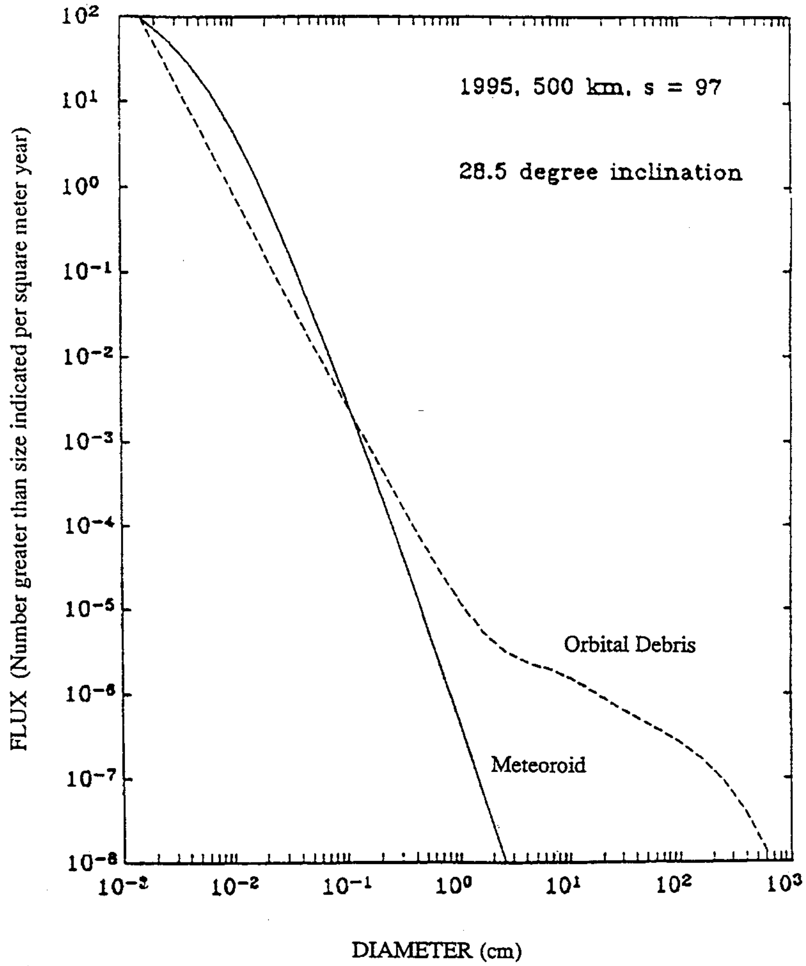


Figure 1. Comparison of meteoroid and orbital debris flux.

However, orbital debris particles have far surpassed meteoroids in number of large particles "dangerous" to manned spacecraft. Figure 1 shows that the orbital debris flux exceeds the meteoroid flux above 1 mm and is significantly higher than the meteoroid flux above 1 cm. Because spacecraft shielding can generally defeat particles up to 1 cm in diameter, the probability of orbital debris penetration is far greater than meteoroid penetration; so much so, in fact, that meteoroid/orbital debris protection analyses for large, long-lived spacecraft can usually omit meteoroid analyses altogether with only marginal (less than 1 percent) error.

Orbital debris also differs from meteoroids in their density distribution. According to "Space Station Program Natural Environment Definition for Design,"[3] orbital debris consists largely of aluminum (65 percent), with the remaining volume fraction consisting largely of epoxy-glass, rubber, titanium, copper, and steel. Because of the preponderance of aluminum and its comparatively "median" density, the density of orbital debris is usually equated to that of aluminum (2.8 gr/cm^2). Conversely, meteoroids generally consist of either ice or stony or ferritic materials bound loosely together with ice. As such, the average density of meteoroids is placed as approximately 0.5 gr/cm^2.

Another major difference between meteoroids and orbital debris is the directionality and velocity of the particles. Because of their interplanetary origin, meteoric particles travel at speeds up to 72 km/s. Orbital debris moves in roughly circular orbits around the Earth, and generally impacts at speeds less than 20 km/s (relative to spacecraft velocity). Whereas the meteoroid environment is roughly "omnidirectional" relative to spacecraft surfaces, orbital debris impacts are highly directional in nature (due to their circular orbits), approaching the spacecraft from its "front," "port," and "starboard" sides only (fig. 2).

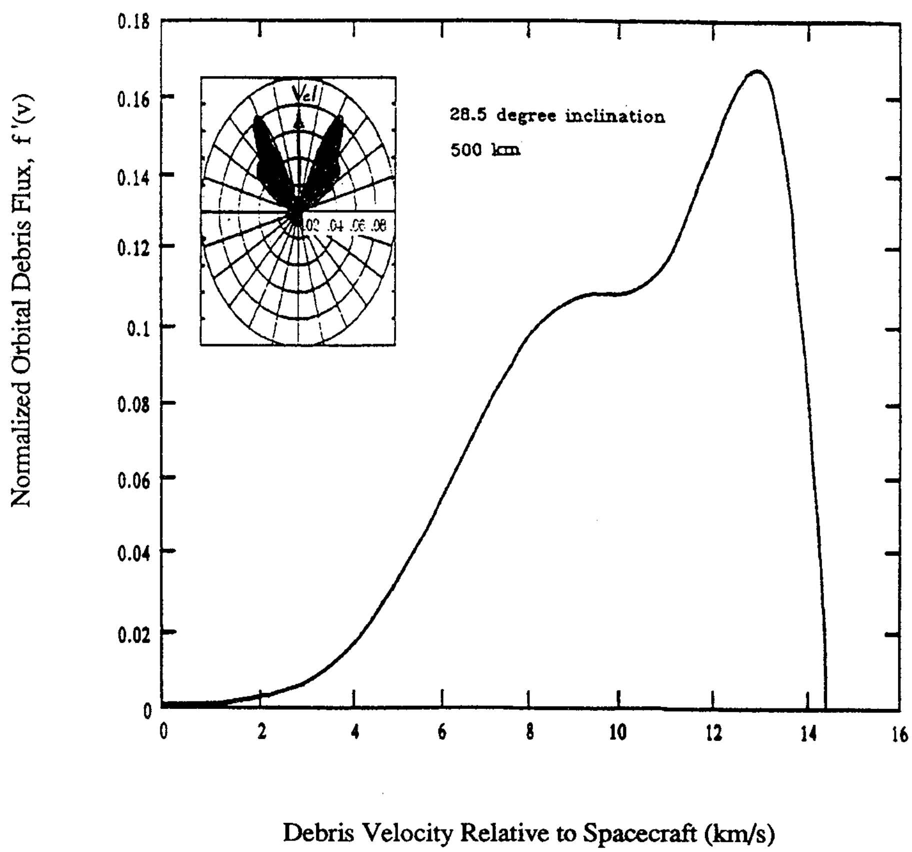


Figure 2. Orbital debris velocity distribution.

The expected orbital debris particle flux varies with altitude, solar flux, and year of operation. As shown in figure 2, the relative velocity and direction of debris impacts are directly related to one another (i.e., particles "coming" from one relative direction always travel at the same velocity relative to the spacecraft), and are themselves determined by the altitude and inclination of spacecraft orbit.

Using the Kessler model for flux, the probability of the spacecraft colliding with an orbital debris particle of a diameter greater than a critical value can be determined. This "probability of impact" function has been described by Horn and Avans[4] (among others) as:

$$P[d>Dcrit] = 1-e^{-fat} \quad , \tag{3}$$

where

f = debris flux, number of particles per square meter–year of diameter d or larger

a = effective area of spacecraft (spacecraft incremental area multiplied by incremental probability of orbital debris approaching from this direction), square meters

t = time in space, years.

Alternative models for the orbital debris population have also been formed. In particular, the European Space Agency[5] and Nicolas Johnson of KAMAN[6] have each proposed independent models for the number of debris particles expected to impact spacecraft as a function of similar orbital parameters. One area of strong difference between these models is the projected increase in debris population with time. While Kessler projects a 2- to 5-percent increase in the number of debris particles per year, Johnson predicts a constant (or decreasing) number of debris particles with time.

Stochastic models of space particle impingements on the surfaces of spacecraft as a function of time have also been developed. Howell describes the time-dependent impact of meteoroids on the Hubble space telescope (HST) in a 1986 paper entitled "A Stochastic Model for Particle Impingements on Orbiting Spacecraft."[7] Recently, Mog[8] used this work as a springboard for the simulation of orbital debris impacts on the exterior of the S.S. *Freedom* manned modules. In this work, Mog generates probability distributions of expected debris particle sizes and directions from the Kessler flux equations. Using these, he draws random numbers to simulate the inter arrival time, size, and direction of orbital debris particles emanating from a large "cylinder" surrounding a computer model of the S.S. *Freedom* module cluster. He then uses an existing target description code (FASTGEN) to calculate the relative angle of impact between the generated particle and the surface of the S.S. *Freedom* modules. This relative impact angle can then be used to calculate the probability of penetration. This report approach uses a strategy similar to Mog's for simulating orbital debris particle velocities, directions, and sizes, but a somewhat different approach for computing impact placement on spacecraft surfaces and relative orbital debris impact angles with these surfaces.

B. Spacecraft Orbital Debris Penetration Protection

Beginning with the Mercury program in the 1960's, NASA managers have established a structural design requirement for preventing meteoroid penetration into inhabited spacecraft. Since the meteoroid population was considered to be well understood, this requirement was probabilistic in nature. Table 1 summarizes the structural "probability of no meteoroid penetration" (PNP) requirements for a number of past NASA programs.[9] In general, these "probabilistic" meteoroid protection requirements were easy to meet, since the probability of meteoroid impact on a small, short-lived spacecraft was very low.

Table 1. Selected probability of no penetration requirements.

Manned Spacecraft	Environment	Requirement
Gemini/Mercury	Unknown	Unknown
Apollo Command	Meteoroid	0.996 PNP per Module 8.3-Day Mission
Skylab Workshop	Meteoroid	0.995 PNP per 8 Months
STS Orbiter Cabin	Meteoroid	0.95 PNP per 500 Missions
Space Lab Module	Meteoroid	0.9990 PNP per Mission (Approx. 7 Days)
HST	Meteoroid and Debris	0.95 Probability of No Mission Failure in 2 Years (15-Year Life)
S.S. *Freedom*	Meteoroid and Debris	0.9955 Probability of No Critical Failure per Critical Element in 10 Years

However, with the growing threat of orbital debris impact, NASA space station managers included orbital debris when formulating meteoroid penetration protection requirements for initial space station elements (fig. 3). According to the "Space Station *Freedom* Preliminary Design Requirements Document,"[10] all pressurized volumes (including the nodes, habitation, laboratory, and logistics modules) are considered as "critical space station core elements." As such, they shall "have a minimum probability value of 0.9955 of experiencing no failure due to meteoroid impact that would endanger the crew or space station survivability for the [10 year] life of the station." Further, the "penetration of a pressure vessel shall be deemed a critical failure" that would endanger the crew. Thus, the practical design requirement for space station module walls became a 0.9955 minimum probability of no meteoroid/orbital debris penetration for 10 years.

The S.S. *Freedom* manned modules have a dual wall design for preventing meteoroid/orbital debris penetration, shown in figure 4. During an impact, the outer wall (bumper) breaks the debris particle into a fine cloud of particles. The inner, pressure-bearing wall (hopefully) stops the cloud of particles from penetrating into the crew cabin area.

Meteoroids impact at velocities above 20 km/s, and usually vaporize upon impact with the bumper. Lower, testable velocities often create more damaging liquid or solid cloud fragments. Thus, previous programs responsible for exceeding a "worst-case" probability of no penetration usually amounted to finding the single particle size that just penetrated the final wall at a "worst-case" test velocity, from 3 to 7 km/s. The probability of no penetration was then equated to the probability of being impacted by a particle of this size or smaller.

Today, orbital debris is at least 10 times more likely to penetrate a spacecraft than a meteoroid, and can impact at velocities ranging from 2 to 15 km/s. Thus, the precise effect of debris impact parameters on penetration are more important than on previous programs. The effect of debris diameter, velocity, and obliquity in determining the performance of this type of dual wall shield is

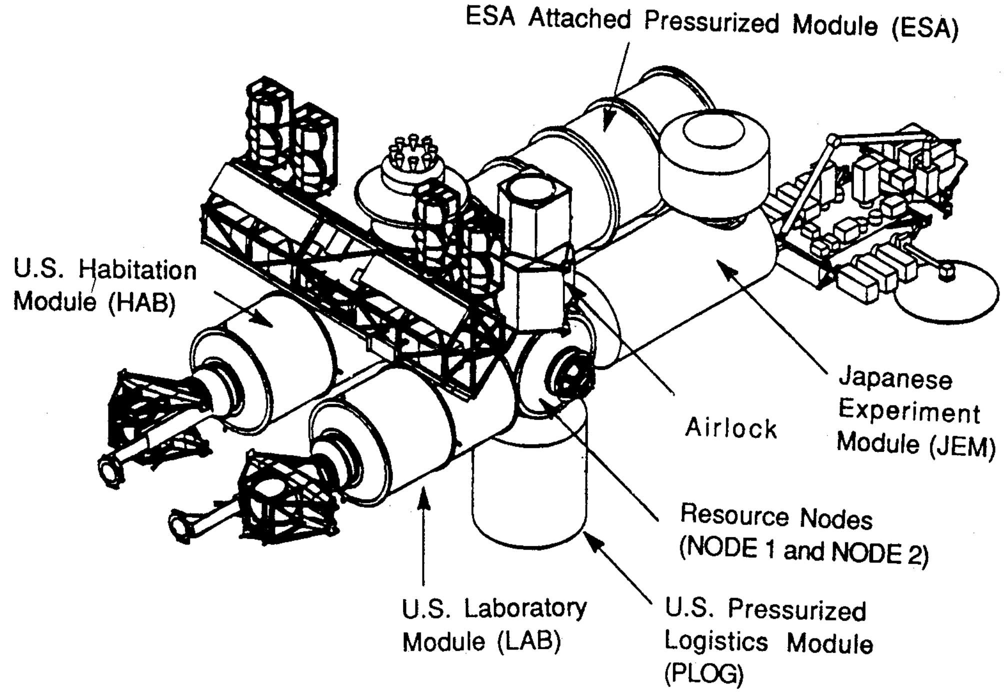


Figure 3. S.S. *Freedom* module configuration.

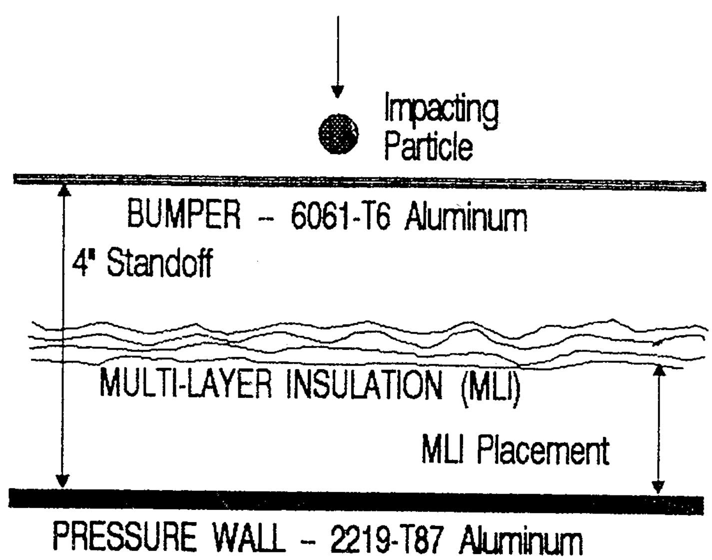


Figure 4. "Typical" Whipple shield configuration.

often described through the use of a ballistic limit curve, shown in figure 5.[12] In a ballistic limit curve, all diameter/obliquity/velocity (dov) combinations "above" the curve are those that would penetrate into the interior of the spacecraft; all those dov combinations "below" the curve would not penetrate.

The computation of the probability of spacecraft penetration from orbital debris computation is thus a significantly more complex task than meteoroid penetration of small spacecraft. In 1987, NASA and Boeing developed a computer program, BUMPER™,[13] that performs this calculation given a specific protection design (ballistic limit curve) and spacecraft geometry (in the form of a finite element model). BUMPER™ compares the impact probability of each diameter, velocity, and

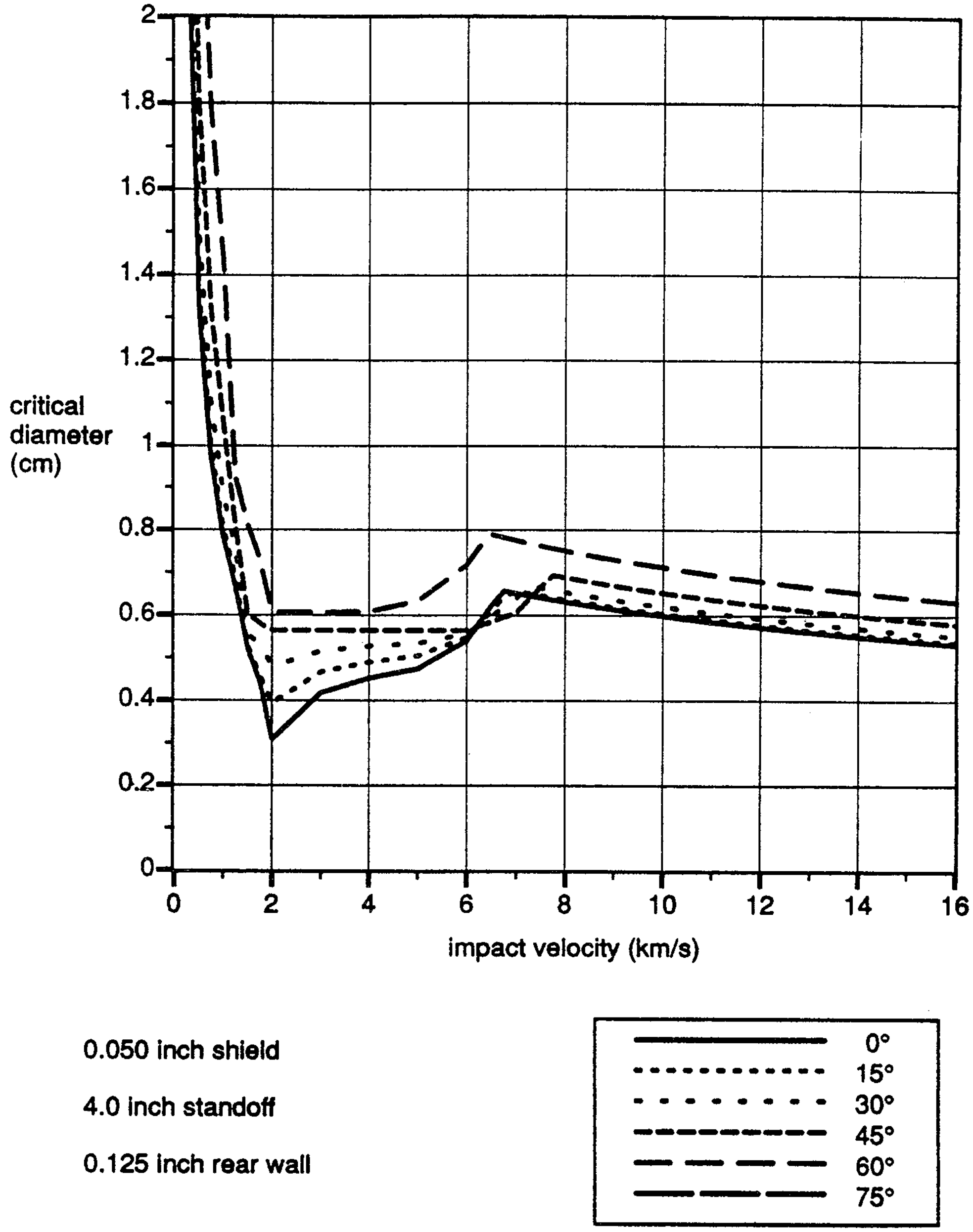


Figure 5. Ballistic limit curve for "typical" Whipple shield.

impact obliquity possible from the debris environment to the "pass/fail" criteria of the shield design's ballistic limit curve, and sums up the "no failure" cases for each discrete area of the finite element model. The result is the total probability of no penetration for the spacecraft, or for each module, as shown in table 2[14] for S.S. *Freedom*. Figure 6[15] is another type of graphical BUMPER™ output showing the probability of penetration per square meter of area for the existing S.S. *Freedom* manned module configuration. This output confirms that a higher number of penetrations are expected on the "sides" of the module facing the orbital debris relative velocity vector.

The ballistic limit curve relating penetration damage to environmental parameters is the linchpin of NASA's current probabilistic meteoroid/debris impact safety analysis technique. This curve is typically formulated around test data performed with spherical aluminum particles to represent orbital debris of specified environmental diameters into unpressurized wall samples. These assumptions have facilitated easier testing, limited the number of tests required to formulate curves,

Table 2. PNP table—space station manned modules.

Module	Exposed Area (m^2)	Probability of No Penetration
U.S. Lab	21.226	0.9980
U.S. Hab	21.226	0.9980
Japanese Module	14.889	0.9976
Columbus Module	18.356	0.9973
Node 2	5.197	0.9995
Node 1	5.197	0.9995
Logistics Module	25.340	0.9975
Airlock	9.095	0.9991

Year 2000, solar flux = 70, altitude 398 km, zero pitch

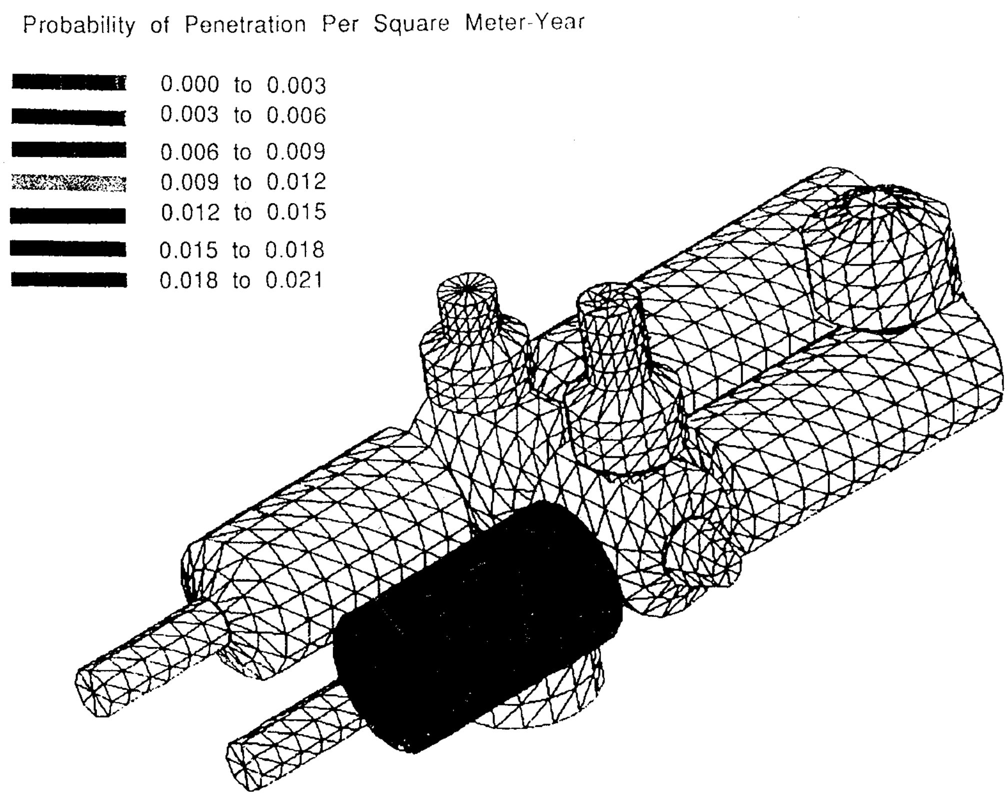


Figure 6. Graphical BUMPER™ output, probability of penetration.

and are thought to reasonably simulate the "typical" particle and wall interaction process. Boeing[12] has performed the majority of ballistic limit testing and regression in the 3- to 7-km/s regime. Additional testing (Piekutowski[16]) and analysis (Jolly/Williamsen[17]) have also been performed.

Although Boeing ballistic limit curves are based upon test data in the 3- to 7-km/s regime, these relationships rely on a modification of the Wilkinson equation to model impact in the 7- to

15-km/s regime.[12] Penetration data are difficult to gather for this regime, but may be collected via velocity scaling[16] or hydrocode analysis.[18] Actual penetration data in this regime have recently been collected by Sandia National Laboratory.[19]

Finally, limited data on the hole size and crack size resulting from penetration of the pressure wall have been gathered by Boeing.[12,20] The configuration of the wall and the multilayer insulation (MLI) between the bumper and wall appears to be important to the resulting hole and crack sizes reported. Norman Elfer of Martin Marietta performed initial research into the critical length of crack that would cause "unzipping" (unstopped crack growth) in the pressurized module wall.[21] Unzipping is expected to cause explosive decompression and loss of all crew exposed to its effects. Further discussion of this important failure mode is detailed in following sections.

C. Military System Survivability/Vulnerability Assessment

Methods for determining the quantitative risk associated with the survival of systems from external threats (system survivability) have been in use since the mid-1960's within military circles. In "Aircraft Combat Survivability,"[22] Ball summarizes Army, Navy, and Air Force requirements to assess and increase system survivability. In this work, Ball describes aircraft vulnerability as the "inability (of the aircraft) to withstand one or more hits by damage mechanisms." Further, "the systematic description, delineation, and quantification of the vulnerability of . . . the total aircraft is known as a vulnerability assessment." This quantitative vulnerability assessment concept is central to military system design from external threats, and forms a natural extension to space station "probability of loss given a penetration" ($P_{\text{loss/pen}}$) analyses described herein.

Because of the need for coordination (and sometimes competition) between service branches, a tri-service organization was formed in 1971 for disseminating information on "accepted" methods for assessing military system survivability/vulnerability. Specifically, the Joint Technical Coordinating Groups on Aircraft Survivability (JTCG/AS) and on Munitions Effectiveness (JTCG/ME) have published a number of reports on "acceptable" methods for vulnerability assessment.[23–25] A major contributor to this group is the U.S. Army Ballistics Research Laboratory (BRL) of Aberdeen, MD. Dietz[26,27] summarizes the current BRL methods used in military systems vulnerability assessment.

Taken as a whole, these references describe over 20 separate, lengthy, and sophisticated computer tools developed over the last 25 years for use in computing the vulnerability of Army, Navy, and Air Force weapon systems to external threats (munitions). Among these codes, VAREA and MAGIC are the oldest (dating to 1965), while the state-of-the-art is well-represented by the FASTGEN II and COVART II family.[26] In general, these codes consist of:

(1) A geometry section that generates a three-dimensional model of the external skin and critical internal components on aircraft or ground targets

(2) A Monte Carlo threat simulation section that generates projectiles from a variety of threat approach angles

(3) A shotline generator that computes all possible shotlines from each external component to each internal component

(4) An endgame program that computes whether a critical component is "killed" given a particular shotline and munitions type, and sums up the final probability of kill.

These previously derived codes are incompatible with the computation of spacecraft vulnerability to orbital debris impacts because the external threats described within these codes utilize penetration mechanisms that operate at velocities far below orbital impact velocities. As such, these codes contain deeply embedded assumptions concerning penetration effects that are fundamentally incorrect for application to the space debris impact problem. Given time, it might have been possible to alter one or more of these existing codes to perform the desired task. However, the computing resources required far exceeded those accessible by this researcher, and the "learning curve" for proper application of even the simplest of these tools is extreme. It was anticipated that the time investment required to remove erroneous assumptions from the codes and implace "reasonable" ones would rival the time needed to develop an "application-specific" simulation tool.

Despite their shortcomings, the vulnerability assessment methods surveyed contain a number of common and important methodologies that can be applied to the problem of assessing crew loss due to orbital debris penetration:

(1) Damage Modes and Effects Analysis—identifies and documents all possible damage modes of a component or subsystem and determines the effects of each damage mode upon the capability of the system (spacecraft) or subsystem (crew) to perform its essential functions.

(2) Threat Description—summarizes the direction of origin and magnitudes of external threats and their relative likelihoods of occurrence.

(3) Relation Between Threat and Damage Mode—relates expected system and subsystem damage to threat characteristics.

(4) Description of the System Geometry—must be provided to determine the likelihood of impact of external threats on critical external and internal system components.

(5) Simulation of External Impact and Internal Shotlines—computes the likelihood of critical damage modes occurring as individual external impacts are simulated.

Thus, although existing JTCG and BRL derived codes were not used per se, many of their underlying assumptions and methodologies were applied and extended within this report approach.

III. PENETRATION EFFECTS

This section discusses orbital debris impact phenomenology. Specifically, it describes short-term failure modes which can lead to immediate loss of spacecraft or crew from orbital debris penetration. These failure modes include rapid decompression, fragment, overpressure, temperature, flash, and critical crack propagation hazards. A discussion of the hazard levels expected to cause crew loss follows, along with a brief summary of the hazard levels measured within orbital debris impact testing to date.

This task also includes a summary of space station design factors and operational modes that are anticipated to mitigate crew hazards. These factors and modes include shield design, crew presence in each module, crew escape rate, module air volume, and internal equipment layout.

A. Meteoroid Penetration Effects Into Spacecraft Cabins

Since the 1960's, NASA has supported a number of studies into the general effects of meteoroid penetration on small space vehicle interiors. In his technical proposal of 1966, Ray[28] summarizes the energy release processes associated with hypervelocity penetration into spacecraft cabins as shown in figure 7. The damage effects from these combustion processes are depressurization, fragments, overpressure, blast heat, and light flash.

Burch's 1967 report[29] details the results from 13 tests at velocities up to 7 km/s into "typical" capsule wall configurations and pressurized oxygen and oxygen/nitrogen atmospheres. Measurements were taken of the intense light flash, shock waves, and heat fluxes formed by the penetration process. Long and Hammitt[30] reported on the results from 10 similar tests conducted in 1969. One important conclusion was that the observed magnitude of fragment, overpressure, light flash, and temperature effects was especially sensitive to the pressure wall design in the test configuration. These reports represent the first attempts to quantify the effect of small spacecraft cabin design on interior penetration effects. However, no attempt was made to model the variation of these effects with impact angle, velocity, and diameter.

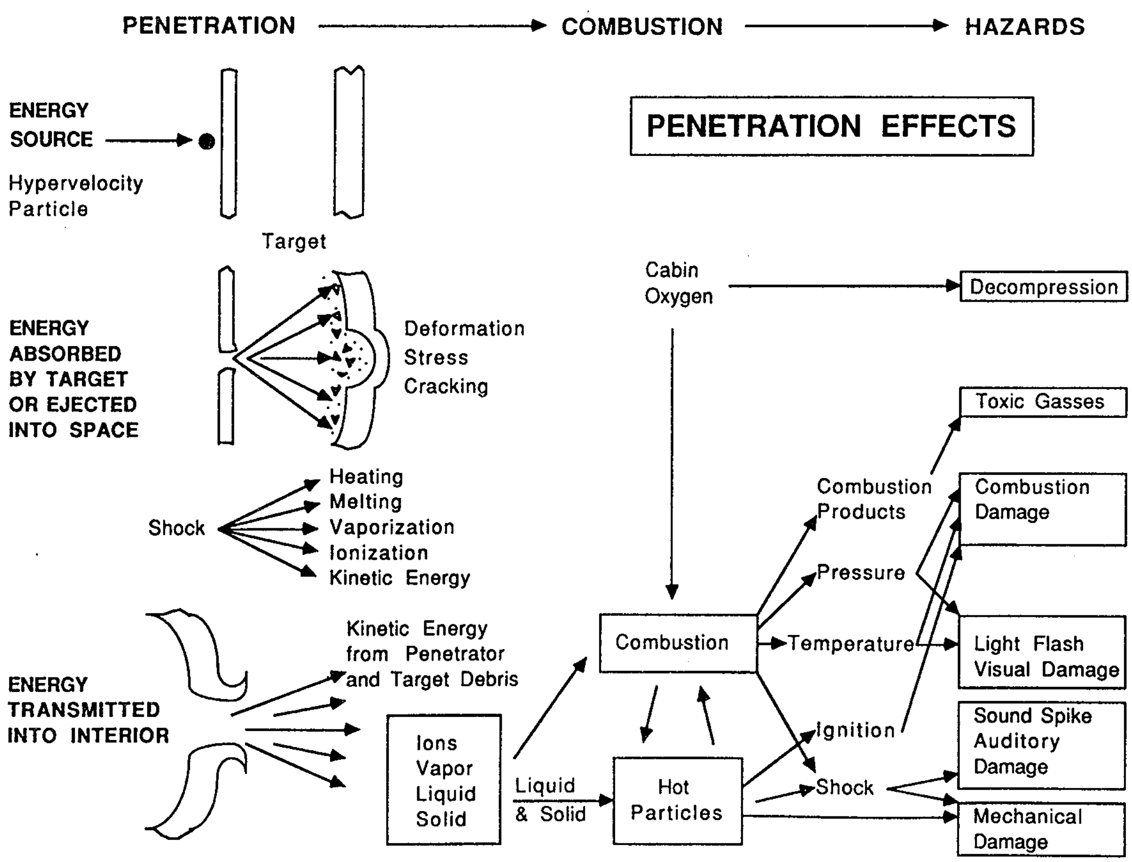


Figure 7. Hypervelocity penetration effects.

Of all these effects, decompression appears to have garnered the greatest attention. Bancroft's[31] 1969 study indicates that an astronaut cannot be expected to survive more than 10 s when subjected to instantaneous decompression. For larger capsules where the likelihood of rapid decompression is slight, Von Beckh[32] reports that the decompression rate and atmospheric composition of the capsule just prior to decompression may be related to the length of time that an astronaut can be expected to survive.

During the 1980's, a number of papers on the general interior effects of meteoroid and orbital debris penetration were released in anticipation of the U.S. space station design effort. At a 1984 Marshall Space Flight Center (MSFC) sponsored "Space Debris and Meteoroid Technology Workshop," Engler[33] summarized the "Physiological and Safety Aspects of Penetration," including limited data gathered in the 1960's by GM and Lockheed. Bauer[34] also discussed general internal penetration effects in his 1987 paper "Meteoroid and Orbital Debris Protection Concepts," including the variation of depressurization rates from manned modules with hole size. "Orbital Debris Risk Analysis and Survivability Enhancement for Freedom Station Manned Modules"[35] also summarizes the results of many of these studies.

The development of S.S. *Freedom* and the growing threat of orbital debris encouraged NASA to conduct a limited study on penetration effects into space station manned modules. In a 1987 study, Boeing[13] reported limited success in 20 tests to measure the flash and overpressure associated with the penetration of the space station module wall design.

B. Military Data on Hypervelocity Penetration Effects

The available literature on hypervelocity penetration effects is broad, dating from prior to World War II to the present. "Hypervelocity" penetration may be loosely defined as a penetration event occurring near or above the speed of sound within the penetrator or target material. Considerable penetration data are available from military sources, such as the "Penetrations Equation Handbook for Kinetic Energy Penetrators" published by the JTCG/ME.[36] This reference describes the depth of penetration and fragment sizes to be expected from rods, fragments, and spheres impacting into thin-walled targets (such as the manned spacecraft walls). Considerable classified data on depth of penetration into specific military targets also exist, but are unavailable to this researcher.

Of primary concern to the survivability analyst is the effect of fragments on crewmen. The JTCG/ME has developed extensive criteria for the probability of "incapacitation" based upon the speed and mass of fragments projected at prone and standing soldiers. According to "Evaluation of Wound Data and Effectiveness of Munitions,"[37] this term refers to the ability of the soldier to carry out commands within a specified tactical situation. The tactical situation most comparable to spacecraft crew appears to be the "assault <30 s" scenario. In this case, the soldier is expected to be able to "engage in the maximum type of physical activity" within 30 s of being hit by fragments of the described energy level.

Additional data on the effect of fragments on crew have been compiled in Zaker's "Fragmentation Hazard Study"[38] and in "Criteria for Incapacitating Soldiers With Fragments and Fragments and Fletchettes"[39] and "Ballistic Limits of Tissue and Clothing."[40] Table 3 summarizes some commonly used values for fragment energy require for fatality levels of 10, 50, and 90 percent. In general, these energy levels are quite low compared to typical orbital debris impact energies.

Table 3. Fragment energy required for specified casualty level.[38]

PENETRATION:	
Injury level	Energy (ft-lb)
Threshold	11
90 percent injury (10 percent fatal)	40
50 percent injury (50 percent fatal)	58
10 percent injury (90 percent fatal)	85
CRUSHING:	
Injury level	Momentum (ft-lb/s)
Threshold	100

The effects of depressurization on air crews have also been studied extensively by military sources. In 1961, Bryan[41] found that rapid depressurization beyond 35,000 ft (4 lb/in^2) in oxygen/nitrogen atmospheres led to immediate dizziness and probable unconsciousness in human subjects. Ernsting[42] reported similar effects, but noted the importance of rate of depressurization and atmospheric makeup in his results.

Blast effects on humans have also been the subject of numerous studies since the 1940's. A classic work on the subject was published by the Defense Atomic Support Agency in 1968.[43] In "Estimate of Man's Tolerance to the Direct Effect of Air Blast," Bowen outlined the probability of human survival as a function of overpressure and human body position. Specifically, overpressures above 10 lb/in^2 are predicted to cause lung damage and decreasing probability of human survival; overpressures below this level might cause hearing loss, but not loss of life. Severin reported the effects of light flash on humans in his 1962 work, "A Study of Photostress and Flash Blindness."[44]

C. S.S. *Freedom* Orbital Debris Survivability

As outlined in the introduction, the tremendous growth of orbital debris is causing NASA to reevaluate its orbital debris protection design for the S.S. *Freedom.* A 1992 Government Accounting Office (GAO) study states that there is a 36-percent probability of penetrating a critical element of the space station (including a manned module) over the 30-year life of the station.[45] This probability of penetration is often equated to "crew safety" within the GAO report, but NASA has responded that "a pinprick in the module could go unnoticed for some time, and not cause problems."

For some time, NASA has been studying the consequences of module depressurization without quantifying the probability of its occurrence. In 1985, Boeing produced a memo entitled "Space Station Module Blowdown from Debris Puncture"[46] in which both isentropic and isothermal blowdown models for module pressure loss through circular holes are discussed. Subsequent references[47 48] have concentrated on the isentropic blowdown model as the most reliable. In NASA's

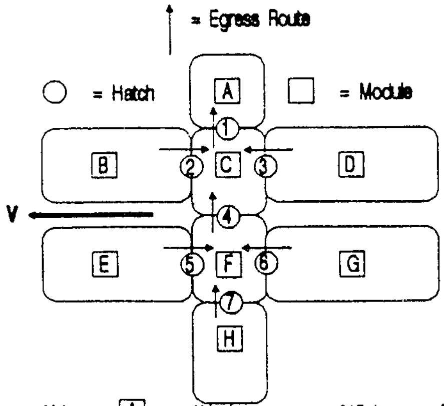
"Space Station *Freedom* Contingency Operations Scenarios,"[49] a relation between time available for crew egress and hole size for the space station module cluster is developed. Within this report, 8.3 lb/in^2 absolute is established as the minimum limit for cabin pressure, below which the crew's physical impairment is "severe."

Given the increase in program weight and cost to be expected from increasing penetration protection, the study of quantitative crew safety following a meteoroid or debris strike has recently become the subject of intensive study at NASA. At a recent American Institute of Aeronautics and Astronautics (AIAA) Space Programs and Technologies Symposium held in March of 1992, Christiansen[35] discusses how the probability of penetration of external elements and manned modules may be computed, and how the survivability of these elements may be qualitatively enhanced through internal spall liners (fragment-stopping blanket materials).

At the same symposium, Williamsen presented the paper "Orbital Debris Risk Analysis and Survivability Enhancement for Freedom Station Manned Modules."[14] This paper summarized the failure modes and hazard mitigating factors associated with orbital debris penetration of manned modules, as shown in table 4, and listed thrust loading from spacecraft decompression as a new mode of possible spacecraft loss from orbital debris penetration. It was the first published work to define and derive quantitative crew "safety" values from space particle impact. In an example problem, it computed a preliminary value for probability of crew survival from slow decompression and its sensitivity to the single operating mode of individual module hatch status (open or closed), as shown in figure 8.

Table 4. Failure modes and probability of loss.[14]

PENETRATION HAZARDS AND FAILURE MODES	CRITICAL HAZARD LEVEL (Preliminary estimates where available)	HAZARD MITIGATION Design Factors and Operating Modes	CRITICAL IMPACT CONDITIONS Observed/Expected to Cause Critical Hazard Levels	PROBABILITY OF LOSS Due to Described Hazard
Wall Breech Hazards				
o Internal Depressurization o Crew unable to ecape prior to unconsciousness o Critical failure of equipment	o 14.7 to 9 psi in 180 seconds or less (11). o 1/3 bar loss in 120 seconds or less (12). o All internal equipment designed to withstand depressurization without hazard (13).	o Hatches open between modules increases air & crew escape time, endangers crew in connecting module. o Crew presence in each module varies with time.	o Critical hole size [1,2] is function of volume available (i.e., hatch status). Small volumes provide less crew time to escape prior to reaching critical threshold (decreasing crew safety), less thrust from outgassing (increasing station safety).	P[crew loss] = P[hole ≥ crit size 1] x P[crew in module]. Crit size 1 (depress) = f(available volume, crew escape time). P[specific hole size] = P[d,o,v impacts module]
o External Atmospheric Outgassing o Thrust from air loss exceeds station control margin, loss of station or equip	o Critical control moment not yet established. o Most equipment designed for stowed launch loads. Thrust load resistance not known, not reqrmnt.	o Hatches closed between modules decreases thrust, increasing safety. o Placement of MLI farther from wall decreases created hole size.	o Need more data relating hole & crack size to diameter, obliquity, velocity (d,o,v) conditions and MLI placement o For 0.375", 7 km/sec, 0 deg Al particle impact (6)(15), No MLI => 2.5" dia. hole, MLI on wall => 5" dia. hole.	P[station loss] = P[hole ≥ crit size 2]. P[specific hole size] = P[d,o,v impacts module] Crit size 2 (outgas) = f(available volume, critical thrust).
o Critical Cracking of Pressure Module Wall o Unstopped growth	o Exact initial crack size for unstopped growth is unknown, estimated from a 7" (14) to a 15" (15) initial crack length.	o Placement of MLI farther from wall decreases critical crack length.	o For 0.375", 7 km/sec, 0 deg Al particle impact (6)(15), No MLI => 6" wall crack, MLI on wall => 13" crack.	P[station loss] = P[crack ≥ crit size]. P[specific crack size]= P[d,o,v impacts module]
Fragment Hazards o Crew injury hinders escape, crew loss, crit equipment damage	o Fragment effects on crew not established. Any injury hinders crew. o Fragments penetrating critical racks, lines.	o Rack structure slows or prevents propagation of fragments, may prevent injury to crew/equipment.	o For 0.375", 7 km/sec, 0 deg Al particle impact without rack structure, fragments penetrate over five 0.020" witness plates behind the pressure wall simulant (6).	P[crew loss] = P[d,o,v penetrates] x P[fragments penetrate racks into aisle] x P[crew is in aisle].
Atmospheric Hazards o Overpressure, Sound, Shock. o Crew injury or equipment loss	o Known magnitude/time/distance relations for crew injury, loss (16) o Unknown equipment resistance level (not design requirement)	o Rack structure slows propagation of overpressure & sound effects, may prevent injury to crew.	o Shock magnitudes exceeding 150 psi lasting 0.1 msecs measured extending several feet into aisle if no rack structure present to inhibit propagation (21), approaches 50% fatality curve (16).	P[crew loss] = P[d,o,v penetrates] x P[shock overcomes rack structure] x P[crew is in aisle].
o Temperature (Blast Heat) o Injury from fire or blast heat, equipment loss	o 120 deg F. minimum, time dependent (17). o Fire resistance required of all internal hardware & varies w/design (13)	o Rack structure slows propagation of blast heat into aisle, may prevent injury to crew.	o Blast heat in debris cloud capable of burning plastic, clothing, hair and other combustibles, starting add'l fire (19). Cabin temps rise > 30 deg outside blast (20).	P[crew loss] = P[d,o,v penetrates] x { P[heat > rack] x P[crew in aisle] + P[rack fire] x P[crew near] }.
o Flash (Light) o Crew hindered by blindness	o Temporary blindness at 100 Lamberts (8), retinal burns at 2.5 cal per sq. steradian/sec (18).	o Rack structure stops propagation of flash into aisle.	o Observed flash levels without rack structure near 1200 watts/steradian, lower than retina burn level (19).	P[crew loss] = P[d,o,v penetrates] x P[flash penetrates] x P[crew observes].



Volume	A	= Airlock	= 815.4	cu ft
Volume	B	= U.S. Hab	= 2717.7	cu ft
Volume	C	= Node 1	= 1544.1	cu ft
Volume	D	= ESA Lab	= 3619.3	cu ft
Volume	E	= U.S. Lab	= 2717.8	cu ft
Volume	F	= Node 2	= 1544.1	cu ft
Volume	G	= JEM Lab	= 3585.1	cu ft
Volume	H	= U.S. P-Log	= 2093.4	cu ft

CREW OF 8	HAB	LAB	NODES	COLUMBUS	JEM
TOTAL HOURS PER DAY (OCCUPIED)	133	17	8	17	17
NUMBER OF CREW MEMBERS	5.52 / AVG.	2 / 8.5 HRS EA.	1 / 4 HRS EA.	2 / 8.5 HRS EA.	2 / 8.5 HRS EA.
PERCENT TIME OCCUPIED	100%	35%	33%	35%	35%
PERCENT TIME EMPTY	0%	65%	67%	65%	65%
TOTAL HOURS PER DAY (EMPTY)	0	15.5	16	15.5	15.5

TOTAL MANHOURS PER DAY (24x8) 192 HOURS

Case	Hatch Condition	Probability that crew is lost given a penetration
1	All hatches open 100 percent of time	22.6 percent of all module penetrations
2	All hatches closed 100 percent of time	21.7 percent of all module penetrations
3	Hatch 2 closed (Hab) 100 percent of time	16.8 percent of all module penetrations
4	Hatch 1,7 closed (Airlock, P-Log) 100 percent of time	19.8 percent of all module penetrations
5	Hatch 1,2,7 closed (A/L, P-Log, Hab) 100 percent of time	15.6 percent of all module penetrations
6	Hatch 1,7 closed 35 percent of time. All hatches closed rest of time (65%)	13.0 percent of all module penetrations
7	All hatches closed 100 percent of time 3 min escape	20.8 percent of all module penetrations
8	All hatches closed 100 percent of time Alter crew model	23.8 percent of all module penetrations

Figure 8. Probability of crew loss from decompression.[14]

On May 22, 1992, NASA directed the Space Station Engineering Integration Contractor (SSEIC) to develop and implement a Meteoroid/Orbital Debris Forward Action Plan (FAP). The objective of this FAP was to "determine which S.S. *Freedom* critical elements are in compliance with program requirements and to identify those items which may need additional protection."[50] An integral part of this identification process is the development and implementation of an "integrated, probabilistic station-level test and analysis program to determine the likelihood that S.S. *Freedom* could experience a catastrophic failure."[50] This term is defined within the body of the SSEIC forward action plan as "any event which endangers (not "could" endanger, as in the case of critical failure, previously defined) crew or station safety."[51]

Thus, the S.S. *Freedom* program has initiated an assessment of the actual probability of crew or station loss (catastrophic failure) from meteoroid/space debris impact. Their main objective behind this is similar to that outlined herein: to identify which elements should receive augmented shielding from orbital debris penetration, and to minimize the amount of that shielding in meeting stated safety levels. Task 4.1.2 of the FAP[51] is to perform an integrated risk assessment of the manned module.

Many of the stated objectives within the FAP have been achieved. The FAP has been instrumental in identifying preliminary decompression levels and critical crack lengths in the module skins that produce crew or station loss through slow or explosive decompression. The October 1992 SSEIC FAP Task One Report[52] and "Interim Report"[53] give preliminary evidence to support a 7.5-lb/in^2 decompression limit prior to onset of hypoxia if no oxygen masks are available to spacecraft crew, or a 3-lb/in^2 decompression limit if oxygen masks are donned prior to reaching a 7.5-lb/in^2 level of cabin atmosphere (both from a 14.7-lb/in^2 original cabin level).

Citing preliminary evidence gathered from a special NASA formed panel of U.S. fracture experts (including Elfer[23]) called the Fracture Control Working Group, SSEIC states that a critical tip-to-tip crack length of 7 in must be created in a 0.125-in 2219-T87 Al manned module pressure wall by the penetration process prior to "unzipping" (unstopped crack propagation) of the module structure. "Unzipping" is the most catastrophic of orbital debris-induced failure modes, and is assumed to cause explosive decompression of the module structure and subsequent loss of the entire crew and station complex. Though it may be possible to stop critical crack propagation through integral ribs and stiffeners in the wall, SSEIC outlines a more effective possible countermeasure to be a uniform thickening of the rear wall. This design alternative delays the onset of "unzipping" by requiring a larger impact-induced critical crack length prior to critical crack propagation. For example, uniformly thickening the 2219-T87 Al module wall to 0.188 in would raise the critical tip-to-tip crack length from 7 to 12 in.

The FAP utilizes a BASIC computer simulation entitled CREW™ to compute the probability of crew loss for manned modules. The random variables within this simulation are selected from "lookup tables" that assume values for the individual probabilities of module impact, hole size, number of crew within each module, impact proximity to crew members, interior blockage, and crew injury. Because CREW™ lacks a geometric model and the orbital debris environment as a primary input variable, it cannot calculate internal penetration effects as a function of internal equipment location or crew proximity to each penetration location. Further, CREW™ is limited to calculating the magnitude of the internal effects within the FAP based on the magnitude of the hole size associated with each "penetration" instead of impact parameters of particle diameter, velocity, and obliquity. Unfortunately, large holes do not necessarily result in significant internal penetration hazard levels; likewise, small holes can often result in significant internal penetration depths and associated hazard levels. Given these observations, the accuracy of the SSEIC model results for injury-related crew loss is somewhat suspect.

Obviously, with a valuable national project such as the space station, cooperation to achieve a realistic value for the probability of spacecraft or crew loss following orbital debris penetration was important to NASA. A good deal of technical interaction continues to take place between the SSEIC team and this researcher on the "correct" orbital debris-induced hazard levels causing loss of the station or crew. Many of the previously baselined SSEIC/FAP values for expected hole size distributions, crack size distributions, and crew injury/decompression levels have improved due in part to this interaction. Throughout the FAP, the simulation tools, inputs, and outputs from this report approach have served the important dual purposes of (1) providing important input parameters to the larger SSEIC effort and (2) providing an independent "top-to-bottom" check on the validity of the SSEIC outputs for the probability of station or crew loss from orbital debris.

Table 5 summarizes important, near-term crew penetration hazards discussed within this report that are included within its associated simulation, Manned Spacecraft Crew Survivability (MSCSurv™). Other "late-time" hazards exist (secondary fires, failure to repair damage, long-term crack growth, air-borne contamination, etc.) that could also cause crew loss. These failure modes were omitted from this discussion due to the assumed existence of assured crew rescue vehicles on large spacecraft (such as the S.S. *Freedom*) and their capability to remove crew prior to experiencing the damaging effects of these hazards.

Table 5. Penetration hazards, critical levels, and sensitivities modeled within MSCSurv™.

Penetration Hazards	Hazard Sensitivities
Unstopped Crack Propagation (Module "Unzipping") Critical Hazard Level: 7-in critical crack for a 0.125-in 2219-T87 Al wall 12-in critical crack for a 0.188-in 2219-T87 Al wall	• Hole size following penetration (Hole size and energy models) • Critical crack uncertainties (1- to 24-in lengths)
Injury (Due to fragments and blast) Critical Hazard Level: 58 ft-lb impact energy	• Spread of internal debris cloud (1 to 3 racks wide) • "Equivalent" density of internal equipment (0 to 0.7 gr/cm^2) • Lethality of crew exposure to debris cloud (0 to 100 percent)
Decompression (from 14.7 lb/in^2) Critical Hazard Level: 7.5 lb/in^2 (baseline) 3.0 lb/in^2 (w/oxygen masks) 9.5 lb/in^2 (equipment failure)	• Crew distribution among modules (asleep and awake) * • Crew distribution within modules (uniform and triangular) * • Crew escape time (1 to 3 min) Hatch position (open, closed, mixed models) • Ratio of free air to total module volume (70 to 95 percent) • Hole size model (Oblique and Burch models) • Hole shape (C_d, isentropic depressurization discharge coefficient, varies from 0.7 to 0.9)

* This mitigating parameter also affects crew injury.

IV. MODEL FORMULATION

In this section, a Monte Carlo simulation model is developed that generates random debris particles (from the NASA environment model) and models the space debris particle arrival process, the impact placement on spacecraft manned modules, the amount of damage (hole size and internal penetration) from each impact, the presence of crew in the module, and the final probability of crew loss given a penetration ($P_{loss/pen}$) averaged over thousands of simulated penetrations. This model will be referred to as MSCSurv™. Figure 9 shows an outline of the basic flowchart for MSCSurv™.

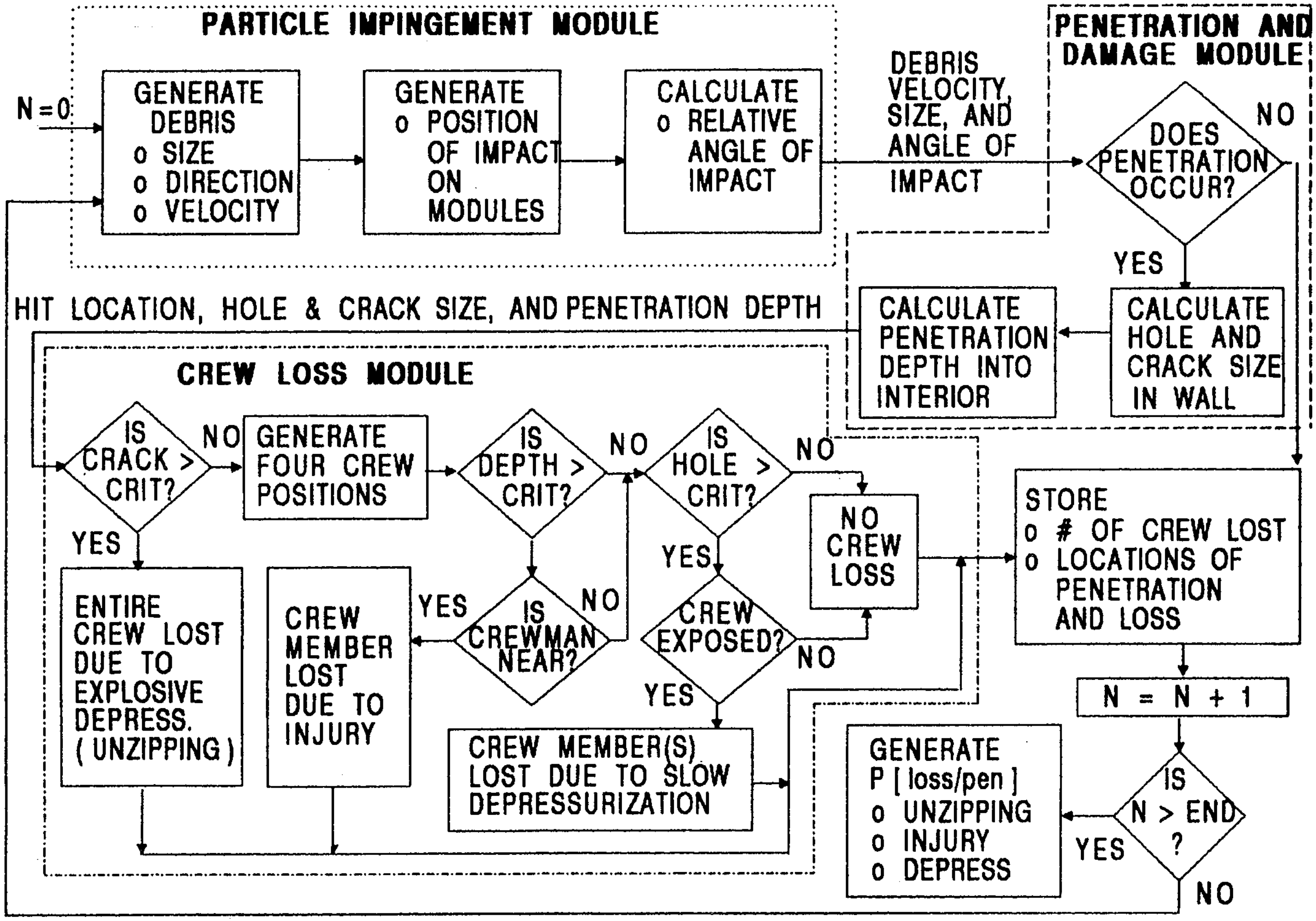


Figure 9. Flowchart for MSCSurv™ simulation.

Microsoft FORTRAN was used to generate and execute the algorithms described. The MSCSurv™ program is listed in its entirety in appendix A.

The first section of the MSCSurv™ computer program draws random numbers to simulate orbital debris impact parameters of diameter, velocity, approach angle, spacecraft impact location, and relative obliquity of impact with spacecraft. It then passes this information along to the second section of the program to determine how many of these particles actually penetrate the spacecraft. For those particles that penetrate the spacecraft, MSCSurv™ computes the number of penetrations that produce at least one crew loss. The expected probability of crew loss then is the total number of penetrations resulting in one or more crew losses divided by the total number of penetrations simulated.

Notice that this "probability of loss" parameter does not differentiate between losing one, two, three, or four crew members. Defining the loss parameter in such a way as to disregard the actual number of crew lost is consistent with current NASA safety philosophy, where the loss of even one crew member is considered to be as severe as the loss of the entire crew.

MSCSurv™ is used to derive the second and third terms of equation (4):

	"First Term"		"Second Term"		"Third Term"	
Probability of Crew Loss From Impact in Time (t) =	Probability of an Impact in Time (t)	$\times$	Probability of Penetration Following Impact	$\times$	Probability of Loss Following Penetration	(4)
computed by	Equation (3)		Sections 1 and 2 MSCSurv™		Section 3 MSCSurv™	
equal to	e^{-Fat}		$\frac{\text{No. Penetrations}}{\text{No. Impacts}}$		$\frac{\text{No. Penetrations Causing Crew Loss}}{\text{No. Penetrations}}$	
Note:	"First term" of Equation (3)				"Second term" of Equation (3)	

As shown above, the first term of equation (4) is calculated from the standard "probability of impact" relation described in equation (3). Note that this is the only term in which the element of time need be addressed (the second and third terms are time independent). Equation (3) shows that this term requires knowledge of the duration of spacecraft time in orbit (t), the flux impinging on the spacecraft (f), and the "exposed area" of the spacecraft to orbital debris (a). The next section will discuss how the "exposed area" of the spacecraft can be derived from the geometry of the spacecraft and the distribution of orbital debris approach angles.

The "second term" in equation (4), the probability of penetration given an impact, $P_{pen/impact}$, is computed by dividing the total number of penetrations observed by the total number of impacts simulated. By the law of large numbers,[54] "the relative frequency of the event is almost sure to be close to the (actual) probability of the event when the number of trials is large." Thus, as the total number of penetrations is increased, the second term computed by MSCSurv™ should converge to a central value representing the "mean" $P_{pen/impact}$. In a similar fashion the third term in equation (4), the probability of loss given a penetration, $P_{loss/pen}$, is computed by dividing the total number of penetrations where one or more crew is lost by the total number of penetrations observed. Over a sufficiently large sample size, its value should also converge to a mean $P_{loss/pen}$. Unless there is something inherently unstable in the model, the overall probability of crew or spacecraft loss should also converge to a central value.

As stated earlier, the primary objective of this report is a discussion of the probability of crew or spacecraft loss following a penetration by orbital debris; given this, the term of real interest to this investigator is the $P_{loss/pen}$. However, the first two terms in equation (4) can be verified through use of other NASA computer models (such as BUMPER™), and are expected to influence the absolute value for $P_{loss/pen}$. Verification of the correct absolute values for the P_{impact} and the $P_{pen/impact}$ from MSCSurv™ will lend confidence to the overall value for $P_{loss/pen}$. Thus, the first and second terms of equation (4) will be computed using MSCSurv™ as a separate exercise and discussed under the "Validation and Verification of Results" section.

A. The MSCSurv™ Impact Model

The first section of the MSCSurv™ computer program (appendix A) draws random numbers to simulate orbital debris impact parameters of diameter, velocity, approach angle, spacecraft impact location, and relative obliquity of impact with spacecraft. This is accomplished by comparing the drawn random numbers with cumulative distributions for debris sizes between 0.3 and 3 cm, 37 approach angles, and exposed (line-of-sight) areas of the spacecraft to each approach angle.

1. Probability Distribution for Debris Diameter

The relative probability distribution of orbital debris diameters impinging on a spacecraft can be determined directly from the Kessler equations (equation (4) and (5)). Since the distribution of debris sizes is dependent upon spacecraft altitude, orbital inclination, and solar flux, some assumption for these parameters is required prior to assembly of the diameter distribution function. For this problem, the spacecraft altitude is assumed to be 398 km, the orbital inclination is assumed as 28.5°, year of operation as 2000, and the solar flux as 70 Janskys ("standard" U.S. LEO values).

Figure 1 shows that a spacecraft is far likelier to be hit by a "small" (less than 1-mm diameter) orbital debris particle than a "large" particle. Experience with the design and reaction of typical spacecraft structures indicates that there is a lower limit on the size of debris particle that can (at worst case) penetrate the spacecraft interior. In order to limit the total number of random numbers drawn to simulate "dangerous" debris to a reasonable value, it is advantageous to limit the program's cumulative distribution for debris to those debris sizes that could possibly penetrate the spacecraft. In a similar fashion, there is an upper limit to the size of large debris that can be "reasonably" expected to impact the spacecraft during its lifetime. An upper limit on debris diameter of less than around 0.01-percent probability of impact during the spacecraft lifetime appears to be a reasonable value on which to base a cumulative distribution function range.

The shield performance for this study example is assumed to be equal to the ballistic limit curve shown in figure 5. This results in a lower debris limit of 0.3-cm diameter. An upper debris diameter limit of 3.0 cm is assumed based on the low probability of this sized particle (or larger) impacting a large, long-lived spacecraft.

Based on these assumptions, a cumulative probability distribution for debris diameters between 0.3 and 3.0 cm has been formulated from the Kessler debris equations as data file "PROBDIA.DAT," shown in appendix B. The first column in PROBDIA.DAT represents the diameter of the impacting particle in centimeters; the second is its cumulative probability of occurrence. This data file is read into the simulation program in lines 11 through 20 of MSCSurv™ (appendix A).

2. Forming the Geometric Model

The spacecraft geometry chosen for this study is based on NASA's (1992) S.S. *Freedom* manned module configuration (fig. 10). This eight module cluster is expected to begin operation as a "Permanently Manned Configuration" (PMC) in the year 2000. For this study, the modules are assumed to be flying in a stable, 0° pitch, roll, and yaw flight mode with respect to the velocity vector (close to the expected S.S. *Freedom* flight mode). Based on NASA's orbital debris environment model, orbital debris will approach the modules in a roughly 180° arc stretching from the $+X$ to the $-X$ axis within the "X–Y" plane. That is, the orbital debris will appear to approach the manned module cluster from the "front," "port," and "starboard" sides only, not the "back" or the "top" of the cluster. The spacecraft velocity vector is parallel to the $+Y$ axis (long axis of the U.S. Lab, Hab, JEM, and ESA modules).

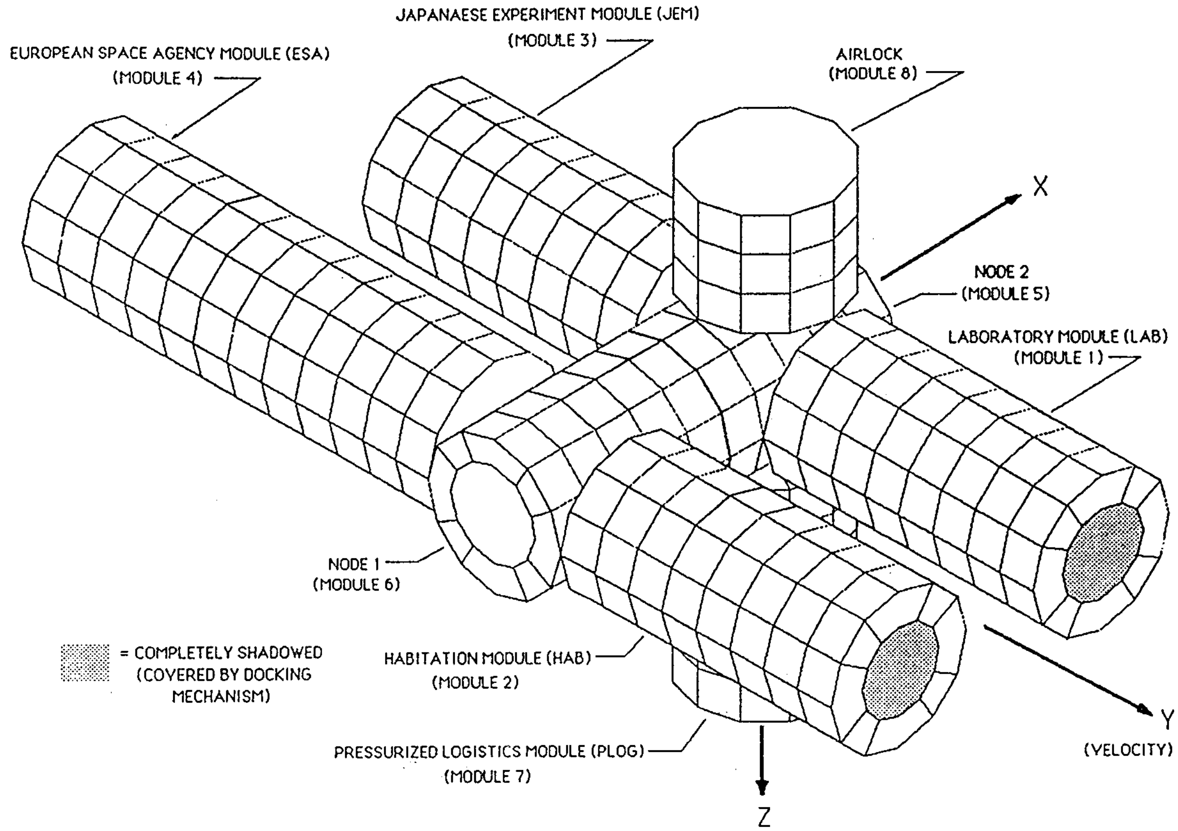


Figure 10. Spacecraft geometry for study example: eight module cluster.

Although the spacecraft modules are (in reality) cylinders with truncated endcones, the construction of a particle impingement model necessitates a simplification of this geometry. The smooth cylinder sides are modeled by a series of 12 joined flat plates, and 5 to 9 flat plates form the endcones. Each of these flat plates is called an element, and is given an associated number within each module; each module has no more than 100 associated elements. Figures 11 through 15 show the numbering scheme for these elements. Note that each element contains roughly the same surface area; they are identically the same on the cylinder sides. Note also that the width of the cylindrical elements are all 42 in (along the axis of the cylinder). This is an important consideration, because all of the manned modules are lined with internal equipment racks, usually of 42-in individual lengths.

Thus, by choosing the exterior geometry with care, it is possible to associate not only individual external shield configurations, but also discrete individual internal equipment "thicknesses" with each element area. This model feature is attractive in the large degree of flexibility it allows in examining the effects of alternate internal equipment configurations on $P_{\mathrm{loss/pen}}$.

Note from figures 11 through 15 that certain module areas are not numbered by elements. Specifically, the endcones and the "inboard" sides of the JEM (module 3) and ESA (module 4) and the endcones of the PLM (module 7) and Airlock (module 8) are not numbered. This is because these areas are completely "shadowed" (or nearly so) from direct impact due to adjoining modules or by their individual orientation to the highly directional debris flux.

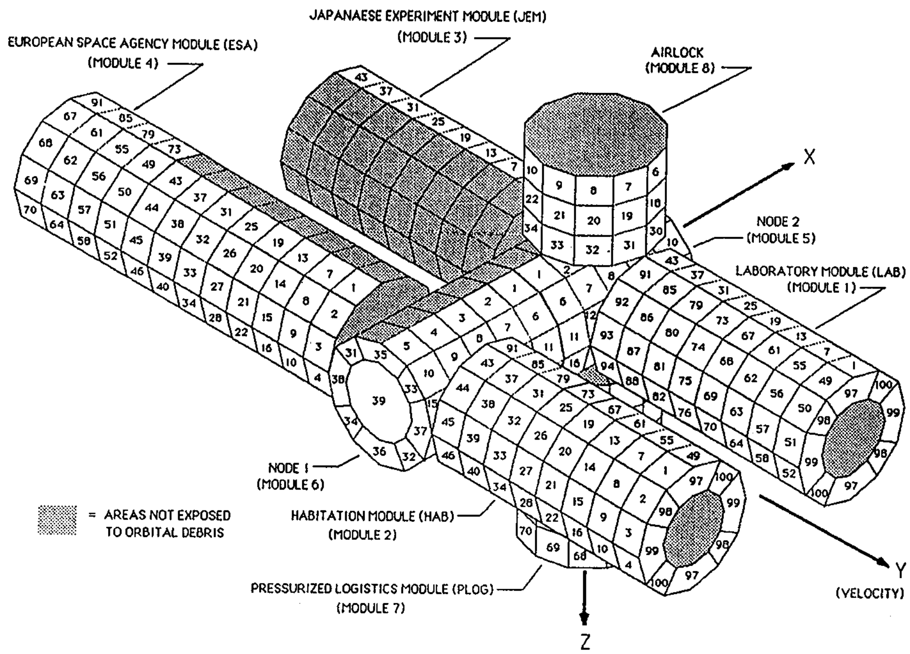


Figure 11. Element numbering scheme for each module (isotropic view).

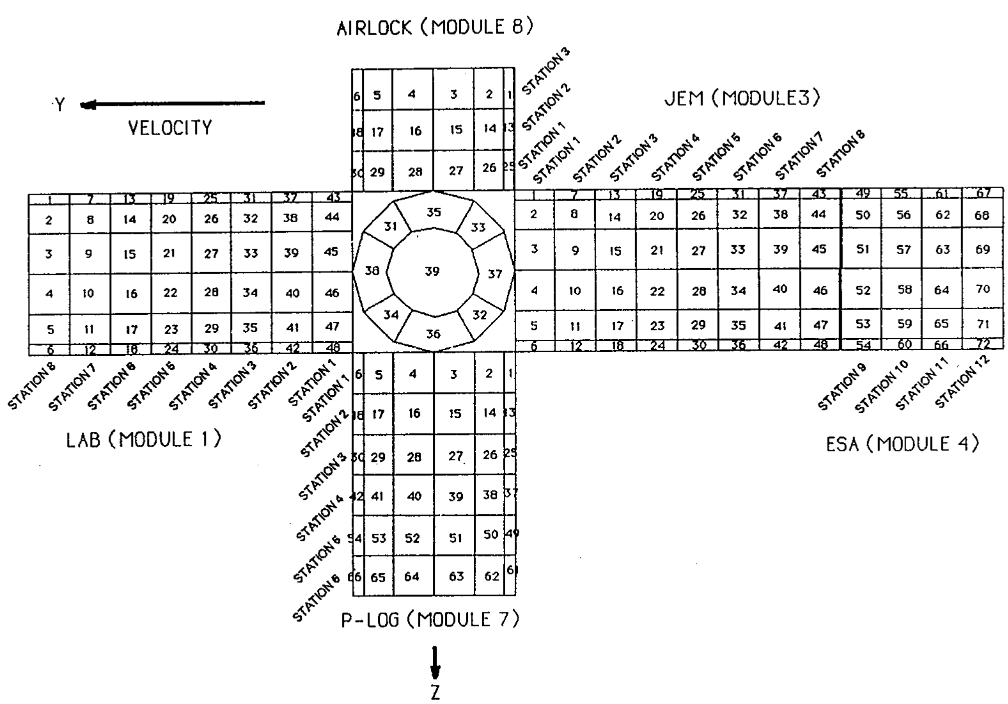


Figure 12. Element numbering scheme for each module (port side view).

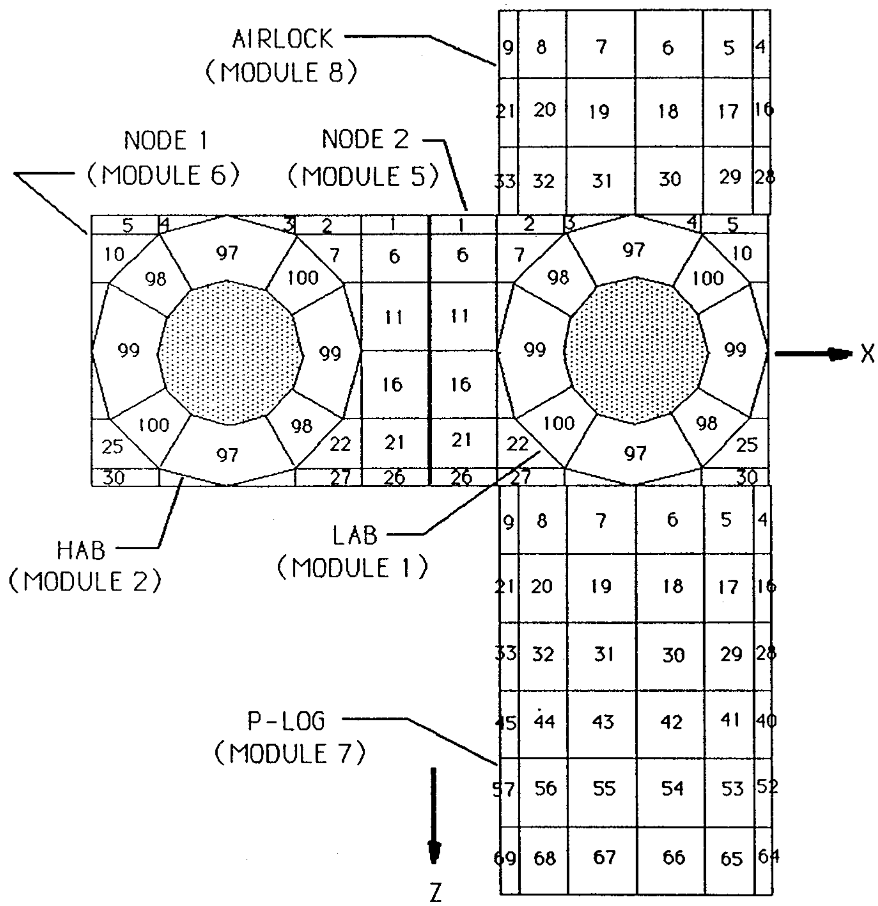


Figure 13. Element numbering scheme for each module (front view).

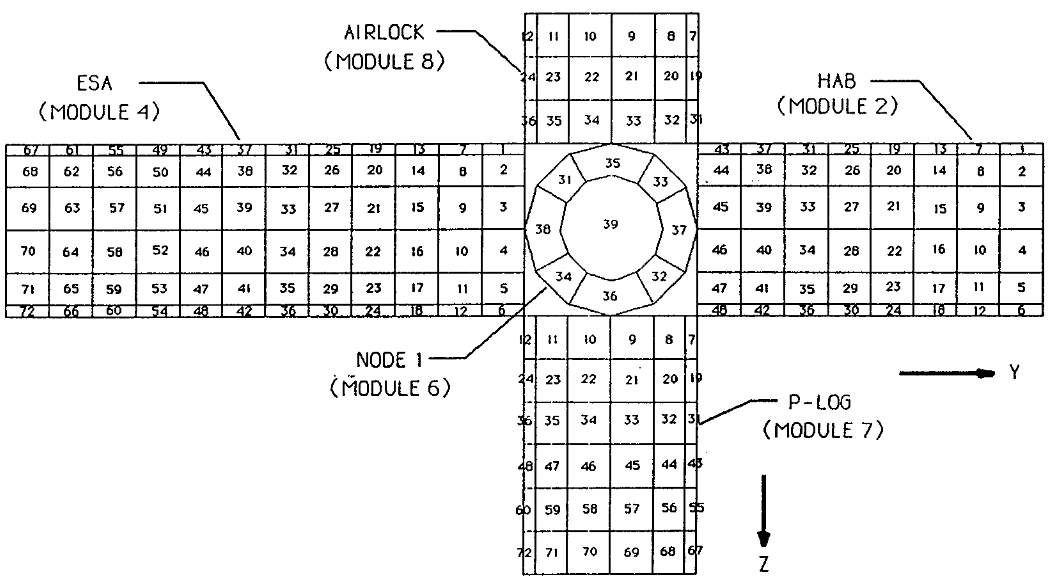


Figure 14. Element numbering scheme for each module (starboard view).

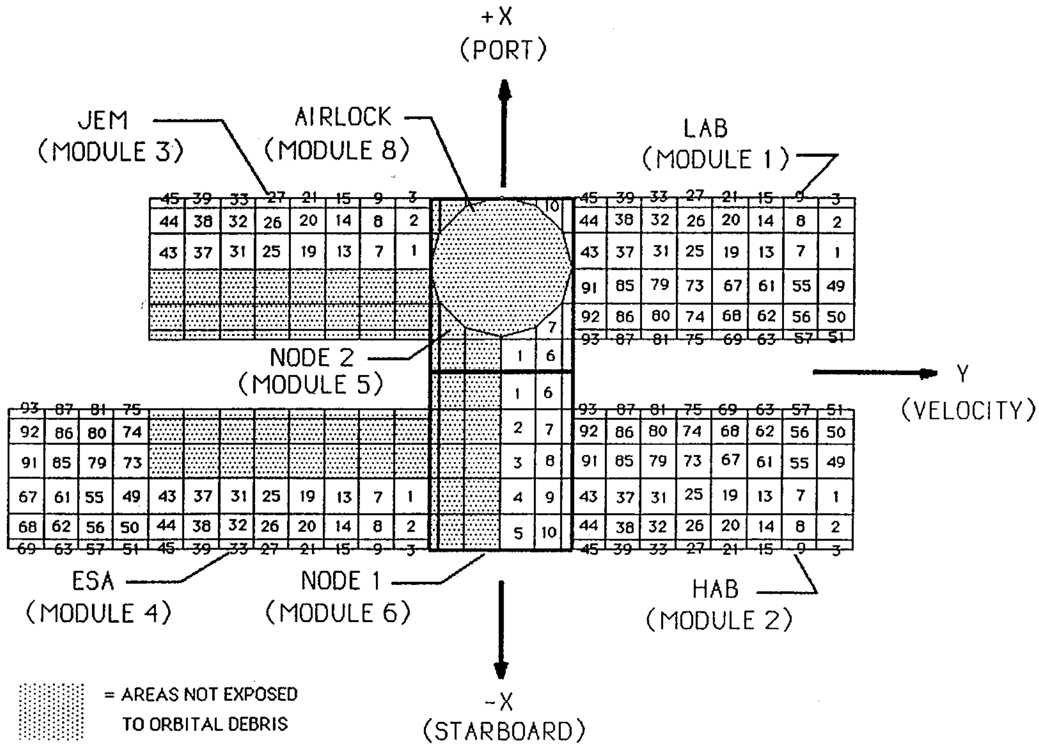


Figure 15. Element numbering scheme for each module (top view).

3. Exposed Areas and Orbital Debris Velocity Distribution

Having established a physical geometry for each of the spacecraft manned modules, the next step is to compute the exposed area of each element "visible" to orbital debris coming from individual (discrete) directions over a 180° arc. The average exposed area for each module is the product of the exposed area of each element times the relative probability of orbital debris coming from that direction, summed over all of the possible approach directions and elements, as described in equation (4):

$$\text{Average Exposed Area} = \underset{j=1}{\overset{j=A}{\text{SUM}}} \{ \underset{i=1}{\overset{i=N}{\text{SUM}}} \text{Area}(i,j) \times \text{Prob}(j) \} , \tag{5}$$

where

Area(i,j) = exposed area of element i "visible" to orbital debris approaching from direction j

Prob(j) = relative probability of orbital debris approaching from direction j

N = number of elements for each module

A = Number of directions from which orbital debris can arrive (37, in this case).

Of course, many elements within each module present "zero" exposed area to certain incoming debris directions. For example, figure 15 shows that only elements 1 through 48 of the U.S. Lab (module 1) show exposed area to orbital debris arriving from the $+X$ (port) direction; elements 49 through 100 do not show exposed area to debris approaching from this direction.

For this study, the 180° arc over which orbital debris may approach the spacecraft is divided into 37 discrete angular increments of 5° each (0°, 5°, 10°, etc. to 180°). Each discrete approach direction is assigned a relative probability of orbital debris "occurrence" based upon the Kessler flux equations described in references 2 and 3. As discussed in section II, a constant orbital debris approach velocity (relative to the spacecraft) is associated with each discrete approach angle. Table 6 lists the relative probability, cumulative probability, and constant relative velocity associated with each of the approach directions for the orbital altitude and inclination associated with this example problem.

Table 6. Distribution of orbital debris approach angles and velocities.

Approach Direction	Approach Angle from +*X* (°)	Velocity (km/s)	Relative Probability	Cumulative Probability
1	0 (+*X*)	0.33	0.0000	0.0000
2	5	1.34	0.0000	0.0000
3	10	2.67	0.0037	0.0037
4	15	4.00	0.0097	0.0134
5	20	5.25	0.0213	0.0347
6	25	6.50	0.0372	0.0719
7	30	7.70	0.0507	0.1226
8	35	8.83	0.0540	0.1766
9	40	9.90	0.0582	0.2348
10	45	10.90	0.0544	0.2892
11	50	11.80	0.0575	0.3467
12	55	12.61	0.0611	0.4078
13	60	13.34	0.0543	0.4621
14	65	13.95	0.0322	0.4943
15	70	14.47	0.0044	0.4987
16	75	14.87	0.0013	0.5000
17	80	15.17	0.0000	0.5000
18	85	15.34	0.0000	0.5000
19	90 (+*Y*)	15.40	0.0000	0.5000
20	95	15.34	0.0000	0.5000
21	100	15.17	0.0000	0.5000
22	105	14.87	0.0013	0.5013
23	110	14.47	0.0044	0.5057
24	115	13.95	0.0322	0.5379
25	120	13.34	0.0543	0.5922
26	125	12.61	0.0611	0.6533
27	130	11.80	0.0575	0.7108
28	135	10.90	0.0544	0.7652
29	140	9.90	0.0582	0.8234
30	145	8.83	0.0540	0.8774
31	150	7.70	0.0507	0.9281
32	155	6.50	0.0372	0.9653
33	160	5.25	0.0213	0.9866
34	165	4.00	0.0097	0.9963
35	170	2.67	0.0037	1.0000
36	175	1.34	0.0000	1.0000
37	180 (–*X*)	0.33	0.0000	1.0000

A spreadsheet program was utilized to calculate the individual exposed areas for each module and element by approach direction. Table 7 shows an example of this spreadsheet input for calculating exposed areas for the airlock module and approach direction 1.

Table 7. Example of "angles and areas" spreadsheet program for calculating exposed areas and obliquities.

Angles and Areas   Approach angle from *X* axis 5° Rad = 0.0873
Approach angle from *Y* axis 85° Rad = 1.4835
Approach angle from *Z* axis 90° Rad = 1.5708

FULL CYLINDRICAL ELEMENT AREA=1.178768

AIRLOCK ELEMENTS 1 TO 36   TOTAL OF ALL ELEMENTS = 27.22785

Element	Alpha-*x*	Beta-*y*	Gamma-*z*	Percent Shadow	Obliquity	Exp. Area
1	75	165	90	0	79.99980	0.204736
2	45	135	90	0	49.99981	0.757850
3	15	105	90	0	19.99983	1.107898
4	15	75	90	0	10.00027	1.161087
5	45	45	90	0	40.00020	0.903164
6	75	15	90	0	70.00019	0.403239
7	105	15	90	1	100.0001	0
8	135	45	90	1	130.0001	0
9	165	75	90	1	160.0001	0
10	165	105	90	1	169.9995	0
11	135	135	90	1	139.9997	0
12	115	165	90	1	120.3441	0
13	75	165	90	0	79.99980	0.204736
14	45	135	90	0	49.99981	0.757850
15	15	105	90	0	19.99983	1.107898
16	15	75	90	0	10.00025	1.161087
17	45	45	90	0	40.00020	0.903164
18	75	15	90	0	70.00019	0.403239
19	105	15	90	1	100.0001	0
20	135	45	90	1	130.0001	0
21	165	75	90	1	160.0001	0
22	165	105	90	1	169.9995	0
23	135	135	90	1	139.9997	0
24	115	165	90	1	120.3441	0
25	75	165	90	0	79.99980	0.204736
26	45	135	90	0	49.99981	0.757850
27	15	105	90	0	19.99983	1.107898
28	15	75	90	0	10.00025	1.161087
29	45	45	90	0	40.00020	0.903164
30	75	15	90	0	70.00019	0.403239
31	105	15	90	1	100.0001	0
32	135	45	90	1	130.0001	0
33	165	75	90	1	160.0001	0
34	165	105	90	1	169.9995	0
35	135	135	90	1	139.9997	0
36	115	165	90	1	120.3441	0

An integral part of calculating the exposed area of each element is to determine the relative angle between its normal surface vector and the approach vector of the incoming debris. This relative angle of impact is commonly referred to as the obliquity. It is computed by the following formula (equation (5)):

$$\text{Obliquity} = A\text{COS}\ \{(\text{COS}\ X1 \times \text{COS}\ X2) + (\text{COS}\ Y1 \times \text{COS}\ Y2) + (\text{COS}\ Z1 \times \text{COS}\ Z2)\}\ , \qquad (6)$$

where

$X1$ = angle between X axis and angle 1 (approach vector)

$X2$ = angle between X axis and angle 2 (surface normal)

$Y1$ = angle between Y axis and angle 1 (approach vector)

$Y2$ = angle between Y axis and angle 2 (surface normal)

$Z1$ = angle between Z axis and angle 1 (approach vector)

$Z2$ = angle between Z axis and angle 2 (surface normal).

The exposed element area for each approach direction is computed through multiplying the full element surface area by the cosine of the obliquity. The obliquity value is itself of great importance in the later computation of whether or not individually generated particles penetrate the modules, as will be discussed later.

Table 8 lists the exposed areas calculated for each of the eight modules by approach direction and in total. This incremental module area (by approach direction) may be divided by the total eight module area (for this approach direction) to determine the relative probability of each module being impacted by a debris particle approaching from this direction. In the same way, the relative exposed area of each element can be divided by the total exposed area for each module to calculate the relative probability of element impact by a debris particle approaching from a particular direction.

The probability of debris impact on the overall module cluster by approach direction is not simply a function of the distribution of debris particles by approach direction i (this would only be true if the module cluster had the same exposed area to every individual approach angle). Rather, it is a function of the product of the exposed area of the module cluster for each approach direction and the relative probability of debris approaching from this angle, as shown in equation (6):

$$P\text{impact}_i = \frac{[\text{Area}_i] \times [P\text{approach}_i]}{\left\{\sum_{i=1}^{i=37} \text{Area}_i / 37\right\}}\ , \qquad (7)$$

where

$P\text{impact}_i$ = probability that debris impacts from approach direction i

Area_i = module cluster exposed area for approach direction i

$P\text{approach}_i$ = probability that debris approaches from direction i

$\sum_{i=1}^{i=37} \text{Area}_i / 37$ = module cluster exposed area averaged over all 37 approach directions.

Table 8. Exposed areas for eight module cluster by approach direction.

Exposed area of eight modules (m^2)

Approach Direction	LAB	HAB	JEM	ESA	NODE 2	NODE 1	PLOG	A/L	Total Area
1	36.4	0.0	36.4	18.2	9.4	0.0	27.3	13.6	141.5
2	37.2	2.1	36.2	15.4	10.7	0.2	27.2	13.6	142.9
3	37.7	4.2	35.8	13.4	11.4	0.5	26.9	13.4	143.6
4	37.9	6.1	35.1	10.1	11.5	0.2	26.3	13.1	140.8
5	37.8	8.4	34.2	7.7	11.7	0.0	26.9	13.4	140.3
6	37.5	10.1	33.0	4.5	11.5	0.0	27.2	13.6	137.6
7	36.8	11.9	31.5	1.5	11.3	0.0	27.3	13.6	134.2
8	35.9	14.2	29.8	0.0	10.9	0.0	27.2	13.6	131.9
9	34.7	15.9	27.9	0.0	10.4	0.0	26.9	13.4	129.4
10	33.2	17.3	25.7	0.0	10.0	0.0	26.3	13.1	125.9
11	31.5	18.7	23.4	0.0	9.4	0.0	26.9	13.4	123.5
12	29.5	20.5	20.8	0.0	8.7	0.0	27.2	13.6	120.6
13	27.4	21.0	18.2	0.0	7.8	0.1	27.3	13.6	115.6
14	25.0	21.2	15.3	0.0	6.9	0.8	27.2	13.6	110.4
15	22.4	21.0	12.4	0.0	5.9	2.2	26.9	13.4	104.5
16	19.6	19.6	9.4	0.0	4.9	6.2	26.3	13.1	99.5
17	16.7	16.7	6.3	0.0	4.6	6.3	26.9	13.4	91.2
18	13.7	13.7	3.1	0.0	6.3	7.3	27.2	13.6	85.1
19	10.6	10.6	0.0	0.0	6.5	6.5	27.3	13.6	75.3
20	13.7	13.7	0.0	4.7	7.3	6.3	27.2	13.6	86.7
21	16.7	16.7	0.0	9.4	6.3	4.6	26.9	13.4	94.4
22	19.6	19.6	0.0	14.1	6.2	4.9	26.3	13.1	104.2
23	21.0	22.4	0.0	18.6	2.2	5.9	26.9	13.4	110.8
24	21.2	25.0	0.0	23.0	0.8	6.9	27.2	13.6	118.1
25	21.0	27.4	0.0	27.3	0.1	7.8	27.3	13.6	124.7
26	20.5	29.5	0.0	31.3	0.0	8.7	27.2	13.6	131.0
27	18.7	31.5	0.0	35.1	0.0	9.4	26.9	13.4	135.2
28	17.3	33.2	0.0	38.6	0.0	10.0	26.3	13.1	138.8
29	15.9	34.7	0.0	41.8	0.0	10.4	26.9	13.4	143.3
30	14.2	35.9	0.0	44.7	0.0	10.9	27.2	13.6	146.8
31	11.9	36.8	0.0	47.3	0.0	11.3	27.3	13.6	148.5
32	10.1	37.5	0.0	49.5	0.0	11.5	27.2	13.6	149.5
33	8.4	37.8	0.0	51.3	0.0	11.7	26.9	13.4	149.7
34	6.1	37.9	0.0	52.7	0.2	11.5	26.3	13.1	148.2
35	4.2	37.7	0.0	53.8	0.5	11.4	26.9	13.4	148.0
36	2.1	37.2	0.0	54.4	0.2	10.7	27.2	13.6	145.6
37	0.0	36.4	0.0	54.6	0.0	9.4	27.3	13.6	141.5
Average Exposed Area	21.8	21.8	11.8	19.6	5.3	5.3	27.0	13.5	

Average eight module exposed area = 126.0 m^2

From these relationships, one can develop a strategy for simulating random particle impacts on the module cluster:

(1) Draw a random number to simulate particle approach angle (and associated particle velocity)

(2) Draw another number to simulate which module is impacted

(3) Draw another number to simulate which element is impacted.

This strategy for drawing random numbers to simulate individual module impacts is reflected in the "MSCSurv™" program as shown in appendix A. Appendix C shows the contents from a data file entitled "VELSTA.DAT," describing the cumulative probability of particle impact on the eight module cluster by approach direction and the corresponding relative velocity of debris particles associated with each direction. This distribution is based on equation (6) given the environment distribution shown in table 6 and the total exposed area for the module cluster shown in table 8. Lines 6 to 10 of MSCSurv™ read VELSTA.DAT, and go on to use these data in lines 220 through 225 to select the particle approach direction and velocity for each simulated impact.

Appendix D shows the contents from a data file entitled "PROBMOD.DAT" that describes the cumulative probability of each module being impacted for each of 37 approach directions. MSCSurv™ reads PROBMOD.DAT (lines 181 to 186), and uses these data in lines 250 through 265 to select the module for each simulated orbital debris impact. Note that the module will only be selected if the minimum possible diameter for penetrating the module shields is exceeded. In this way, computer run time is conserved through avoiding unnecessary calculations.

Appendices E through L show eight data files entitled LAB.DAT, HAB.DAT, ESA.DAT, JEM.DAT, NODE2.DAT, NODE1.DAT, PLOG.DAT, and ALOCK.DAT. The first column of each of these data files lists the cumulative probability of individual element impact for each of 37 approach directions within each of the eight modules in the example problem. In the second column, these files list the corresponding relative obliquity that impacting debris particles make with the individual element for each direction. MSCSurv™ reads these files in lines 22 through 180, and uses these data in lines 260 through 265 to select the impacted element within the module and the corresponding relative obliquity between element and incoming debris particle for each simulated impact. Note that all of the data files make use of a cumulative (not relative) probability distribution. This allows one to employ a conveniently short algorithm for association of random numbers with these orbital debris impact parameters.

B. The MSCSurv™ Penetration and Damage Model

The second section of MSCSurv™ determines whether or not the simulated particles impacting on the module cluster penetrate, and if so, it calculates the hole sizes made and depth of penetration into the module interior. This information is then passed along to section 3.F MSCSurv™ (crew loss model) to determine the likelihood of crew loss given a penetration.

As stated earlier, a ballistic limit curve describes the combinations of impact parameters (particle diameter, obliquity, velocity) that penetrate the module. Each shield typically has a unique ballistic limit curve. For this study case, all of the spacecraft surfaces are assumed to be covered with shields identical to that shown in figure 4. This Whipple shield has the general ballistic limit curve performance described in figure 5. This curve uses the Boeing interpolation ballistic limit curve for debris velocities below 7 km/s and the "Modified Wilkinson" ballistic limit relation above 7 km/s. The basis for these baseline ballistic limit relations is described in detail in reference 12. An important assumption within both of these ballistic limit relations is that all impact obliquities greater than 60° act as if the obliquity were identical to 60°. Without this assumption, the form of the relations would allow the critical diameter to approach infinity as the obliquity approached 90° from the target normal.

In lines 266 through 289, MSCSurv™ uses the impact parameters of velocity and obliquity for each simulated particle to calculate the critical diameter that would just penetrate the module pressure wall using the ballistic limit relations described above. If the simulated impact particle has a larger diameter than this critical diameter, the number of penetrations is incremented by one. If the selected diameter is less than the critical diameter for its associated velocity and obliquity, the program begins the selection process for a new impact particle.

Immediately following a "penetration," MSCSurv™ calculates the hole size resulting in the pressure wall. In doing this, MSCSurv™ uses a preliminary relation for oblique hole size given impact properties of particle diameter, velocity, and obliquity that appears in appendix M and in lines 290 through 305 of the program in appendix A. This oblique hole size relation was derived through collaboration between SSEIC and MSFC scientists, and is based in part on empirical data and in part on an expectation of Whipple shield penetration phenomenology in the nontestable (greater than 7 km/s) regime. The baselined oblique hole size relation listed in lines 290 through 305 of MSCSurv™ computes both a "major" (long axis) hole diameter and an "equivalent" hole diameter. This equivalent hole diameter may be thought of as the "circular average" of the major and minor hole diameters, and is used to find the equivalent hole area.

Figure 16 shows the "equivalent" hole diameters resulting from a variety of debris diameters and velocities impacting simple Whipple shields at 0° and 60° obliquity. MSCSurv™ uses independent regressions based on figure 16 for each of 14 possible discrete velocities in order to increase the precision of the hole size predictor (R^2 greater than 0.98 for each regression detailed in lines 290 through 305).

Because of the lack of hole size data, this oblique hole size relation is extremely preliminary in nature, and is used here primarily because of the lack of other comprehensive hole size models suitable for use throughout the wide velocity range (2 to 15 km/s), diameter range (0.3 to 3 cm), and obliquity range (0° to 90°) associated with orbital debris impacts. It is likely that the hole size (and crack size) resulting in a test sample is somewhat different than that resulting in an actual pressurized module wall (where wall curvature, stress, and other local structure may affect the resulting wall damage). However, it may be argued that the high energy nature of the penetration phenomena "dwarfs" these local effects to the extent that it is reasonable to ignore them.

To determine the sensitivity of the $P_{loss/pen}$ term to the hole size model chosen, an alternative hole size relation (the Burch D_{90} model[11]) was also used to compute hole size following a penetration. Note that the Burch hole size predictor, located in lines 305 through 310 of MSCSurv™, has no term to account for particle obliquity. While his "Multiplate Damage Study" noted that the obliquity of the impact did indeed affect the hole size, he made no attempt to incorporate the complex phenomena associated with oblique impacts into his empirical hole size model. A more comprehensive test program to determine a more accurate oblique hole size predictor is highly recommended.

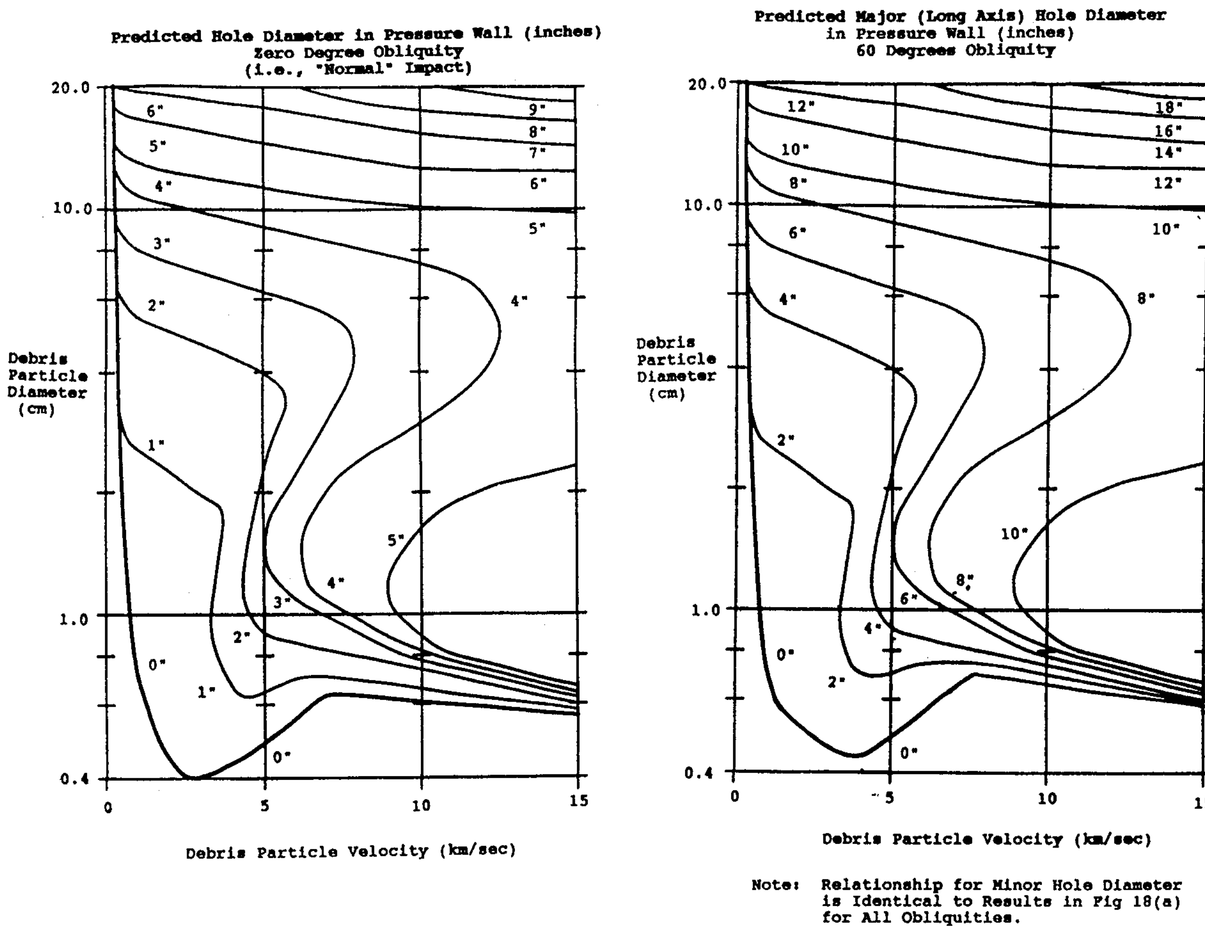


Figure 16. Oblique hole size as a function of debris diameter and velocity at 0° and 60° obliquity.

MSCSurv™ follows the calculation of hole size with a calculation of maximum crack size following a penetration. This calculation is integral to determining whether unstopped crack propagation occurs in the module wall. Data for crack size following a module wall penetration are also extremely limited. Crack size data from a variety of tests made at MSFC, at the University of Alabama in Huntsville, and by Boeing Aerospace at the University of Dayton Research Facility are summarized in figure 17 as a function of observed hole diameter. Note that the crack size can vary significantly for a given hole size.

A comprehensive, independent (and accurate) model for the maximum tip-to-tip crack size that results from a penetration is of equal importance to an accurate hole size model for determining the likelihood of crew loss given a penetration. This relation should ideally use the parameters of debris diameter, velocity, and obliquity as direct inputs. However, because figure 17 shows that maximum crack size generally increases with hole size, a preliminary dependent model for crack size could be generated using the independent hole size model as its direct input. Given the sparsity of data required to form an independent crack size model, MSCSurv™ uses a crack size model that uses hole size as its input parameter.

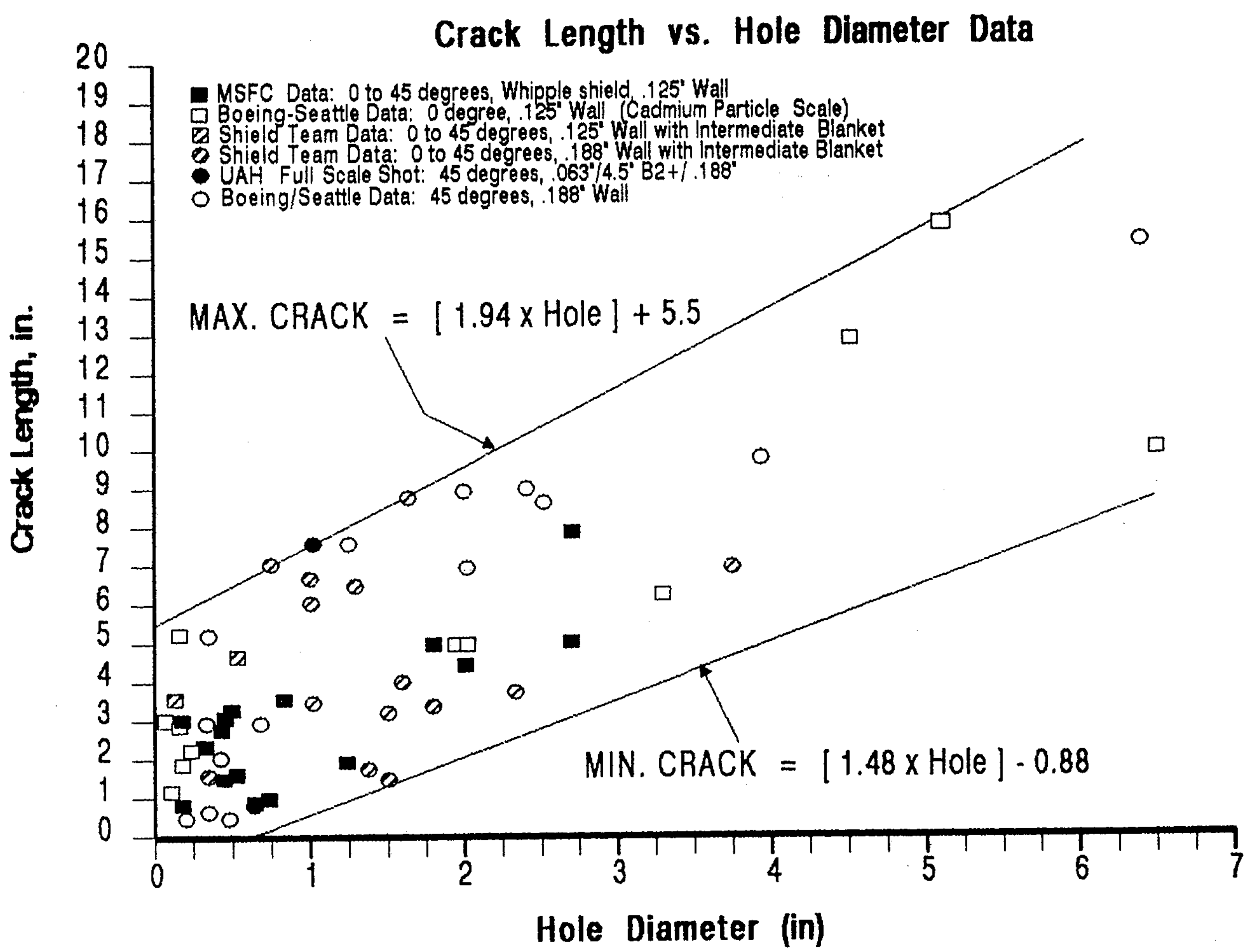


Figure 17. Crack size as a function of hole size.

Between lines 211 and 220, MSCSurv™ queries the user for a hole size crack "multiplier"—a constant factor (based on data shown in fig. 17) that is multiplied by hole size to obtain crack size for each simulated impact. If the user selects the unique input of "0.3," MSCSurv™ randomly selects a constant multiplier between the maximum and minimum observed crack size (fig. 17) for each individual hole size generated. For example, if a 2-in hole is randomly generated, MSCSurv™ may select a corresponding tip-to-tip crack size anywhere between 2 to 9 in.

In order to check the sensitivity of the $P_{loss/pen}$ result due to this important hazard, MSCSurv™ offers an alternative crack formation model based on the total impact energy impinging on the module exterior. Figure 18 shows that a 7-in critical crack may be formed with total impact energies varying from 28,000 to 70,000 ft-lb; a 12-in crack could be formed with energies varying from 60,000 to 100,000 ft-lb.

This "energy" model was based largely on limited data from a modified, "advanced" Whipple shield design employing a Nextel/Kevlar blanket between the bumper and pressure wall. Because this design is so closely associated with the formation of the energy model, it is probably more properly applied to this advanced shield design than the "baseline" Whipple bumper. Despite the somewhat low confidence in this model's fidelity, it should be useful in estimating the sensitivity of $P_{loss/pen}$ to the critical crack model chosen.

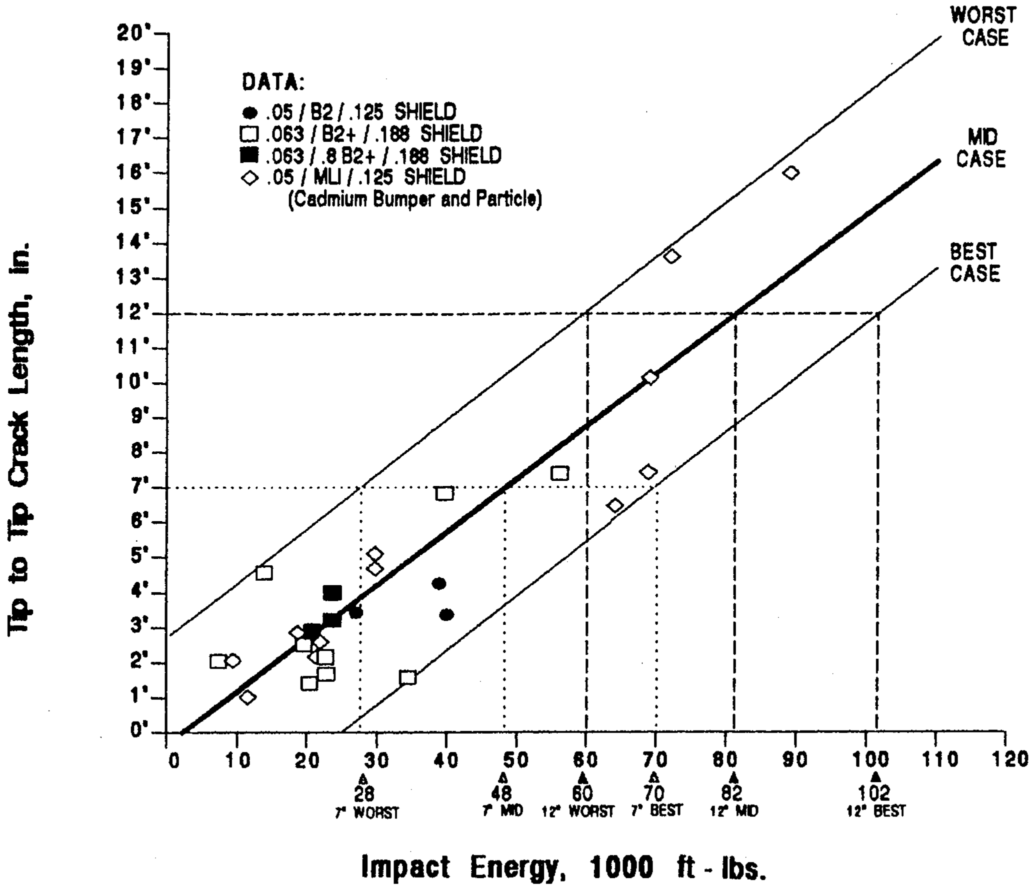


Figure 18. Crack length versus total impact energy.

By the law of large numbers[54] if a "sufficient" number of impacts are generated, a converging hole size and crack size distribution for each module will result. A hole size distribution for each of the eight modules is shown in table 9. Following its formation, this distribution was adopted by the space station engineering integration contractor as its baseline for its independent calculation of probability of crew loss following a S.S. *Freedom* manned module perforation in April 1993. As mentioned in section III, SSEIC uses these hole size distributions for determining the number of unzipping cases, the depressurization rate, and internal hazard levels following individually simulated penetrations.

Finally, MSCSurv™ computes the penetration depth of the randomly simulated particles into the interior of the eight spacecraft manned modules. To accomplish this, a simple method to describe the amount of and penetration resistance of interior equipment located behind each of the individual module exterior elements was required. Hypervelocity test experience tells one that the interior resistance to penetration following wall perforation is dependent upon the medium through which the fragments travel as well as the energy and composition of the fragment debris cloud. Figure 19[55] shows an artist's sketch for a possible interior equipment layout for the U.S. Laboratory module within S.S. *Freedom.* Figure 20[56] shows just one of the many proposed layouts of the individual equipment racks within the S.S. *Freedom.* As of the date of this study, the interior layout of the S.S. *Freedom* manned modules has not yet been finalized.

Table 9. Distribution of "effective" and "major" hole diameters for eight module cluster.

Oblique Hole Size Distribution (Williamsen, 3/25/93)

Effective Diameter = ((Minor Dia/Cos Obl)*(Minor Dia))**.5

Hole Size (in)	LAB	HAB	ESA	JEM	N2	N1	PLM	A/L
0 to 1	0.15	0.15	0.19	0.21	0.14	0.18	0.16	0.16
1 to 2	0.10	0.10	0.12	0.12	0.11	0.13	0.11	0.11
2 to 3	0.10	0.10	0.10	0.11	0.08	0.11	0.12	0.12
3 to 4	0.11	0.11	0.11	0.10	0.08	0.10	0.12	0.12
4 to 5	0.09	0.09	0.09	0.09	0.08	0.10	0.12	0.12
5 to 6	0.19	0.19	0.11	0.10	0.10	0.12	0.26	0.26
6 to 7	0.13	0.13	0.13	0.13	0.15	0.15	0.07	0.07
7 to 8	0.13	0.13	0.15	0.15	0.08	0.12	0.04	0.04
Over 20	0	0	0	0	0.18	0	0	0

Distribution of Major Diameters for Oblique Holes

Basis for Crack Size Distribution (Williamsen, 3/25/93)

Hole Size (in)	LAB	HAB	ESA	JEM	N2	N1	PLM	A/L
0 to 1	0.12	0.12	0.17	0.17	0.16	0.16	0.14	0.14
1 to 2	0.09	0.09	0.12	0.12	0.13	0.13	0.11	0.11
2 to 3	0.09	0.09	0.07	0.07	0.07	0.07	0.11	0.11
3 to 4	0.09	0.09	0.08	0.08	0.09	0.09	0.12	0.12
4 to 5	0.08	0.08	0.06	0.06	0.09	0.09	0.10	0.10
5 to 6	0.11	0.11	0.09	0.09	0.09	0.09	0.22	0.22
6 to 7	0.13	0.13	0.07	0.07	0.08	0.08	0.07	0.07
7 to 8	0.08	0.08	0.06	0.06	0.07	0.07	0.05	0.05
8 to 9	0.05	0.05	0.06	0.06	0.08	0.08	0.03	0.03
9 to 10	0.06	0.06	0.07	0.07	0.06	0.06	0.02	0.02
10 to 11	0.10	0.10	0.13	0.13	0.08	0.08	0.03	0.03

Unfortunately, penetration equations have simply not been derived to cover even a portion of the probable combinations of material types, thicknesses, and distributions of equipment expected to exist within these complex spacecraft walls. Figure 19 indicates that these materials can include wiring, electronic components, utility lines (cabin air, water, etc.), graphite and/or aluminum support structure, food, uniforms, and other stores.

However, a number of penetration equations have been derived that predict with some confidence the number of equally spaced, equally thick aluminum plates that are penetrated by aluminum impact particles. One empirical model that appears to give good results in this area is the Burch equation.[11] Given the input parameters of particle velocity and diameter, target bumper thickness, standoff, and rear wall thickness, the Burch equation predicts the number of spaced aluminum plates equal in thickness to the rear wall that are expected to be penetrated by the impacting particle.

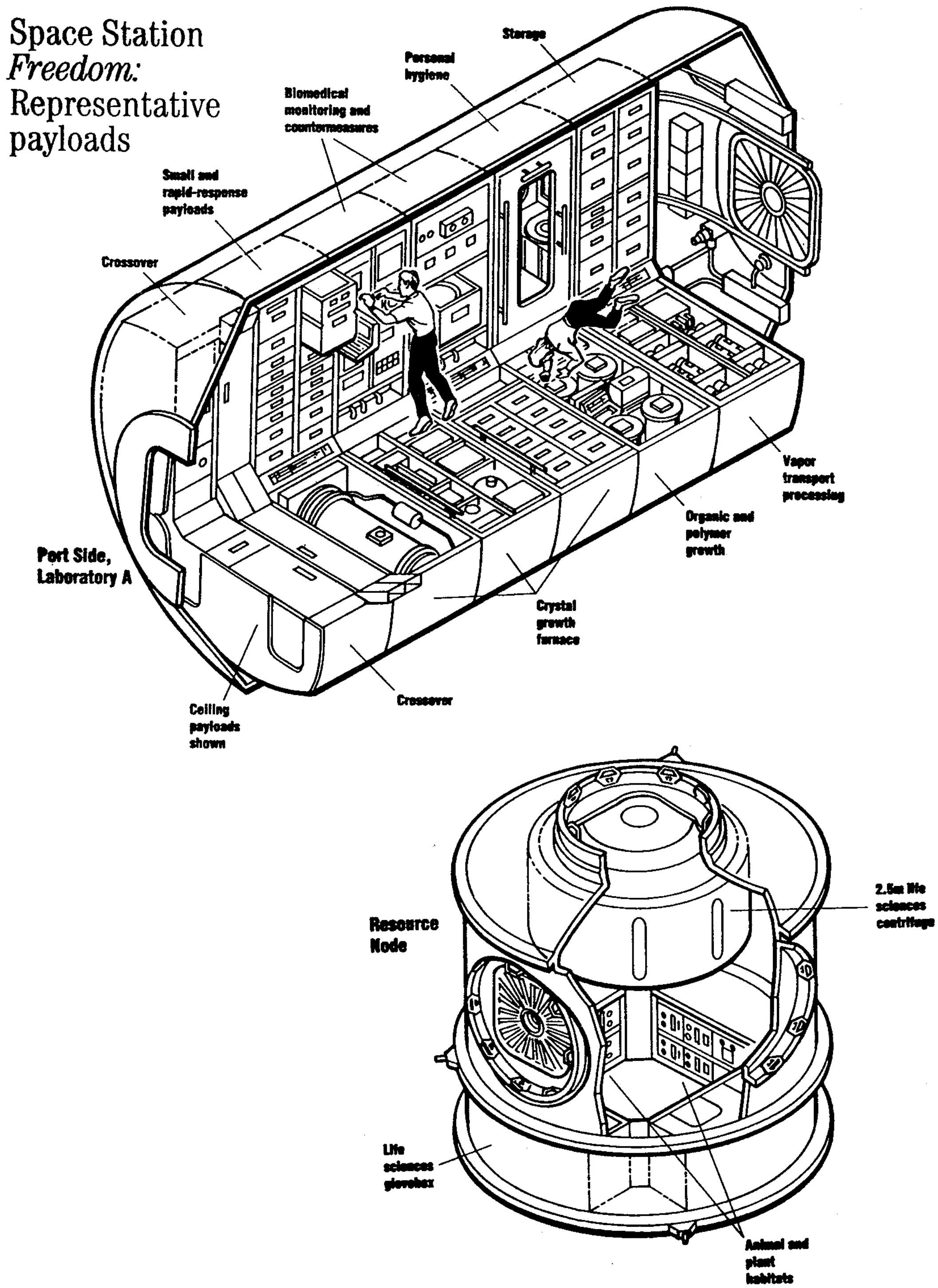


Figure 19. "Typical" interior module equipment layout.[55]

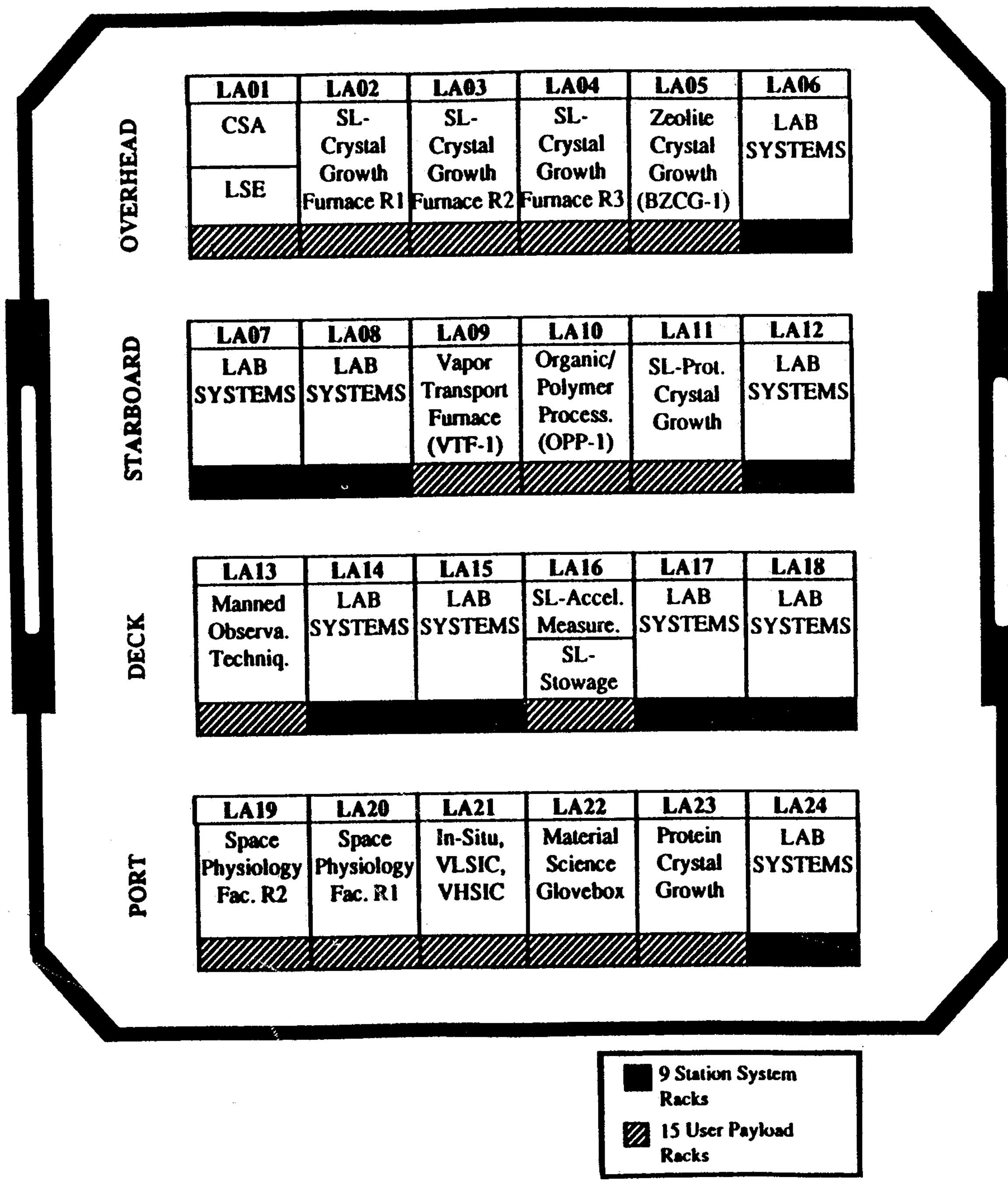


Figure 20. Example of proposed equipment rack layout within S.S. *Freedom* laboratory module.[56]

For this exercise, the measure of local interior resistance to penetration following wall perforation will be stated in terms of an "equivalent areal density" of spaced aluminum plates. As with many other portions of this exercise, this simplifying assumption obviously requires some "judgment" as it is applied to individual equipment locations along the spacecraft's interior walls. A precise description of individual equipment locations along S.S. *Freedom* walls does not yet exist, and makes a model based upon this configuration impossible to create at this time. Additionally, an overestimate of the amount of interior equipment will add to the optimistic nature of what must already be an incomplete analysis of $P_{loss/pen}$.

Because of these uncertainties, the baseline model includes no interior equipment resistance. However, the sensitivity analyses will include a model for interior penetration resistance using an areal equivalent of two 0.125-in plates behind each external element. This alternative assumption is largely based upon the existing design of the interior equipment for the S.S. *Freedom*, shown in figure 21.[57 58] A secondary reason for choosing the 0.125-in equivalent plate thickness was to be consistent with the Burch interior penetration equation, which describes the number of interior plates penetrated in terms of the pressure wall thickness (0.125-in aluminum, in this study case).

MSCSurv™'s capability to correlate an individual internal equipment "thickness" with each of its external geometric elements opens up the possibility of placing "thicker" internal equipment racks in positions that will increase shielding of spacecraft occupants from internal fragment hazards. It also offers the capability to compute the improvement in crew safety offered by such military innovations as internal spall liners. By carefully positioning equipment racks and/or spall liners where debris is more likely to penetrate the spacecraft, spacecraft designers should be capable of identifying large reductions in crew injury through the use of MSCSurv™.

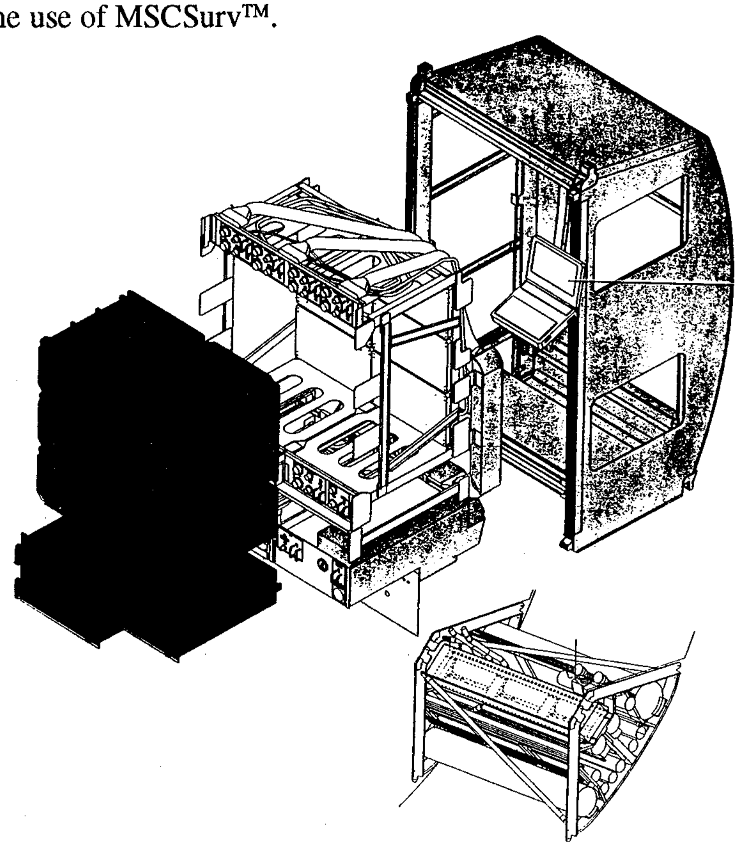


Figure 21. "Typical" space station internal equipment.[57 58]

This interior equipment assumption can be easily modified by changing the input file describing the number of interior "equivalent plates" behind each exterior element, if desired. The description of the individual equipment behind each exterior element is given in the data file SHIELD.DAT, found in appendix N. The first and second columns of this file list the module and exterior element number. The third column lists the interior "station number" corresponding to this element (discussed in the following section). The fourth column lists the type of shield that is located on the "exterior" of the spacecraft element (all the same for this study case). The fifth column of this data file lists the number of "equivalent" 0.125-in plates located behind the module exterior elements. These data are read into MSCSurv™ lines 187 through 193. The actual depth of penetration for each simulated debris perforation is computed in lines 361 through 365.

C. The MSCSurv™ Crew Loss Model

The remainder of MSCSurv™ is devoted to calculating the probability of crew loss following a simulated orbital debris penetration. For each penetration, this is accomplished through (1) determining which of the simulated hazards in the spacecraft (wall crack size, hole size, and internal penetration depth) exceed established critical levels, and if so, (2) seeing which of the crew members are physically near enough to the penetration for these hazards to cause their loss. Accurate assumptions for critical hazard levels, crew position, and escape time are essential.

Previous sections have detailed how the levels of three hazards associated with each penetration (wall crack size, hole size, and internal penetration depth) are derived from individual orbital debris particle and spacecraft impact characteristics. Each hazard can cause a unique mode of crew loss if it exceeds a critical level:

(1) Pressure wall cracking causes loss of the entire crew (and spacecraft) by explosive decompression if the crack exceeds a critical level and propagates unstopped.

(2) Internal penetration causes crew loss due to direct injury by fragments if the internal equipment is penetrated and the crew is near the penetrated area.

(3) Pressure wall hole size causes slow decompression and eventual crew loss of one or more crew members if the hole size causes hazardous loss of air prior to the crew's ability to escape and close the hatch on the depressurizing module. Note that crew members can be lost in modules other than the penetrated module if they fail to close the hatch on their own module in time.

The critical levels causing crew loss for each hazard were derived in earlier sections and are summarized in table 9.

MSCSurv™ operates in a "cascading" mode in determining overall $P_{loss/pen}$, as shown in figure 9. It first determines whether the initial crack created by impact is sufficient in size to propagate unstopped. If it is, then the loss of the entire crew is assumed for this penetration, and MSCSurv™ goes on to simulate a new debris impact. If the critical crack size is not exceeded, then MSCSurv™ checks to see if (and how many) crewmen are lost due to injury. For those crew not lost due to injury, MSCSurv™ checks to see if (and how many) crewmen are lost due to slow decompression. MSCSurv™ then sums the number of crew lost for each simulated penetration (if any) from these two sources and goes on to simulate a new debris impact. The $P_{loss/pen}$ is then taken as the total number of penetrations where one or more crew is lost divided by the total number of penetrations.

The critical crack hazard level is assumed to be 7 in for a 0.125-in wall and a 12-in crack for a 0.188-in wall.[52 53] Figure 18 shows that a 7-in critical crack may be formed with total impact energies varying from 28,000 to 70,000 ft-lb, and a 12-in crack could be formed with total impact energies varying from 60,000 to 100,000 ft-lb. In lines 351 through 360, MSCSurv™ compares the user-defined crack size or energy-based critical hazard level to either of these simulated penetration hazards, and sums those cases where a critical crack length or energy is exceeded.

The two remaining crew loss modes of "injury" and "slow decompression" (henceforth referred to as "decompression") both require a model for crew position versus time to be generated. MSCSurv™ randomly generates crew position versus time for each simulated penetration using two data files, PCREWMOD.DAT and POSITION.DAT, located in appendices O and P. Columns 2 through 5 of PCREWMOD.DAT list the module that each of the four crew members inhabits for each of the 24 h of the crew day. Column 1 lists the cumulative probability that the debris strike will happen during each of the 24 h (equal probability each hour). PCREWMOD.DAT is read into MSCSurv™ in lines 199 through 203 of MSCSurv™.

Column 3 of POSITION.DAT lists the cumulative probability that a crew member is at a particular station number (column 2) when he is located in a particular module (column 1). Each station number is a discrete 42-in increment of distance from the exit hatch of the module closest to the center of gravity of the eight module cluster, and corresponds to a cylindrical "segment" of the module. Columns 1 through 3 of SHIELD.DAT in appendix N relate module station numbers to element numbers for each of the eight modules in this study. POSITION.DAT is read into MSCSurv™ in lines 194 through 198.

The baseline crew distribution among modules given in PCREWMOD.DAT was formulated by SSEIC [52] through brief discussions with the NASA Johnson Space Center Operations Integration Office, and, as such, should be considered as the best available today (superior to that used by this author[14]). Because the factor of crew sleep position was identified as a large driver of overall crew safety, an alternate sleep position model (where all the crew members sleep in Node 1) will be studied to obtain the sensitivity of $P_{loss/pen}$ to this factor. This alternative data file, PCREWMO2.DAT, is located in appendix Q.

The position of each crew member within each module is assumed to be uniformly distributed among all of the module's stations over time for the baseline model (described within the data file POSITION.DAT). During sleep, the crew may be located in any of the stations within modules 1 and 2 (Lab and Hab modules). Two alternative models are offered here for sensitivity studies. The first uses a triangular distribution for crew station location over time, with each crew member being more likely to be close to the hatch (where inter-module travel would be most likely to "concentrate"). The second sensitivity model assumes that a crewman's position is uniformly distributed among module stations as in POSITION.DAT except when sleeping, when the crewman is located next to a hatch (for quick egress). This model assumption is described in line 405 of MSCSurv™.

Once the positions of each of the four crew members is selected for each impact, MSCSurv™ goes on to compute whether any crew are injured through exposure to the debris fragment spray. Note from table 9 that the critical level of fragment energy that is assumed to cause serious crew injury is quite low (58 ft-lb)[38] compared to the energy magnitudes of impacting debris particles (on the order of thousands of ft-lb, fig. 18). For this reason, MSCSurv™ assumes that any fragment cloud penetrating the internal equipment will have sufficient energy present to seriously injure the crew. MSCSurv™ also assumes that the internal module debris spray will spread laterally into equipment one station either side of the penetrated station (three stations, total). This assumption was derived from limited observations of the debris cloud spray angle (angle between edge of debris cloud and debris approach vector) following bumper penetration. This means that any crew member located at or next to a station number where the internal equipment is penetrated is automatically assumed to be injured. However, it is possible that the crew may survive the initial exposure to the debris spray, depending on the spread of the debris cloud, the level of energy remaining in the cloud and the severity of the crew's injuries. Additional test data is needed to determine these energy levels, spread angles, and the crew's exposure.

Given these uncertainties, several alternatives are examined within the sensitivity analyses:

(1) The internal debris cloud is contained within the penetrated crew station number (i.e., the internal debris spread is only one equipment rack wide).

(2) The crew is injured less than 100 percent of the time when exposed to the initial debris spray, and escape at an slower rate than uninjured crew. However, a percentage of these injuries later prove to be serious, causing loss of the crew.

In order to determine the probability of individual crew loss due to (slow) depressurization, several additional pieces of information must be input into MSCSurv™ by the user. The volume of air available prior to penetration for each crewman to breathe is a function of the total volume available to the individual crew member (i.e., hatch position) and the amount of spacecraft interior volume that is not occupied already by equipment (free air ratio).

The baseline model assumes that all hatches are open except those to modules 7 and 8 (the airlock and P-Log), so the total module volume of air available to the crew is the sum of the volume of modules one through six (22,469 ft^3) times the free air volume. An alternative assumption is that all of the hatches operate closed (and must be opened prior to crew escape from penetrated hatches. Each module's volume is listed in table 10. A second alternative assumption examined within this study was a "mixed" mode of hatch operation with hatches open during the crew members' "day" cycle and hatches closed during their sleep cycle (8 h). This operating mode was shown to increase crew safety considerably in reference 14 (fig. 8). The "free air ratio" is baselined as 70 percent, but may be as high as 95 percent. Both cases are examined in following sections.

Table 10. Module total air volume (empty).

Module	Volume	Module	Volume
1 - LAB	3,882 ft^3	5 - NODE 2	2,206 ft^3
2 - HAB	3,882 ft^3	6 - NODE 1	2,097 ft^3
3 - JEM	5,127 ft^3	7 - P-LOG	2,991 ft^3
4 - ESA	5,170 ft^3	8 - AIRLOCK	1,165 ft^3

When a module is penetrated, a "race" is begun between the slow depressurization of the module (and any connecting modules) and the crew's ability to "escape" the depressurizing area. In this case, the term "escape" refers to either the action of physically leaving the damaged module and closing the hatch on it (if the crew member is occupying the damaged module) or moving to the end of an undamaged module and closing the hatch on it (if the crew member is in an undamaged module). In the latter case, the trapped crew would be safe for only a limited time, requiring rescue or an alternate method of escape prior to losing the remaining oxygen in their separated module. MSCSurv™ does not include this possibility of "late" loss in its simulation.

The time required for the crew to escape is comprised of several discrete elements, including a delay time for discovering the leak and initiating movement, time to move to the hatch, and time to operate the hatch. Of course, these actions will be performed by weightless crew members that are likely to be in a state of confusion (at the very least). As such, the specific time values associated with each of these actions are difficult to obtain without an accurate crew simulation in the absence of gravity. Future studies to determine these values have been proposed by the NASA Safety and Mission Assurance Office using the NASA KC-135 aircraft. For the present, however, these values must be estimated. For this exercise, preliminary values for each of the components of escape time were arrived at through consultation with members of the MSFC Safety and Mission Assurance Office, the NASA Level 2 Program Office, and the Space Station Engineering and Integration Contractor.[59] These assumed escape time components are:

(1) Delay time to discover leak and initiate escape. When the crew is awake, this is baselined as 35 s; when the crew is asleep, the baseline is assumed to be 100 s. The longer delay time during the crew sleep period is due primarily to the extra time required to egress their sleeping restraints.

(2) Time to move to the hatch and begin closure. This is baselined as 30 s average for each module for a healthy crew member. For an injured crew that is conscious and capable of movement, the baselined time for movement to the hatch is increased to 60 s. Likewise, penetrations taking place between any crew member and the escape hatch is assumed to increase this crew member's movement time to 60 s (due to "hindrance" caused by possible equipment strewn into the aisle).

(3) Time to close the hatch. This is baselined at a maximum of 30 s. For the S.S. *Freedom*, this was an actual requirement levied against the hatch design, and as such has a higher degree of confidence associated with it than the other two components of escape time. As a corollary, the time required for the crew to open a closed hatch is also baselined at 30 s.

Because the baselined values for delay time and movement time are somewhat arbitrary, it is important to vary them in the sensitivity analyses in order to determine their effect on $P_{loss/pen}$. Accordingly, the operator may vary any of these "operational" assumptions by direct input as MSCSurv™ is initialized. Within the sensitivity analysis, the delay and movement times are cut approximately in half: the delay time is changed from 100 to 50 s, and the movement time is halved to 15 s (normal status) and 30 s (injured/hindered status).

Alternatively, the operator may input the rate of crew movement (in feet per second) for normal, injured, and hindered crew members. MSCSurv™ calculates individual crew movement time from these rates given the distance of each crew member from the hatch and the condition of the crew following each penetration. A rate of 0.5 ft/s equates roughly to our "nominal" escape time of 30 s for a 30-ft lab module (15 ft "average" escape distance/0.5 ft/s = 30 s); a rate of 0.25 ft/s equates roughly to 60-s escape time. These escape rates will be used within the sensitivity analyses to determine the effect of rate-based crew movement on $P_{loss/pen}$.

The time required for the modules to reach a critical depressurization limit is calculated using an isentropic "blowdown" equation described by Boeing,[46] and is listed in its entirety in line 405 of MSCSurv™. This equation assumes as a baseline that the temperature of the module air is 70 °F, the discharge coefficient is 0.9, the initial operating pressure is 14.7 lb/in^2, and the final pressure is 7.5 lb/in^2.[53] The discharge coefficient reflects the shape of the hole, and may vary somewhat with hole shape and petal size. As such, it is varied to a $C_d = 0.7$ within the sensitivity analyses. As shown in table 10, the final pressure following blowdown required prior to crew loss due to slow decompression could range as high as 9.5 lb/in^2 or as low as 3.0 lb/in^2, and is also varied within the following sensitivity analyses.

V. BASELINE AND SENSITIVITY ANALYSES

This section uses the MSCSurv™ simulation tool to compute the baseline probability of (one or more) crew loss given a spacecraft penetration ($P_{loss/pen}$), and determine its sensitivity to choice of input parameter(s). In "one-way" sensitivity analyses, each assumption and/or design parameter identified in the previous section will be varied individually to observe its effect on the final $P_{loss/pen}$. Following this, selected parameters will be grouped together to observe their interactions in determining $P_{loss/pen}$. Validation and verification of the developed simulation model and software tool will be discussed. At the conclusion of this task, those design and operational factors most effective in reducing $P_{loss/pen}$ will be identified.

Table 11 summarizes the baseline and alternative assumptions developed in the previous section. Each alternative assumption has a corresponding <number> highlighted in the table from <1> to <20>. Note that with a few exceptions, most alternative assumptions are more "optimistic" than the baseline (that is, can be expected to lower the overall $P_{loss/pen}$). Using "conservative" assumptions to form the baseline safety analysis is in keeping with NASA's general hazard analysis methodology.

The probability of (one or more) crew loss given an orbital debris penetration for the described eight module cluster is given in table 12 as 0.74. That is, a penetrating orbital debris particle could be expected to cause loss of at least one crew member in 74 of every 100 debris penetrations of the module cluster as a whole. Note that the $P_{loss/pen}$ values for each module vary from the total cluster value. The U.S. Lab module has the highest incidence of expected crew loss (0.83); the ESA module has a lower value (0.69); the P-Log and airlock have the lowest $P_{loss/pen}$ (0.66). This is due primarily to the lack of crew members in modules 7 and 8, where injury and slow depressurization losses amount to zero. Because modules 7 and 8 are unoccupied to such a large extent (and are, as such, not representation of "manned" spacecraft), the $P_{loss/pen}$ values reported hereafter will include the average of only modules 1 through 6. Given this footnote, the "baseline" $P_{loss/pen}$ value referred to throughout this study is 0.76 (table 12).

Recalling equation (4), one must multiply the $P_{loss/pen}$ by the probability of penetration given an impact ($P_{pen/impact}$) and the probability of impact (P_{impact}) to determine the actual probability of crew loss (P_{loss}) in a 10-year period. Table 13 reports these P_{loss} values, using the effective area values reported in table 8. Note that the P_{impact} of particles larger than 3 cm must be added to the P_{loss} output by MSCSurv™ to compute the total P_{loss}. This is because MSCSurv™ simulation is limited to particles from 0.3 to 3 cm in diameter (see appendix B). While they are scarce, it is clear from examination of the ballistic limit for this shield design (fig. 5) and the hole size relation (fig. 16) that debris particle impacts above 3-cm diameter can be reasonably expected to cause "automatic" loss of the crew. Thus, in these cases, the P[loss from 3-cm particles] = P[impact of 3-cm particles].

Table 11. Summary of baseline/alternative simulation assumptions.

	Baseline Assumptions	Alternative Assumptions	
Critical crack length	7-in critical crack prior to module unzipping	• 12-in critical crack • 24-in critical crack	<1> <2>
Hole size model	Oblique hole model	Burch hole model	<3>
Crack formation model	Crack size based on hole size	Crack size based on "normal" impact energy	<4>
Internal debris cloud spread	Three crew stations (racks) wide	One crew station (rack) wide	<5>
Lethality of debris cloud	Crew lost 100 percent of time if exposed to debris cloud	• 50-percent loss w/50-percent "late" loss • 10-percent loss w/10-percent "late" loss	<6> <7>
Structure of internal equipment	No internal equipment	Internal equipment with ave. areal density of 0.7 g/cm^2	<8>
Crew distribution among modules	SSEIC model (60)	• Node 2 sleep position	<9>
Crew position within modules	Uniform distribution	• Triangular distribution • Stationary sleep position	<10> <11>
Hatch position	Hatches open within six module cluster	• Hatches normally closed • Hatches closed at night	<12> <13>
Crew movement to hatch	30 s (normal), 60 s (hindered or injured)	• 0.5 ft/s (normal) 0.25 ft/s (hindered or injured) • 15 s (normal), 30 s (hindered or injured)	<14> <15>
Crew reaction time prior to escape	35 s (awake), 100 s (asleep)	15 s (awake), 50 s (asleep)	<16>
Critical pressure prior to blackout	7.5 lb/in^2	• 9.5 lb/in^2 (equip. failure) • 3.0 lb/in^2 (w/O^2 masks)	<17> <18>
Ratio of "free" air to total volume	70-percent free air ratio	95-percent free air ratio	<19>
Hole shape (discharge coefficient)	$C_d = 0.9$	$C_d = 0.7$	<20>

Table 12. "Baseline" probability of crew loss given a penetration, $P_{loss/pen}$, for eight modules.

	Crack	Injury	Slow Depress	Total
Module 1 (U.S. Lab)	0.73	0.09	0.01	0.83
Module 2 (U.S. Hab)	0.73	0.09	0.01	0.83
Module 3 (JEM)	0.71	0.01	0.00	0.72
Module 4 (ESA)	0.67	0.02	0.00	0.69
Module 5 (Node 2)	0.73	0.05	0.01	0.79
Module 6 (Node 1)	0.71	0.02	0.01	0.74
Module 7 (P-Log)	0.66	0.00	0.00	0.66
Module 8 (Airlock)	0.66	0.00	0.00	0.66
Total (1 through 8)	0.69	0.04	0.01	0.74
Total (1 through 6)	0.70	0.05	0.01	0.76

Table 13. Probability of crew loss due to orbital debris impact for eight module spacecraft, baseline assumptions (1 year).

	<---------0.3 to 3 cm diameter------->						>3 cm		
Module	P_{impact}	×	$P_{pen/imp}$	×	$P_{loss/pen}$	+	P_{impact}	=	P_{loss}
1	0.012291	×	0.167	×	0.83	+	0.000202	=	0.00190
2	0.012291	×	0.167	×	0.83	+	0.000202	=	0.00190
3	0.006672	×	0.166	×	0.72	+	0.000109	=	0.00090
4	0.011057	×	0.166	×	0.69	+	0.000182	=	0.00150
5	0.003002	×	0.167	×	0.79	+	0.000049	=	0.00044
6	0.003002	×	0.167	×	0.74	+	0.000049	=	0.00044
7	0.015199	×	0.190	×	0.66	+	0.000251	=	0.00215
8	0.007600	×	0.190	×	0.66	+	0.000126	=	0.00107
1 – 8	0.068966	×	0.174	×	0.74	+	0.001173	=	0.00888
1 – 6	0.047370	×	0.167	×	0.76	+	0.000796	=	0.00680

A. Single Factor Sensitivity Analyses

Table 11 lists 20 alternative input parameters for the MSCSurv™ simulation of $P_{loss/pen}$. This section details how the $P_{loss/pen}$ changes with the change in input parameters.

Figure 22 shows how the $P_{loss/pen}$ changes with critical crack length assumption for module 1 (U.S Lab), and figure 23 shows this relationship for the six module cluster. As the "inherent" critical crack length causing module wall "unzipping" increases, the ratio of unzipping failure

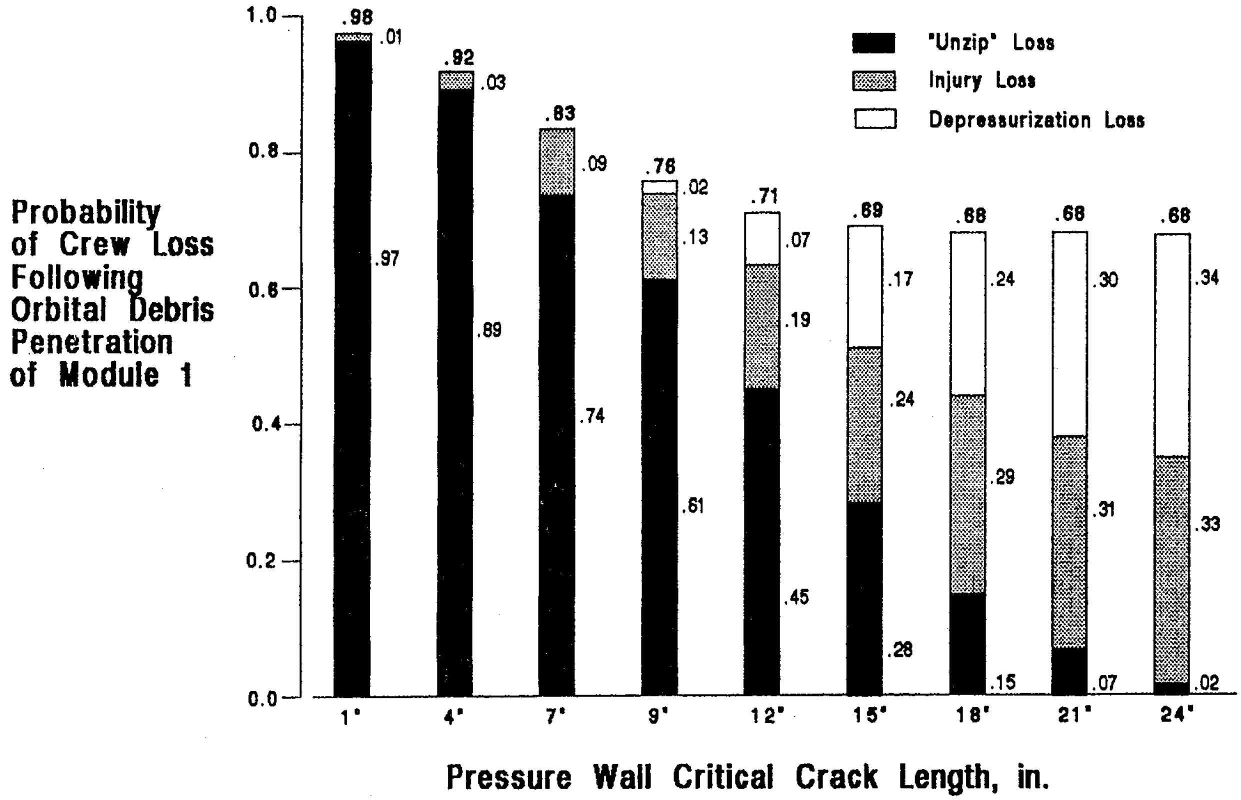


Figure 22. $P_{loss/pen}$ for module 1 (U.S. Lab) versus pressure wall critical crack length.

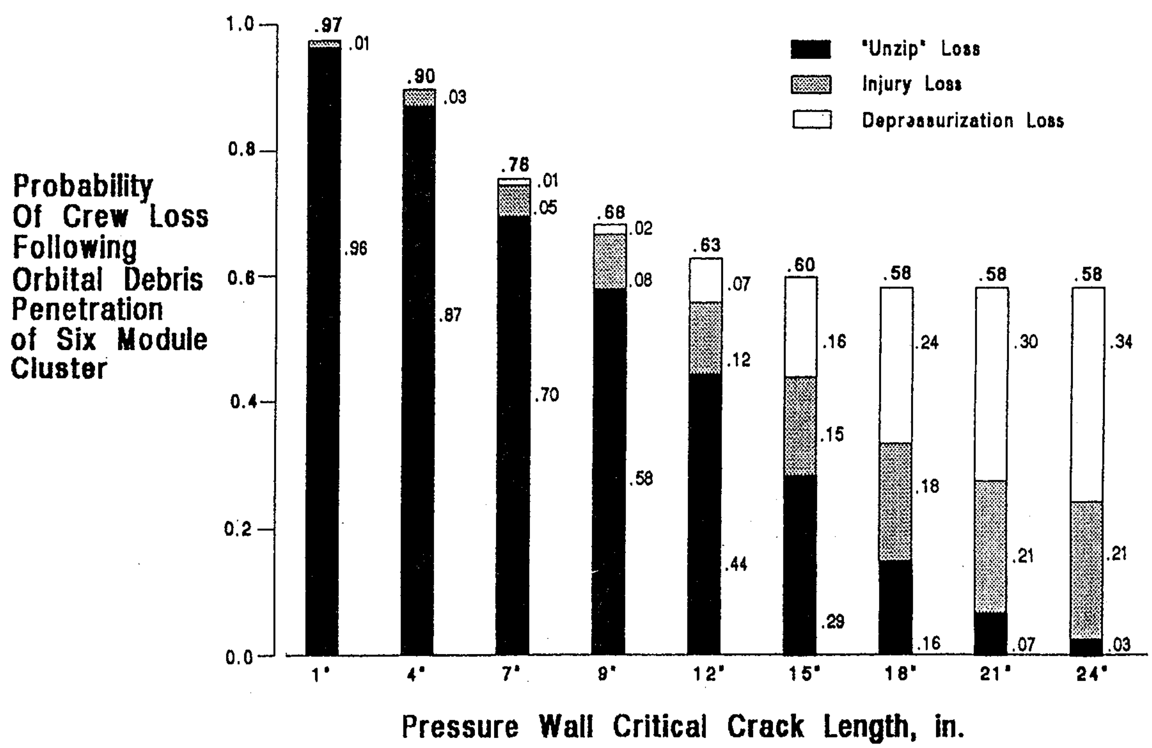


Figure 23. $P_{loss/pen}$ for six module spacecraft cluster versus pressure wall critical crack length.

decreases, as does the overall $P_{loss/pen}$. As the unzipping ratio decreases with larger critical crack lengths in the module pressure wall, the slow depressurization loss ratio and injury ratio increases (somewhat), until a lower asymptote is reached in overall $P_{loss/pen}$ for large critical crack lengths at around 0.58 for the six module cluster.

For the baseline case (7-in critical crack length), unzipping is the predominant mode of crew loss, with 0.70 out of a total 0.76 $P_{loss/pen}$. Unzipping is reduced considerably for alternate <1>, a 12-in critical crack length, but still predominates the injury and depressurization loss modes. In alternate <2>, a 24-in critical crack length appears to have little or no unzipping loss, whereas depressurization has become the predominant loss factor. As stated earlier, increasing the thickness of the pressure wall and/or adding integral stiffeners to the wall design are both effective methods of increasing the "inherent" length at which penetration-induced cracks will propagate unstopped (unzip). Thus, if a 0.188-in pressure wall thickness can increase the critical crack parameter from 7 to 12 in (as theorized in reference 53), figure 23 shows that this increased wall thickness decreases the overall $P_{loss/pen}$ by nearly 20 percent (from 0.76 to 0.63).

Unzipping is an independent loss mode from the cases of crew injury or slow depressurization, and obviously predominates the other two modes in the baseline (7-in critical crack) case. As they can only affect 6 percent of the 76-percent total $P_{loss/pen}$ value for the baseline case, even relatively large changes in the input assumptions affecting depressurization and injury losses will have little total effect on the overall $P_{loss/pen}$ ratio. However, for the 12- and 24-in critical crack assumptions, injury and depressurization losses grow as a proportion of the total $P_{loss/pen}$. As such, input assumptions affecting depressurization and injury losses should increasingly affect the $P_{loss/pen}$ for these cases. To test this hypothesis, the single parameter sensitivity analyses reported in table 14 for the 7-in critical crack assumption are repeated in tables 15 and 16 using 12- and 24-in critical crack assumptions, respectively.

Alternate assumption <3> involved using the Burch D_{90} hole model[11] instead of the baselined oblique hole model (appendix M). In general, the Burch hole model predicts smaller holes for the same parameters of diameter and velocity than the oblique model. Tables 14 through 16 show that the Burch hole model predicts slightly less "unzipping" loss than the baselined model for the 7-in critical crack length, and considerably less unzipping loss for the 12- and 24-in cases. Note that both the unzipping loss and the total $P_{loss/pen}$ falls much more rapidly for increasing critical crack lengths when using the Burch hole model than when using the baseline model. Note also that the overall $P_{loss/pen}$ seems to remain approximately 0.200 lower than the baseline oblique hole model for the 12- and 24-in critical crack lengths, appearing to parallel the $P_{loss/pen}$ asymptote shown for the baseline assumptions in figure 23.

As noted earlier, as the unzipping loss goes down, the slow depressurization and injury losses rise somewhat. This is because the number of penetrations with sufficient energy to exceed the 12- and 24-in critical crack lengths are fewer, but are still sufficient in penetration energy to make large holes (causing depressurization losses) and deep penetrations (causing injury losses). The baseline assumptions of relatively slow crew escape time and lack of rack protection appear to couple with the Burch model for the 7-in crack case in the same way as they did with the oblique hole model for the 12- and 24-in case, lowering the unzipping loss and raising the depressurization/injury losses. From table 14, one concludes that the overall $P_{loss/pen}$ is relatively insensitive to the hole size model chosen for the 7-in critical crack length, but has a large effect at the 12- and 24-in

Table 14. Probability of crew loss given a penetration ($P_{loss/pen}$), alternative assumptions with 7-in critical crack, six module cluster.

Single Factor Sensitivity Analysis
7-in Critical Crack Length

{ }= Rank

		Unzip	Injury	Depress	Total	Delta from Baseline
"Baseline" Assumptions		0.698	0.060	0.003	0.761	----
<3>	Burch Hole Model	0.659	0.071	0.029	0.760	–0.001
<4>	Energy-Based Crack Size	0.380	0.133	0.093	0.606	–0.155 {1}
<5>	Narrow Debris Spread	0.698	0.028	0.003	0.729	–0.032 {4}
<6>	Crew Exposed to Debris 50-percent Lost + 50-percent Late Loss	0.698	0.049	0.003	0.750	–0.011
<7>	Crew Exposed to Debris 10-percent Lost + 10-percent Late Loss	0.698	0.013	0.003	0.715	–0.046 {3}
<8>	Internal Equipment with 0.7 g/cm^2 Areal Density	0.698	0.006	0.003	0.707	–0.054 {2}
<9>	Crew Sleeps in Node 2	0.698	0.038	0.003	0.739	–0.022 {5}
<10>	"Triangular" Crew Distance Within Module	0.698	0.071	0.003	0.772	+0.011
<11>	Crew Sleeps Near Hatch	0.698	0.060	0.003	0.761	–0.000
<12>	Hatches Closed	0.698	0.060	0.021	0.779	+0.018
<13>	Hatches Closed (Night)	0.698	0.060	0.011	0.769	+0.010
<14>	Rate-Based Crew Movement	0.698	0.060	0.001	0.759	–0.002
<15>	Fast Crew Movement	0.698	0.060	0.001	0.759	–0.002
<16>	Fast Crew Reaction Time	0.698	0.060	0.001	0.759	–0.002
<17>	9.5 lb/in^2 Crit Depress	0.698	0.060	0.006	0.764	+0.003
<18>	3.0 lb/in^2 Crit Depress	0.698	0.060	0.001	0.759	–0.002
<19>	95-percent Free Air Ratio	0.698	0.060	0.001	0.759	–0.002
<20>	$C_d = 0.7$	0.698	0.060	0.001	0.759	–0.002

Table 15. Probability of crew loss given a penetration ($P_{loss/pen}$), alternative assumptions with 12-in critical crack, six module cluster.

Single Parameter Sensitivity Analysis
12-in Critical Crack Length <1> { } = Rank

		Unzip	Injury	Depress	Total	Delta from Baseline
"Baseline" Assumptions		0.438	0.119	0.068	0.625	- - - -
<3>	Burch Hole Model	0.110	0.191	0.122	0.423	–0.202 {1}
<4>	Energy-Based Crack Size	0.243	0.163	0.192	0.598	–0.027
<5>	Narrow Debris Spread	0.438	0.055	0.080	0.571	–0.054 {5}
<6>	Crew Exposed to Debris 50-percent Lost + 50-percent Late Loss	0.438	0.094	0.074	0.609	–0.016
<7>	Crew Exposed to Debris 10-percent Lost + 10-percent Late Loss	0.438	0.029	0.090	0.556	–0.069 {3}
<8>	Internal Equipment with 0.7 g/cm^2 Areal Density	0.438	0.013	0.083	0.534	–0.091 {2}
<9>	Crew Sleeps in Node 2	0.438	0.077	0.075	0.590	–0.035
<10>	"Triangular" Crew Distance Within Module	0.438	0.137	0.062	0.633	+0.016
<11>	Crew Sleeps Near Hatch	0.438	0.119	0.069	0.626	+0.001
<12>	Hatches Closed	0.438	0.119	0.078	0.635	+0.010
<13>	Hatches Closed (Night)	0.438	0.119	0.066	0.623	–0.002
<14>	Rate-Based Crew Movement	0.438	0.119	0.031	0.589	–0.036
<15>	Fast Crew Movement	0.438	0.119	0.050	0.607	–0.018
<16>	Fast Crew Reaction Time	0.438	0.119	0.040	0.597	–0.028
<17>	9.5 lb/in^2 Crit Depress	0.438	0.119	0.112	0.669	+0.044
<18>	3.0 lb/in^2 Crit Depress	0.438	0.119	0.007	0.562	–0.063 {4}
<19>	95-percent Free Air Ratio	0.438	0.119	0.038	0.595	–0.030
<20>	$C_d = 0.7$	0.438	0.119	0.044	0.601	–0.024

Table 16. Probability of crew loss given a penetration ($P_{loss/pen}$), alternative assumptions with 24-in critical crack, six module cluster.

Single Parameter Sensitivity Analysis
24-in Critical Crack Length <2> { } = Rank

		Unzip	Injury	Depress	Total	Delta from Baseline
"Baseline" Assumptions		0.027	0.210	0.344	0.581	- - - -
<3>	Burch Hole Model	0.010	0.212	0.151	0.373	–0.208 {2}
<4>	Energy-Based Crack Size	0.158	0.182	0.255	0.595	+0.014
<5>	Narrow Debris Spread	0.027	0.095	0.408	0.530	–0.051
<6>	Crew Exposed to Debris 50-percent Lost + 50-percent Late Loss	0.027	0.167	0.372	0.566	–0.015
<7>	Crew Exposed to Debris 10-percent Lost + 10-percent Late Loss	0.027	0.048	0.435	0.510	–0.071
<8>	Internal Equipment with 0.7 g/cm^2 Areal Density	0.027	0.027	0.428	0.482	–0.099 {4}
<9>	Crew Sleeps in Node 2	0.027	0.142	0.380	0.549	–0.032
<10>	"Triangular" Crew Distance Within Module	0.027	0.244	0.325	0.596	+0.015
<11>	Crew Sleeps Near Hatch	0.027	0.210	0.344	0.581	+0.000
<12>	Hatches Closed	0.027	0.210	0.166	0.403	–0.178 {3}
<13>	Hatches Closed (Night)	0.027	0.210	0.277	0.514	–0.067
<14>	Rate-Based Crew Movement	0.027	0.210	0.250	0.487	–0.094 {5}
<15>	Fast Crew Movement	0.027	0.210	0.306	0.543	–0.038
<16>	Fast Crew Reaction Time	0.027	0.210	0.286	0.525	–0.056
<17>	9.5 lb/in^2 Crit Depress	0.027	0.210	0.417	0.654	+0.073
<18>	3.0 lb/in^2 Crit Depress	0.027	0.210	0.085	0.322	–0.259 {1}
<19>	95-percent Free Air Ratio	0.027	0.210	0.268	0.505	–0.076
<20>	$C_d = 0.7$	0.027	0.212	0.287	0.526	–0.055

critical crack level. These results are consistent with the Burch model's tendency to predict fewer large holes, and therefore fewer large cracks to exceed 12- and 24-in lengths.

The effect of implementing an energy-based crack formation model is examined as alternative <4> in tables 14 through 16. As previously discussed, this alternative basis for crack formation is considered to be conjectural, but within the realm of possibility given the extreme lack of data on the crack formation process itself. This model uses 48,000 ft-lb as the impact energy required to produce 7-in cracks, 82,000 ft-lb to produce 12-in cracks, and 132,000 ft-lb to produce 24-in cracks (fig. 9). Table 14 shows that the unzipping loss predicted by this model is less than that predicted by the baseline model for the 7-in critical crack assumption. For the 12-in case, table 15 shows that this alternative produces less unzipping than it did in the 7-in case and less than the baseline case for a 12-in critical crack. However, for the 24-in case, while producing still less unzipping loss than the 12-in case, the energy-based crack size produces more unzipping loss than the baseline oblique hole-based assumption (table 16). Comparison of the amount of unzipping loss reduction between 7, 12, and 24 in for the energy-based versus hole-based crack size assumptions shows that the energy-based assumption is less sensitive to increasing critical crack length than the hole-based assumption.

Assumptions <5> through <10> have an effect on injury and depressurization losses, but do not affect the proportion of unzipping loss. Close examination of the injury and depressurization losses in tables 14 through 16 shows that as the injury loss decreases, the depressurization loss shows a slight increase; as the injury loss increases, the depressurization loss decreases somewhat. The reason for this is similar to that described earlier for the unzipping/injury relationship: an increase in the number of penetrations causing injury means that there are fewer large holes "available" that can additionally cause loss of crew to decompression. Recall that the $P_{\mathrm{loss/pen}}$ denotes the probability of losing at least one crewmember (that is, one or more) following a penetration. Once a single crewmember is lost to unzipping, that penetration is "counted" solely as an unzipping-related loss when calculating the $P_{\mathrm{loss/pen}}$ ratio, and is not "double-booked" by MSCSurv™ as an injury or depressurization loss (fig. 9). The same is true for injury-inducing penetrations; they cannot additionally contribute to the depressurization loss ratio, even though the hole size may be sufficiently large to cause loss of one or more crewmembers in addition to the injury-related loss.

Given this "cascading" fashion of determining overall probability of a single crew loss, it is clear that assumptions <5> through <10> directly affect the ratio of crew losses due to injury; the change in the decompression loss ratio is merely a side-effect of the change in the injury loss ratio. Tables 14 through 16 show that the spread of the interior debris cloud (assumption <5>) appears to be important in its direct effect on crew injury. For any of the three (7-, 12-, or 24-in) critical crack levels, changing the baselined assumption of a three-rack wide internal debris fragment spread to a one-rack wide spread of fragments inside the module appears to cut the amount of crew injury roughly in half. This makes sense in that a smaller proportion of crew would be exposed to the penetrating internal debris fragment cloud, resulting in fewer injuries. As expected, this effect becomes more important as the injury loss ratio grows in proportion to the overall $P_{\mathrm{loss/pen}}$ ratio.

In a similar fashion to alternate assumption <5>, the assumptions <6> and <7> on the likelihood of crew injury following exposure to the debris cloud directly reduces the overall injury loss ratio. A 50-percent immediate plus a 50-percent "late" loss reduces the overall injury loss ratio by 25 percent for all critical crack levels; a 10-percent immediate plus a 10-percent "late" loss assumption similarly reduces the injury loss ratio by 80 percent. The injury loss ratio appears to vary in a roughly linear fashion with the percentages assumed here.

Internal equipment has the effect of reducing the injury ratio by reducing the exposure of the crew to the fragmenting internal debris cloud. As shown under assumption <8> in tables 14 through 16, this factor can be one of the most important in reducing crew injury, though its reduction in overall $P_{loss/pen}$ reaches an asymptote with increasing critical crack lengths (above 12 in).

The two final factors that appear to directly affect crew injury appear as alternatives <9> and <10>. In <9>, all four crew members sleep in node 2 instead of two in the Lab and two in the Hab (the baseline case). For this alternative, the injury loss seems to decrease only slightly, but becomes a more measurable effect as the critical crack length increases. In alternative <10>, the distribution of the crew within the modules is changed from a uniform distribution between all stations to a triangular distribution, where the individual crew members (if present within a module) are much more likely to be near the exit than near the opposite bulkhead. This assumption tends to increase the injury loss ratio somewhat, though the overall effect is very small. From this information, one can conclude that the overall $P_{loss/pen}$ appears to be relatively insensitive to the postulated changes in crew distribution throughout the modules during awake or asleep periods (when operating with hatches open).

Alternative input assumptions <11> through <20> appear to solely affect the ratio of crew loss due to depressurization following a penetration of the six module cluster, as shown in column 3 of tables 14 through 16. All 10 alternatives have an increasing effect on the total $P_{loss/pen}$ as the critical crack length increases from 7 to 24 in.

Alternatives <11> through <13> detail three operational modes that may be incorporated within the three module cluster with little or no cost. In alternative <11>, the four crewmembers sleep near the hatch for quicker escape during the crew sleep period. However, tables 14 through 16 indicate that this alternative has no effect on the depressurization loss. This is probably because the crew movement time from the module to the hatch is baselined as constant; that is, no matter how far away from the hatch a crewmember is, he/she still takes 30 s to move to the hatch. In following sections, this alternative will be combined with a position-dependent (i.e., rate-based) crew movement time to see if it is significant when applied in such a fashion.

Alternatives <12> and <13> apply two different hatch closure conditions to the baseline model. In alternative <12>, the hatches are closed during normal crew operations and during the sleep period (except when a crew member is traversing through them when crossing from module to module). This alternative shows increased depressurization losses at the 7- and 12-in critical crack levels, but a significantly reduced depressurization loss ratio at the 24-in critical crack level. Note that as the critical crack length increases, the depressurization loss (and $P_{loss/pen}$) appears to decrease dramatically after a 12-in critical length.

In alternative <13>, the hatches are closed at night only. This operational mode shows slightly increased decompression loss for the 7-in critical crack length, but decreased decompression loss for the 12- and 24-in critical crack cases. As with alternative <12>, the depressurization loss (and $P_{loss/pen}$) appears to decrease dramatically after a 12-in critical length.

The $P_{loss/pen}$ should be considered as relatively sensitive to these hatch position factors, but may be somewhat dependent upon the baselined hole size model and crew escape time from the module. In reference 14, a different hole size model and crew escape time was used to determine the depressurization loss ratio (without unzipping or injury losses included, similar to the 24-in critical crack length alternative). It showed that the open hatch and closed hatch operational models provided approximately the same level of $P_{loss/pen}$, but that the "hatches closed at night" model produced significantly less $P_{loss/pen}$ than either of these alternatives.

Alternatives <14> through <16> change selected portions of the baselined crew escape parameters. Alternative <14> changes the crew movement model from a constant time to a rate-based movement time, based on crew position within the module. This alternative assumes that the crew moves at 0.5 ft/s when escaping in a healthy condition, at 0.25 ft/s when escaping in a hindered or injured status. Alternative <15> reduces the baselined constant crew movement from 30 to 15 s when healthy and from 60 to 30 s when injured. Alternative <16> reduces the baselined crew reaction time (prior to initiating movement) from 35 to 15 s when awake and from 100 to 50 s when asleep. Each of these three factors (when acting on their own) only appears to become significant at the 24-in critical crack length. However, it is highly possible that these factors, when combined, would cause a strong reduction in depressurization loss, since the total escape time would be reduced by over 75 percent. If the baselined crew injury rate after "immediate" exposure to the debris cloud were dropped from 100 percent to say 50 percent, the injured crew members would also benefit from these faster reaction and movement times. As it is, however, the baselined "100 percent loss if injured" assumption limits the benefit of the reduced reaction and movement times to healthy or hindered crew members.

Alternatives <17> and <18> change the baselined critical (lowest) level of crew depressurization resistance prior to unconsciousness and eventual loss from 7.5 to 9.5 lb/in^2 and 3.0 lb/in^2, respectively. The 9.5-lb/in^2 alternative raises the depressurization loss ratio from 0.003 to 0.073 higher than the baseline for increasing critical crack lengths. Conversely, the 3.0-lb/in^2 depressurization limit alternative is one of the five most significant factors that reduce $P_{loss/pen}$ for the 12-in critical crack length and is the largest single factor in reducing $P_{loss/pen}$ for the 24-in critical crack assumption. This alternative corresponds to oxygen masks being immediately available to the crew following a module penetration. The crew would need to be trained extensively on the correct emergency procedure following a penetration to receive the benefit of this lowered $P_{loss/pen}$.

Alternative <19> increases the free air ratio from 70 percent of the total interior volume of the modules to 95 percent. By increasing the volume of air available to the crew members, the crew has more time to escape the module prior to losing consciousness. As expected, this alternative decreases the $P_{loss/pen}$ (up to 0.076 for the 24-in critical crack length), but does not appear to be one of the more significant factors affecting the probability of crew loss following a penetration.

Alternative <20> reduces the coefficient of discharge in the module depressurization equation (line 407 of MSCSurv™), effectively lowering the rate at which the module depressurizes. This alternative has much the same effect on $P_{loss/pen}$ as increasing the free air ratio (alternative <20>), measurably lowering the depressurization ratio for the 24-in critical crack length (table 16).

To summarize, the probability of crew loss (one or more) following a module penetration can vary significantly from the baselined ratio of 0.76 $P_{loss/pen}$, depending on the input parameters chosen. The largest factor affecting the total $P_{loss/pen}$ is the critical crack length causing module "unzipping" (uncontrolled crack growth) and explosive decompression. Increasing the module wall thickness can conceivably increase the critical crack length from 7 to 24 in, reducing the $P_{loss/pen}$ from 0.76 to 0.58. As the critical crack size increases, the $P_{loss/pen}$ is made up increasingly of injury-related and slow depressurization-related losses.

The other input factors affecting the overall $P_{loss/pen}$ vary in importance, depending on the critical crack length within the module pressure wall. For the baselined 7-in critical crack length, table 14 shows the $P_{loss/pen}$ to be most sensitive to crack size model chosen, but is also affected to a lesser extent by such injury-related factors as amount and location of internal equipment, spread of the debris cloud within the modules, and likelihood of crew injury when exposed to the debris cloud. For the 12-in critical crack length, the same injury-related factors are drivers in reducing $P_{loss/pen}$ as in the 7-in case, but the most important factor appears to be choice of the hole size model due to its effect in further reducing unzipping losses. For the 24-in critical crack length, the most important factors appear to be those that affect depressurization losses, including crew depressurization limit, hole size model, hatch position, and speed of the crew's movement following penetration.

So far, this sensitivity analysis includes the effects of altering the critical crack length assumption in conjunction with other factors, one at a time. The next section examines the sensitivity of the $P_{loss/pen}$ value to altering multiple selected factors.

B. Multiple Factor Sensitivity Analysis

This section examines the interaction between major factors identified by MSCSurv™ in the previous section to have measurable effects on the overall probability of crew loss (one or more) following an orbital debris penetration of a six-manned module cluster. In a second case, a limited set of "interesting" variables in the 24-in crack case is examined for interactions that might lower the $P_{loss/pen}$ further than they otherwise might by acting singly. Within this section, a "Taguchi" technique (L_{16} orthogonal array) is employed to determine two-way interactions between five selected factors for the two cases.

Although it would be desirable to identify the level of $P_{loss/pen}$ associated with interaction of all variables (henceforth referred to as factors) and levels identified in table 11, time and space limitations render this impractical here. Therefore, five factors that appear to have large effects on $P_{loss/pen}$ are chosen from tables 14 through 16 for further interaction analysis. The five major factors chosen for interaction analysis are shown in table 17, and include (A) critical crack length, (B) internal equipment, (C) critical decompression level, (D) injury loss ratio, and (E) hatch position. Table 17 shows that each of these factors is set at two levels—level "1" was generally associated with "low" $P_{loss/pen}$ values and level "2" with "high" $P_{loss/pen}$ values.

The type of Taguchi analysis chosen for this examination of two factor interactions involves use of the L_{16} orthogonal array pattern. According to "Hands-On Taguchi,"[60] this analysis allows the user to rank the significance of up to five single input factors and 10 two-factor combinations in determining the measurable output of a process or system (in this case, the total $P_{loss/pen}$ within the six module cluster). The L_{16} pattern requires 16 separate experimental "runs" using a specific combination of high and low levels for each of the five factors in order to establish the ranking of which factors are most important.

Following this, a "level average" analysis is performed using the output of the 16 runs. This analysis essentially computes the "delta" in average $P_{loss/pen}$ between all runs where the factor was

Table 17. Taguchi analysis for interaction between five major factors.

	Factor	Level 1	Level 2
A	Critical Crack Length Prior to Unzipping	24 in	7 in
B	Internal Equipment	Yes—Two Plates of 0.125-in Aluminum	No Internal Equipment
C	Critical Level of Depressurization	3.0 lb/in^2	9.5 lb/in^2
D	Rate of Loss Following Injury	10-percent Initial Loss; 10-percent Late Loss	100-percent Loss
E	Hatch Position	Closed	Open

Factor and Level Combinations

Run	A	B	A × B	C	A × C	B × C	D × E	D	A × D	B × D	C × E	C × D	B × E	A × E	E	Result
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.317
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	0.150
3	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2	0.561
4	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	0.381
5	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	0.196
6	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1	0.382
7	1	2	2	2	2	1	1	1	1	2	2	2	2	1	1	0.391
8	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2	0.659
9	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	0.701
10	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1	0.721
11	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1	0.746
12	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2	0.717
13	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	0.721
14	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2	0.757
15	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2	0.725
16	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1	0.782
Delta ($\times 10^{-3}$)	354	40	15	126	115	2	1	24	4	112	86	4	12	21	4	
Rank	1	6		2	3					4	5					

maintained at level 1 and all runs where the factor was maintained at level 2. A higher average $P_{loss/pen}$ delta between levels indicates a higher importance of this factor or combinations of factors. Although sometimes criticized for lacking sufficient statistical strength, this type of Taguchi analysis is useful because of its ease of applicability and consistent ability to identify the most important factors and interactions governing a process.

Table 17 confirms the observations shown in figures 22 and 23, that the critical crack length is by far the most important factor in determining overall $P_{loss/pen}$. The second most important factor appears to be the decompression level, followed by the interaction between the critical crack length and the decompression level. This is consistent with the information shown in tables 14 through 16: the decompression level grows in overall effect on $P_{loss/pen}$ as the critical crack length grows. The third most important factor is the interaction between the first and second most important factors. The fourth most important factor is the interaction between internal equipment and injury loss rate. Notice that both of these factors affect injury, but each are much less effective on overall $P_{loss/pen}$ when acting alone. The fifth most important factor is the interaction between decompression level and hatch position. Note that the hatch position is relatively ineffective when acting alone.

Table 16 lists a number of additional variables that showed promise of interacting to measurably lower the probability of (one or more) crew loss given a penetration, $P_{loss/pen}$. The factors identified for this analysis include (A) the crew movement model, (B) the crew distribution within each module (awake), (C) the crew sleep position within the cluster, (D) the crew sleep distribution within each module, and (E) the hatch closure position. Each of these factors has two levels (table 11). The first of these levels produced a lower $P_{loss/pen}$, and the second level (in this case, always the one associated with the baseline) produces a higher $P_{loss/pen}$.

Table 18 shows the results of the level average analysis for the L_{16} Taguchi pattern using the five selected factors at the 24-in critical crack length. This analysis indicates that of these five factors and 10 interactions, the three most important are factor E (hatch position), factor A (crew movement to hatch), and factor C (sleep position within cluster). The fourth most important factor from the Taguchi analysis appears to be the interaction between factor C and factor E, although it is not as strong as the action of the main factors.

This result and the magnitude of the delta associated with each of the main factors differs somewhat from the single factor analysis within table 16, where the more important of the factors was factor A (rate-based crew movement), not factor E (hatches closed at night). However, one clue identifying the reason for this difference might lie in the apparent interaction between factor E and factor C (crew sleep position). Taguchi analysis has the disadvantage of sometimes attributing interactions between factors to the main factors themselves. The explicitly examined interaction between factors E and A indicates that factor E may have a "tendency" to reduce $P_{loss/pen}$ through interactions with other factors. It is possible that some three-way interactions between these five factors that include factor E (hatch closure position) have been lumped under the single factor E, thus increasing its importance beyond what was seen in the single factor analysis (table 16). This type of clue should be followed up in subsequent analyses to determine the precise interactions of factor E with other input variables.

Apparently, the rate-based crew movement (level 1, factor A) does not interact significantly with either the triangular crew distribution (level 1, factor B) or the sleep position near the hatch (level 1, factor D) to lower the overall $P_{loss/pen}$. This result was somewhat unexpected. However, it is still possible that these factors interact when placed in conjunction with a faster crew movement rate or reaction time. Further analysis of the interaction between these variables also appears merited.

Table 18. Taguchi analysis for interaction between multiple input factors, 24-in critical crack assumption.

	Factor	Level 1 (Low)	Level 2 (High)
A	Crew Movement To Hatch	Rate-Based Crew Movement	Constant Movement Time
B	Crew Position Within Modules (Awake)	Triangular Distribution	Uniform Distribution
C	Sleep Position Within Cluster	In Node 2	In Hab and Lab
D	Sleep Position Within Module	Near Hatch	Variable
E	Hatch Position	Closed at Night	Open

Factor and Level Combinations

Run	A	B	A × B	C	A × C	B × C	D × E	D	A × D	B × D	C × E	C × D	B × E	A × E	E	Result
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.353
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	0.484
3	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2	0.507
4	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	0.444
5	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	0.476
6	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1	0.343
7	1	2	2	2	2	1	1	1	1	2	2	2	2	1	1	0.427
8	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2	0.486
9	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	0.579
10	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1	0.436
11	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1	0.529
12	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2	0.594
13	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	0.429
14	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2	0.564
15	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2	0.587
16	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1	0.520
Delta	90	8	2	58	2	6	8	2	4	4	30	4	6	2	10	
($\times 10^{-3}$)															4	
Rank	2			3							4				1	

C. Validation and Verification of Results

This section briefly discusses the steps taken to validate the performance of the MSCSurv™ software tool and to verify the correctness of the model's input assumptions and output for accurate results.

Verification of a software tool generally requires proving that the tool performs all of its functions as designed. These functions include generating correct distributions for input variables, reading input files, writing output files, and assuring that the program operates in the proper sequence. In this case, most of the software verification occurred during the writing and debugging of the MSCSurv™ program. Many of the verification exercises undertaken are still present within the MSCSurv™ program as "comment" statements (FORTRAN statements preceded by a "C"), as shown in appendix A. The verification exercises generally included adding write statements (to the screen and to a printer) that designated when input, output, and "handoff" functions were performed by MSCSurv™, and (by their absence) when these functions did not occur. Through running MSCSurv™ with low numbers of repetitions (under 100 or so), sufficient data were generated and sent to the printer. Although time consuming, these data were examined at length and eventually served to verify that the computer program was functioning as designed.

An important verification exercise included ensuring that the output of MSCSurv™ reached convergence. As a rule, Monte Carlo analysis results can be considered "well-behaved" if the results are within $1/N^{1/2}$ of the mean, where N is the number of total runs (or in this case, the total number of penetrations into the manned module cluster). MSCSurv™ results for overall $P_{loss/pen}$ using 10,000 penetrations never varied more than 0.01 in value from the mean result ($1/10{,}000^{1/2}$). In a similar fashion, $P_{loss/pen}$ values derived from 100,000 penetrations varied less than 0.003 in relative difference from one another. As such, this program can be considered to reach satisfactory convergence for any total (six module) $P_{loss/pen}$ value derived from 10,000 total penetrations or more. However, in order to assure accuracy in the "unzipping," "injury," and "depressurization" suballocations, all $P_{loss/pen}$ values reported were derived from runs using 100,000 penetrations or more unless otherwise noted.

Validation of the accuracy of the model output is a more difficult task. As stated earlier, all of the input assumptions have associated uncertainties. The most important assumptions to the final value of $P_{loss/pen}$ appear to be the hole size model, crack size model, and depth of penetration model selected. Sensitivity analyses (in the previous section) using alternative assumptions were designed to bound the accuracy of the final results. These analyses showed that the absolute value of $P_{loss/pen}$ could vary significantly depending on input assumptions used. True validation of the value of $P_{loss/pen}$ cannot be accomplished until the "correctness" of these input assumptions are established. In most cases, this requires additional test data to be generated (this is discussed in section VI).

Many of the verification exercises for MSCSurv™ also served to validate that the MSCSurv™ outputs were accurate (that is, as accurate as possible, given the uncertainty in input variables). Many of these validation exercises are also still included in the MSCSurv™ program as "comment" statements, and include:

(1) Writing the debris diameter, velocity, and obliquity after their generation, comparing these distributions to the original environment for correctness

(2) Writing the combinations of debris diameters, obliquities, and velocities (dov) that penetrate the shields, comparing them to the ballistic limit curve for accuracy

(3) Writing out the hole and crack sizes following a penetration along with the corresponding dov input combinations, comparing them with the oblique (or Burch) hole size models and crack models for accuracy

(4) Writing out the module and element numbers impacted by each simulated debris strike, comparing this distribution to other locations on comparable modules that should receive equal numbers of hits

(5) Writing out the location of the injured crewman following a penetration to assure that this distribution is consistent with the input distribution

(6) Writing out the hour of the debris strike, assuring that this distribution was uniform and accurate in comparison to crew location following penetration

(7) Writing out the penetration depth with input dov combinations to assure consistency with penetration depth equation

(8) Writing out the depressurization time corresponding with each hole size, assuring consistency with the isentropic blowdown equation.

Of course, the most convincing validation of program accuracy is from comparable sources of information. In this case, two resources existed that could independently produce part of the same information that MSCSurv™ produces, and their outputs were compared to MSCSurv™ to assure MSCSurv™ accuracy. The BUMPER™ program was used to generate a finite element model similar in geometry to the MSCSurv™ model, and the exposed area and PNP outputs for each of the eight modules produced by both models were compared. Table 19 compares the similarities in output data from each of these completely independent sources.

With the exception of the JEM, MSCSurv™ appears to slightly underpredict the PNP of each module in comparison to the BUMPER™ results. This is compatible with the slightly larger exposed area prediction by MSCSurv™ (recall that larger exposed areas lead directly to lower PNP's due to the corresponding increase in the number of orbital debris impacts). Comparison of the MSCSurv™ model geometry in figure 10 with the BUMPER™ model geometry in figure 6 yields several insights into the slight differences in output between the two models. Note that the number of exterior elements are far fewer within the MSCSurv™ geometry model for any particular manned module; that is, the element sizes are much larger in the MSCSurv™ modules than in the BUMPER™ modules. BUMPER™ runs using otherwise identical input models with differing element sizes indicate that models with larger element sizes consistently show a measurable increase in exposed area and lower PNP when compared to models with smaller element sizes.[13] If this element size is an important factor within the BUMPER™ model, it is reasonable to assume that it may account for at least part of the slight difference between MSCSurv™ and BUMPER™ results.

In addition to the differences in element size, the MSCSurv™ model differs somewhat in exterior dimensions from the BUMPER™ model. For example, the MSCSurv™ model does not include conical endcones or inter-module tunnels (called berthing mechanisms); the BUMPER™ Lab module is 174 inches in diameter versus MSCSurv™'s 168-in diameter. These model differences were

Table 19. Exposed area and probability of no penetration comparison between MSCSurv™ and BUMPER™.

	Lab	Hab	Node 2	Node 1	JEM	ESA	Plog	A/L
MSCSurv™ Exposed Area (m^2)	21.8	21.8	5.3	5.3	11.8	19.6	27.0	13.5
BUMPER™ Exposed Area (m^2)	21.2	21.2	5.2	5.2	14.9	18.3	25.3	9.1
MSCSurv™ PNP	0.9975	0.9975	0.9995	0.9995	0.9987	0.9980	0.9969	0.9984
BUMPER™ PNP	0.9980	0.9980	0.9995	0.9995	0.9986	0.9982	0.9975	0.9991

Conditions Used:

- SSP30000 Rev A1 Debris Environment
- Constant Debris Density
- Exposure Period—Year 2000
- Attitude—Zero Roll, Pitch, and Yaw
- Altitude—398 km
- Inclination—28.5°
- Constant Solar Flux—70 Janskys
- Boeing Penetration Equations
- Bumper Material—0.050-in 6061T6 Aluminum
- Back Wall Material—0.125-in 2219T87 Aluminum
- Standoff—4 in (All Elements).

driven by the desire to make all MSCSurv™ modules the same diameter, and therefore simplify the geometry inputs within MSCSurv™.

Essentially, examination of the MSCSurv™ and BUMPER™ results gives confidence that the penetration portion of MSCSurv™ appears to be producing accurate results for the input geometry selected. Although the PNP portion of MSCSurv™ is not the area of greatest interest here ($P_{loss/pen}$ is), it nevertheless indicates that the "exterior" variables of debris dov are being input correctly into MSCSurv™'s $P_{loss/pen}$ model. Because these inputs are at the very heart of calculating the magnitude of the hole size, crack size, and interior penetration (and as such, the crew loss following a penetration) within the module, this PNP result lends confidence to the $P_{loss/pen}$ result by direct extension.

One additional source was used to directly validate MSCSurv™ $P_{loss/pen}$ results. Recall from section II that SSEIC was tasked in May 1992 by the Level 2 Space Station Program Office to initiate a similar study on the probability of crew or station loss following penetration of S.S. *Freedom* critical elements, including the module cluster. The information in this report (initiated in September 1991) was developed roughly in parallel to the broader SSEIC study, and served as an independent check on the accuracy of the SSEIC results concerning $P_{loss/pen}$ of the manned module cluster. Because the SSEIC program (CREW) models only depressurization and injury losses, unzipping losses had to be computed separately for the SSEIC results and added in after each model. At the suggestion of the NASA Safety and Mission Assurance (S&MA) Office, input conditions of crew escape time, depressurization limit, and hole size distribution identical to those developed within this study were eventually baselined within the SSEIC model, and results were compared for accuracy. Despite the differences in construction, results from the two models were similar. At last comparison, the MSCSurv™ model was computing approximately 5 percent higher probability of crew loss for each module than the SSEIC model at the 7-in critical crack length, mostly due to increased crew injury (9 percent versus approximately 4 percent). Part of the difference in results may lie in the SSEIC model's inclusion of a rescue algorithm within their baselined model; MSCSurv™ currently assumes (as a baseline) that all injured crew are lost. Other basic model differences are detailed in section II.C (S.S. *Freedom* Orbital Debris Survivability).

To summarize, a considerable effort was undertaken within this study to validate the values obtained for the probability of (one or more) crew loss following an orbital debris penetration and to verify the software model that produced them. However, the real value of this type of analysis is not necessarily the absolute value of the $P_{loss/pen}$ achieved, but the identification of operational and design variables that measurably reduce this value. Regardless of the absolute value of $P_{loss/pen}$, an ability to measure the relative decrease in the $P_{loss/pen}$ value associated with individual improvements in spacecraft design and crew operations allows managers to pursue those safety improvements that offer highest reduction in $P_{loss/pen}$ for available resources. Only when trading against such parameters as reduced shielding (and PNP) to avoid exceeding a targeted overall probability of crew loss does the absolute accuracy of $P_{loss/pen}$ become critically important.

D. Summary of Design and Operational Alternatives

As stated in the previous section, one of the real values in performing a quantitative analysis of the probability of (one or more) crew loss following a spacecraft orbital debris penetration ($P_{loss/pen}$) is the opportunity to identify the relative importance of alternative design and operational factors in reducing overall probability of crew loss. This allows managers to pursue those safety improvements that offer highest reduction in $P_{loss/pen}$ for available resources.

Eight design and operational alternatives listed in tables 14 through 16 were shown to measurably increase the safety of astronaut crew members from the hazardous effects of orbital debris penetration. Each of these alternatives is listed in table 20, along with a brief discussion of its advantages and possible difficulties in application.

Increasing the critical crack length within the spacecraft pressure wall prior to initiating unstopped crack propagation (unzipping) was found to be the single most important parameter in decreasing $P_{loss/pen}$ from the baseline configuration and assumptions. Raising the critical crack length within a module pressure wall from 7 to 12 in was shown to decrease the probability of crew loss following a penetration from an average of 0.76 to 0.62 for a six module cluster; raising the critical

Table 20. Summary of design and operational alternatives reducing $P_{loss/pen}$ of manned modules by orbital debris.

Alternative	Advantages	Implementation
Increase Critical Crack Length in Pressure Wall From 7-in Baselined Critical Length	Decreases $P_{loss/pen}$ from 0.76 to 0.58 for Increase from 7- to 24-in Critical Crack Length by Lowering Probability of Unzipping	Increase Wall Thickness from 0.125 to 0.188 in for 12-in Critical Length or Add Integral Wall Stiffeners
Increase Internal Areal Density in Areas Vulnerable to Debris Penetration	Decreases $P_{loss/pen}$ from 0.58 to 0.48 for 24-in Critical Length by Lowering Probability of Injury	Place Internal Equipment or Additional Spallation Blankets Along Interior Pressure Walls
Crew Sleeps in Module Least Likely To Be Penetrated	Decreases $P_{loss/pen}$ from 0.58 to 0.57 for 24-in Critical Length by Lowering Probability of Injury	Crew Sleeps in Node 1 or Node 2, Since Both Minimize Crew Exposure to Debris Penetration
Lower Critical Limit of Crew Tolerance to Depressurization to 3.0 lb/in^2 from 7.0 lb/in^2	Decreases $P_{loss/pen}$ from 0.58 to 0.32 for 24-in Critical Length by Lowering Probability of Depressurization	Add Portable Oxygen System; Keep Near Crew Members, Especially During Sleep Period
Close Intermodule Hatches, Limiting Depress Hazards from Other Modules	Decreases $P_{loss/pen}$ from 0.58 to 0.51 for 24-in Critical Length by Lowering Probability of Depressurization	Close Hatches During Crew Sleep Period; Assure Crew Has Egress Plan in Case of Module Penetration
Reduce Crew Reaction Time to Penetration and Depressurization	Decreases $P_{loss/pen}$ from 0.58 to 0.52 for 24-in Critical Length By Lowering Probability of Depressurization	Train Crew to Egress Work and Sleep Stations Rapidly; Install Alarm System for Penetrations
Reduce Crew Movement Time to Hatches (add Rate-Based Movement Assumption)	Decreases $P_{loss/pen}$ from 0.58 to 0.49 for 24-in Critical Length By Lowering Probability of Depressurization	Train Crew to Move Rapidly in Zero Gravity, (in KC-135?) Against Simulated Air Flow
Crew Sleeps Near Egress Location	No Measurable Decrease in $P_{loss/pen}$	Crew Sleeps Near Hatch; Only Implement if Later Proven Helpful

crack length to 24 in was shown to almost eliminate the unzipping hazard, lowering the $P_{loss/pen}$ to 0.58 from the baselined 0.76 value. A SSEIC study released in March 1993[53] reported that the 7-in critical crack length within a 0.125-in 2219T87 aluminum pressure wall could be raised to 12 in by thickening the pressure wall to 0.188 in. These reported levels require additional testing on the nature of impact-generated dynamic crack growth in pressurized aluminum skins to increase confidence in their absolute values. However, increasing pressure wall thickness is certainly a "good investment" in quantitatively increasing crew safety from the explosive decompression hazard that accompanies penetration-induced rupture of the spacecraft wall. "Unzipping" is the most costly form of penetration-related hazard to the spacecraft and crew, usually causing loss of the entire spacecraft and crew due to explosive decompression. Therefore, investment in design solutions that increase the critical crack length should result in a larger "expected value" cost savings (cost of a penetration hazard times reduction in probable occurrence) to the program over its life than any of the other hazard-mitigating features discussed here.

Adding internal equipment to those areas where debris is most likely to penetrate (such as the "sides" of the laboratory module) was found to be the second most important of the "controllable" design factors in decreasing $P_{loss/pen}$. This factor directly decreased the probability of crew injury losses due to fragments, and probably also decreases other secondary hazards to the crew such as light flash, pressure pulse, and temperature rise (although these factors were not explicitly examined within this study). Any increase in the resistance to "incoming" debris fragments would serve to decrease this crew hazard. As such, this design solution could be implemented by moving equipment racks to the "sides" of the modules facing the debris threat, or by adding internal blankets that reduce the spallation hazard on-orbit to increase crew safety. This type of design solution would probably be easier to implement than increasing external shielding to prevent orbital debris penetration. Similarly, sleeping in Node 2 would provide increased injury protection to the crew during their sleeping period (since the nodes are one of the least likely locations for penetration).

The remaining six identified alternatives describe operational factors that were shown to reduce the probability of crew loss due to slow depressurization (resulting from smaller penetration-induced holes). Two of these factors involved crew operations during the crew's sleep period, when the crew's reaction time to a depressurizing module was most affected. Closing the hatches during the sleep period appears to increase crew safety from depressurizations that may occur in other modules if they are penetrated. However, this solution would likely be less attractive if the MSCSurv™ program included probable "long-term" losses associated with crew being unable to escape a module if separated from the rest of the station by a vacuum. No significant advantage was shown for the crew to sleep near the escape hatch, although it may prove marginally effective when combined with a faster reaction or movement time.

A decrease in the baselined crew reaction time (time required to discover, locate, and initiate escape from a penetrated module) provides a measurable reduction in crew loss due to decompression. This might be brought about by training the crew to egress their workstations, exercise stations, sleeping restraints, etc., in a faster fashion. The reaction time could also be decreased through implementing an effective impact-detection and leak-location and warning system aboard the spacecraft. A faster (position-based) crew movement to the hatches to escape or to close off the penetrated module also measurably reduced the $P_{loss/pen}$. It would also require crew training to implement.

One of the most effective methods in reducing the probability of crew loss due to depressurization following a penetration was to extend the depressurization limit of the crew members from 7.5 lb/in^2 down to 3.0 lb/in^2, primarily by the crew donning oxygen masks immediately following a penetration. However, several important factors must be considered prior to realizing this possible increase in crew safety. The system must be completely portable; it must be within reach at all times; the existing oxygen mask/bottle combination must be capable of functioning at this low pressure level. Perhaps a realistic compromise would be a system that hangs near the crew member during his/her sleep period for easy access during this critical period, with additional systems stored in easily accessible locations throughout the modules.

To underline the points made above, these eight "controllable" design and operational alternatives were combined together in two analyses to determine the "minimum" $P_{loss/pen}$ possible if all eight factors are adopted. In this case, the critical crack length was increased to 12 and 24 in by increasing the rear wall thickness to 0.188 and 0.250 in, respectively. The results of these analyses appear in tables 21 and 22. Note that the $P_{loss/pen}$ has fallen from 0.76 to 0.46 for the 12-in critical crack length; injury losses due to fragments and slow depressurization have fallen to almost zero.

Table 21. "Improved" probability of crew loss (one or more) given a penetration, $P_{loss/pen}$, for six modules, 12-in critical crack length.

	Crack	Injury	Slow Depress	Total
Module 1 (U.S. Lab)	0.45	0.01	0.00	0.46
Module 2 (U.S. Hab)	0.46	0.01	0.01	0.48
Module 3 (JEM)	0.43	0.00	0.00	0.43
Module 4 (ESA)	0.42	0.02	0.04	0.48
Module 5 (Node 2)	0.46	0.01	0.06	0.53
Module 6 (Node 1)	0.40	0.01	0.00	0.41
Module 7 (P-Log)	0.30	0.00	0.00	0.30
Module 8 (Airlock)	0.33	0.00	0.00	0.33
Total (1 through 6)	0.44	0.01	0.01	0.46

"Improved" Controllable Design and Operational Assumptions Employed:

- 12-in Critical Crack Length (0.188-in Rear Wall)
- Internal Equipment (0.7 g/cm^2) Along Inner Pressure Wall
- 3.0 lb/in^2 Critical Depressurization Limit
- Crew Sleeps in Node 2
- Close Hatches During Crew Sleep Period
- Fast Crew Reaction Time
- Fast (Rate-Based) Crew Movement Assumption
- Crew Sleeps Near Egress Location

Table 22. "Improved" probability of crew loss (one or more) given a penetration, $P_{loss/pen}$, for six modules, 24-in critical crack length.

	Crack	Injury	Slow Depress	Total
Module 1 (U.S. Lab)	0.016	0.022	0.000	0.038
Module 2 (U.S. Hab)	0.017	0.025	0.024	0.067
Module 3 (JEM)	0.018	0.001	0.001	0.020
Module 4 (ESA)	0.017	0.007	0.000	0.023
Module 5 (Node 2)	0.193	0.025	0.000	0.218
Module 6 (Node 1)	0.012	0.049	0.161	0.222
Module 7 (P-Log)	0.005	0.000	0.000	0.005
Module 8 (Airlock)	0.005	0.000	0.000	0.005
Total (1 through 6)	0.026	0.019	0.015	0.060

"Improved" Controllable Design and Operational Assumptions Employed:

- 24-in Critical Crack Length (0.250-in Rear Wall)
- Internal Equipment (0.7 g/cm^2) Along Inner Pressure Wall
- 3.0 lb/in^2 Critical Depressurization Limit
- Crew Sleeps in Node 2
- Close Hatches During Crew Sleep Period
- Fast Crew Reaction Time
- Fast (Rate-Based) Crew Movement Assumption
- Crew Sleeps Near Egress Location

Table 22 shows that the $P_{loss/pen}$ for a 24-in critical length with "improved" controllable design and operational alternatives has fallen from 0.76 to 0.06. Note that most of these losses occur in nodes 1 and 2, where the crew sleeps. Recall that this analysis includes only three of the seven identified modes of crew loss (table 4); however, this large drop in expected $P_{loss/pen}$ highlights the magnitude of benefit possible from employing improved design and operational alternatives in lowering the likelihood of crew loss due to orbital debris penetration in manned spacecraft.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

The following objectives were established in section I and met within the body of this report:

(1) Conducted research into methods for estimating quantitative risk that were applicable to the manned spacecraft orbital debris impact problem (section II).

(2) Identified penetration-induced failure modes that induce spacecraft or crew loss and those internal design and/or operational factors that most affect these failure modes (section III).

(3) Summarized baseline assumptions from above studies, and developed a detailed probabilistic model and simulation tool (MSCSurv™) for computing loss of crew from three "significant" orbital debris penetration failure modes considering eight alternative operational/design variables and twelve alternative hazard input variables (section IV).

(4) Performed baseline research and sensitivity studies on probability of crew loss from orbital debris penetration for spacecraft manned modules (sections V.A and V.B). Performed validation and verification of developed simulation tool (section V.C). Identified operational modes and design alternatives that increase crew safety, and possible roadblocks to their implementation (section V.D).

This report shows that it is possible to quantify the probability of the loss of one or more crew members from orbital debris penetration into manned spacecraft. This is due primarily to the unique nature of the orbital debris threat, which has been shown through NASA studies to possess predictable probability density functions (PDF's) for debris velocity, direction, and mass. Through a Monte Carlo simulation, these orbital debris PDF's can be coupled with knowledge of the hazard levels generated following hypervelocity orbital debris impact and hazard thresholds associated with crew loss to derive the expected probability of crew loss following a spacecraft penetration, $P_{loss/pen}$.

Section V shows that the absolute $P_{loss/pen}$ value is highly dependent on the magnitude of the hazard levels (hole sizes, crack sizes, penetration depth, etc.) associated with the impact process. It is also quite sensitive to the hazard levels assumed to result in crew loss (fragment energy, crew depressurization levels, etc.). Tables 14 through 16 describe some of these $P_{loss/pen}$ sensitivities.

A measurable relative increase in crew safety (decrease in the $P_{loss/pen}$) can be achieved through modifying selected spacecraft design factors and/or crew operations. Comparison of table 13 to table 20 shows that adoption of eight design and operational alternatives can cut the $P_{loss/pen}$ for the baselined six module spacecraft cluster almost in half (from 0.76 to 0.46). Adoption of a pressure wall even more resistant to critical cracking (24-in critical crack length) could reduce this even further (table 22).

The clearest benefit in calculating the probability of crew loss from orbital debris penetrations is an ability to identify highly effective design and operational safety improvements. Quantifying the relative decrease in $P_{loss/pen}$ associated with a variety of design/operational alternatives allows the system engineer to identify and "rank" those alternatives that most measurably reduce the probability of crew loss. With this information, managers may pursue those safety improvements that offer highest reduction in $P_{loss/pen}$ for available resources. Table 19 shows the relative decrease in $P_{loss/pen}$ possible from each of eight individual design factors. These results indicate that increasing the critical crack resistance in the spacecraft pressure wall, the protective capability of the internal equipment, and crew access to oxygen following penetration are most effective in reducing the probability of crew loss from orbital debris penetration. These solutions are even more effective when combined with customized operational protocols for module hatch closure and crew sleep position.

B. Recommendations for Future Work

This study must be expanded in order to completely quantify the probability of crew loss (one or more) given a spacecraft penetration by orbital debris. As detailed in section III, the $P_{loss/pen}$ reported herein was limited to only three manned module failure modes—explosive decompression due to critical crack propagation ("unzipping"), crew injury due to interior fragments, and "slow" depressurization. Although these three failure modes are considered by this researcher to be the largest contributors leading to crew loss following manned spacecraft penetration by orbital debris, other failure modes leading to crew or spacecraft loss are listed in table 5. These failure modes could be added to the MSCSurv™ code developed herein, or added through separate analysis, as required. Briefly, these failure modes include:

(A) Crew Loss from External Atmospheric Outgassing. In this failure mode, the thrust from air loss through the module pressure wall causes the spacecraft to tumble out of control. Additional data required here is the control authority of the spacecraft (i.e., the moment-resisting capability of spacecraft thrusters, gyroscopes, etc.), the mass and center of gravity of the spacecraft, the location of the strike, the size of the hole, and the volume of air behind the hole prior to the initiation of module depressurization. Because MSCSurv™ already calculates the location of the hole and size of the strike, it should be fairly easy to add a control moment "threshold" and a calculation subroutine to check if individual penetrations (wherever they occur on the spacecraft) exceed this threshold. If so, a crew/station loss could be registered.

(B) Crew Loss from Overpressure, Temperature, or Flash. In these failure modes (generally referred to as "secondary" or "atmospheric" hazards), part of the energy of the debris cloud impinging into the spacecraft cabin atmosphere causes damaging waves of heat, light, and pressure to travel through it, injuring crew members if the magnitude exceeds established limits of human endurance. Unfortunately, the relative amount of penetration energy that is transformed into each of these damage mechanisms is still unknown, although it is reasonable to assume that their magnitude is somehow related to the total amount of penetration energy entering the module. As such, the magnitude of the atmospheric hazard energy should be able to be related to the familiar impact energy parameters of debris mass dov. It is also almost assuredly related to the target parameters of shield type and amount and type of equipment behind the shield. Since MSCSurv™ already generates and contains inputs for all of these parameters, all that appears lacking for inclusion of this failure mode is a relationship between impact energy and its resulting atmospheric hazard magnitudes, considering each target type. It seems clear that these failure modes will require extensive test data prior to their inclusion.

(C) Crew Loss from Internal Equipment Failure. Internal equipment racks could contain hazardous materials, utility lines, or other equipment whose failures could cause loss of station or crew if penetrated. A clearer definition of the design of internal equipment would allow expansion of MSCSurv™ to include an additional possibility of crew loss to occur following a penetration in these areas.

In addition to expanding the types of failure modes considered within this analysis, a number of simplifying assumptions used to develop the $P_{loss/pen}$ values for the three failure modes included herein require additional verification or expansion to increase the accuracy and confidence in their results. Some of the more important areas include:

(1) Development of independent models for hole size and crack length created within pressure wall following hypervelocity penetration. The baselined model for crack size contained herein is dependent on hole size; the hole size model in itself remains preliminary and empirical in nature. While some relationship may exist between hole size and crack size, both of these output parameters require a better understanding of their dynamic formation under a variety of test conditions.

(2) Verification of internal penetration model and spacecraft geometry. This study assumed that the depth of internal spacecraft penetration could be related to the average internal areal density of interior spacecraft equipment. Other qualities of the interior equipment (geometry, material strength, shock impedance, etc.) will almost certainly affect both the depth of penetration and the amount of energy that remains in the debris cloud upon exit. Both a more sophisticated penetration model and a more defined spacecraft interior equipment layout are required to enhance our confidence in the existing results for overall $P_{loss/pen}$.

(3) The crew's capability to rescue stricken comrades could significantly lower the probability of crew loss due to depressurization or injury. However, this advantage would be offset somewhat by the possibility of additional crew loss. In either case, additional data on the speed of crew reaction and movement while healthy, hindered, or injured in a zero gravity environment is definitely required.

(4) The effect of advanced shielding should be examined to see if "heavier" shields, when penetrated, cause more interior damage (and thus a higher $P_{loss/pen}$ value) than the baselined shields. This factor was not included in the study, and must be added if we desire to examine the tradeoffs in the cost of external shielding versus the "savings" in expected internal penetration costs resulting from their use.

Finally, although MSCSurv™ addresses the probability of losing one or more crew members given an orbital debris penetration, MSCSurv™ could be modified slightly to also compute the average number of crew members lost following a penetration. Although current NASA philosophy makes no distinction between losing one crew member versus losing more than one crew member, this information could be valuable if two competing designs produced the same $P_{loss/pen}$.

C. Example Using $P_{loss/pen}$ to Minimize System Costs

In concluding this study, it seems reasonable to include an example illustrating how information on the $P_{loss/pen}$ might be used to minimize the overall system costs associated with meeting established orbital debris safety requirements. In this example, the manufacturer of a laboratory module similar in baseline design to module 1 wishes to meet an improved probability of no crew loss (PNCL) of 0.9995 per year. The current module design (with its 0.125-in pressure wall) maintains a 0.9975 PNP, or a 0.0025 probability of penetration per year. Using the results of the baseline analysis presented here for the manned module cluster (where $P_{loss/pen = 0.76}$), the manufacturer discovers that his existing design already offers a 0.0019 P_{loss}, or a 0.9981 PNCL. Because this value is far short of the desired safety level of 0.9995 per year, the manufacturer decides that he must upgrade the meteoroid/debris protection system.

Alternative 1 is to switch out the external bumper for one that offers a 0.99935 PNP. The cost for this system is \$5 million in development costs and 1,800 lb (\$18 million in launch costs), for a subtotal of \$23 million. The manufacturer makes the preliminary assumption that the new shield offers the same $P_{loss/pen}$ as the baseline shield (0.76). Alternative 1 then offers a P_{loss} of 0.00049, or a PNCL of 0.99951, exceeding the stated PNCL requirements.

In alternative 2, by spending an additional \$5 million for development and 1,200 lb of weight (equivalent to \$12 million in launch costs at \$10,000 per lb), the manufacturer could install a lighter, redesigned bumper and a 0.188-in rear wall and increase his probability of no penetration to 0.99890. Using the study results shown in table 15 for the baseline assumptions and a 12-in critical crack length, the manufacturer computes that the $P_{loss/pen}$ for alternative 2 is 0.62, and offers a PNCL of 0.99932 for a subtotal of \$17 million. Alternative 2 appears to fall short of the stated PNCL requirement of 0.9995 per year.

However, if the manufacturer moves several equipment racks to positions that prevent debris penetration into the aisles, adds oxygen bottles, initiates training of the crew to decrease reaction time, etc., he can reduce the $P_{loss/pen}$ of alternative 2 to 0.47 (as shown in table 20). Alternative 2a would then offer a P_{loss} of $\{1-[(1-0.9989)\times(0.47)]\} = 0.9995$, just reaching the PNCL requirement. However, alternative 2a would cost an additional \$5 million to implement over alternative 2, for a total of \$22 million in "implementation" costs, \$1 million less than option 1.

This cost/benefit analysis would indicate option 2a to be the most cost effective solution to meeting the stated safety requirements, despite the higher cost of equipment relocation and crew training in option 2a. However, the manufacturer chooses to run one additional tradeoff to include the expected cost of a penetration for both option 1 and option 2a. Through intensive analysis, the manufacturer has determined that any penetration will cause repair costs of \$10 million. Penetrations causing a crew injury will result in at least \$100 million in costs to repair the module and to bring the crewmember home for emergency medical treatment. However, those penetrations causing unzipping of the module wall will result in loss of the utility of the entire module, at least \$10 billion (this figure also includes the cost of bringing surviving crewmembers back to Earth).

Multiplying the probability of the different types of penetration effects by their expected ratios of occurrence leads to an expected overall penetration cost of \$4.6046 million for alternative 1 and \$4.8026 million for alternative 2a. This is primarily due to the slightly higher overall probability of unzipping for alternative 2a (despite the fact that alternative 2a has a lower probability of unzipping following a penetration, offset due to its larger probability of penetration). However, table 23 shows that the total costs including both expected penetration costs and implementation costs is still \$800,000 lower for alternative 2a than for alternative 1. Given this information, alternative 2a should be pursued by the manufacturer.

Of course, this analysis neglects a number of indirect and/or incalculable costs that are also associated with meteoroid and orbital debris penetrations. For example, recall that the overall probability of unzipping was slightly higher for the alternative 2a than for alternative 1. Not reflected in the cost analysis is the fact that more crew members can be expected to be lost (on average) during unzipping failures. Given this, alternative 2a can be expected to produce a slightly higher number of crew members lost (on average) for a penetration than alternative 1. Although NASA does not apparently differentiate between one crew loss and more than one crew loss, information on the difference in average expected numbers of crew lost between competing designs that are otherwise so evenly matched might be a deciding factor to program safety engineers. Also neglected here is the incalculable cost to an organization associated with hardware failure and loss (or near loss) of a crew member. Given that alternative 2a has a 40-percent higher probability of a penetration, this might be viewed by some as a 40-percent higher probability of "bad press," thus rendering the slightly more expensive option 1 as the more palatable choice.

This study highlights the fundamental utility of quantitative risk assessment: to pinpoint those areas of a system's design that drive its overall safety, and to offer solutions that may increase system safety while lowering its cost. It is likely that future spacecraft designers will increasingly require the flexibility in design solutions offered by quantitative risk assessment if the orbital debris environment grows as predicted.

Table 23. Example problem—trade study for improved Lab module shielding.

	Alternative 1	Alternative 2	Alternative 2a
Shield Type	Bumper Upgrade	Thicker Rear Wall	Thicker Rear Wall
Delta Weight	1,800 lb	1,200 lb	1,200 lb
Launch Costs	1,800 × \$10K/lb = \$18 Million	1,200 × \$10K/lb = \$12 Million	1,200 × \$10K/lb = \$12 Million
Dev Costs	\$5 Million	\$5 Million	\$5 Million
Additional Costs			\$5 Million (Move Racks, Provide O_2 Train Crew)
Total Cost of Implementation	\$23 Million	\$17 Million	\$22 Million
P[penetration]	0.00065	0.00110	0.00110
$P_{loss/pen}$	0.76	0.62	0.47
P_{loss}	0.00049 (Meets Requirement)	0.00068 (Misses Requirement)	0.00050 (Meets Requirement)
$P_{Unzip\ loss}$	(0.72/0.76)×(.00049) = 0.00046		(0.45/0.47)×(0.00050) = 0.00048
$P_{Injury\ loss}$	0.00003		0.00002
P_{pen} - P_{loss}	0.00016		0.00060
Expected Cost of Unzipping	(0.00046)×(\$10 Billion) = \$4.6 Million		(0.00048)×(\$10 Billion) = \$4.8 Million
Expected Cost of Injury	(0.00003)×(\$100 Million) = \$0.003 Million		(0.00002)×(\$100 Million) = \$0.002 Million
Expected Cost of Penetration	(0.00016)×(\$10 Million) = \$0.0016 Million		(0.00060)×(\$10 Million) = \$0.006 Million
Total Expected Penetration Costs	\$4.6046 Million		\$4.808 Million
Total Penetration + Implementation Costs	\$27.6 Million		\$26.8 Million

REFERENCES

1. Kessler, D.J., and Cour-Palais, B.G.: "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt." Journal of Geophysical Research, vol. 63, 1978.

2. Kessler, D.J., et al.: "Orbital Debris Environment for Spacecraft Designed to Operate in Low Earth Orbit." NASA Technical Memorandum 100-471, 1989.

3. Space Station *Freedom* Program Office: "Space Station Program Natural Environment Definition for Design." NASA SSP 30425, revision A, 1991.

4. Horn, et al.: "Analysis Procedures for Meteoroid/ Debris Protection of Space Structures." Fifth Technical and Business Exhibition/Symposium, Huntsville, AL, 1989.

5. European Space Agency: "Space Debris." ESA Report No. SP-1109, 1988.

6. McKnight, D., and Johnson, N.: "Debris Growth: Isolating Sources and Effects." AIAA Space Programs and Technologies Conference, AIAA-92-1284, 1992.

7. Howell, L. W.: "A Stochastic Model for Particle Impingements on Orbiting Spacecraft." The Journal of Astronautical Sciences, vol. 34, No. 4, 1986.

8. Mog, R.: "Optimization Techniques Applied to Passive Measures for In-Orbit Spacecraft Survivability." Final report on contract NAS8-37378, 1992.

9. Horn, J., and Williamsen, J., Briefing Material to NASA Space Station *Freedom* WP01 Chief Engineer's Office, 1989.

10. NASA SSP 30000, Revision H. 1990. Space Station *Freedom* Preliminary Design Requirements Document, paragraph 3.1.1.

11. Burch, G.T.: "Multiplate Damage Study." Air Force Systems Command Report AFATL-TR-67-116, 1967.

12. Bjorkman, M.: "Preliminary Results of the Ballistic Limit Testing of Aluminum Meteoroid/ Debris Shields." Boeing Contract No. NAS8-50000, Preliminary, 1990.

13. Coronado, A. R., et al.: "Space Station Integrated Wall Design and Penetration Damage Control." Final report D180-30550-1, NASA contract No. NAS8-36426, 1987.

14. Williamsen, J.E.: "Orbital Debris Risk Analysis and Survivability Enhancement for *Freedom* Station Manned Modules." AIAA Space Programs and Technologies Conference, AIAA-92-1410, 1992.

15. Huntsman, D.: "Space Station *Freedom*—Status of Meteoroid and Orbital Debris Design Requirements." NASA briefing to Level 2 Space Station *Freedom* Program Office, 1991.

16. Piekutowski, A.J.: "Characteristics of Debris Clouds Produced By Hypervelocity Impact of Aluminum Spheres With Thin Aluminum Plates." Hypervelocity Impact Symposium, HVIS 049-G1, 1992.

17. Jolly, W., and Williamsen, J.: "Ballistic Limit Curve Regression for *Freedom* Station Orbital Debris Shields." AIAA Space Programs and Technologies Conference, AIAA-92-1463, 1992.

18. Tipton, J., and Williamsen, J.: "Hydrocode Analysis for *Freedom* Station Orbital Debris Penetration Protection." AIAA Space Programs and Technologies Conference, AIAA-90-2773, 1990.

19. Chhabldis, L., and Hertel, E.: "Hypervelocity Impact Tests of Whipple Shield Concepts at Velocities Between 8 and 12 km/s." 1992 AIAA Space Programs and Technologies Conference, AIAA-92-1587, 1992.

20. Bjorkman, M.: "Biaxially-Stressed Ballistic Limit Testing of Aluminum Plates." Boeing Contract No. NAS8- 50000, preliminary, 1990, p. 21.

21. Elfer, N.: "Structural Damage Prediction and Analysis for Hypervelocity Impacts." NASA-Marshall Space Flight Center contract No. NAS8-38856, preliminary, 1992.

22. Ball, R.E.: "Aircraft Combat Survivability." AIAA Press, Inc., 1985.

23. Thompson, R.S., et al.: "Vulnerability Analysis of the Soviet HIND-A/D Helicopters to Single and Multiple Fragment Impacts and to External Blast (U)." Ballistic Research Laboratory technical report ARBRL-TR- 02395, 1982.

24. Joint Technical Coordinating Group for Munitions Effectiveness: "Methodology Report." Report No. 61A1-3-6, 5, 1974.

25. Joint Technical Coordinating Group for Munitions Effectiveness: "Derivation of JMEM/AS Open End Methods." Report No. 61JTCG/ME-3-7, 1990.

26. Dietz, Paul, et al.: "Current Simulation Methods in Military Systems Vulnerability Assessment." Ballistic Research Laboratory Memorandum Report BRL-MR-3880, 1990.

27. Deitz, Paul H., et al.: "An Integrated Environment for Army, Navy and Air Force Target Description Support." Ballistic Research Laboratory Memorandum Report BRL-MR- 3754, 1989.

28. Ray, J.V.: "Technical Proposal—Cabin Hazards Due To Meteoroid Penetration." LTV report No. 00.852, 1966.

29. Burch, G.T.: "Hypervelocity Particle Penetration Into Manned Spacecraft Atmospheres." Boeing report D2- 24149-1, 1967.

30. Long, L., and Hammitt, R.: "Meteoroid Perforation Effects on Space Cabin Design." AIAA Hypervelocity Impact Conference, Cincinnati, OH, 1969.

31. Bancroft, R.W.: "Comments and Review of Decompression Hazards in Manned Orbiting Systems." Proceedings of Orbital International Laboratory and Space Science Conference, report No. A70-43626 22-30, 1969.

32. Von Beckh, H.J.: "Protective Measures Against Accidental Decompression in Space and Atmospheric Flight." 6571st Aeromedical Research Laboratory Report No. ARL-TR- 70-4, 1970.

33. Engler, E.E.: "Physiological and Safety Aspects of Penetration." Space Debris and Meteoroid Technology Workshop, Marshall Space Flight Center, 1984.

34. Bauer, E.: "Meteoroid and Orbital Debris Protection Concepts." MBB/Erno Report No. A87-16081, 1987.

35. Christiansen, E.: "Survivability of Space Station *Freedom* External Elements in the Meteoroid/Debris Environment." AIAA Space Program and Technologies Conference, AIAA-92-1409, 1992.

36. Joint Technical Coordinating Group for Munitions Effectiveness: "Penetration Equations Handbook for Kinetic Energy Penetrators." Report No. 61JTCG/ME-77-1, 1991.

37. Joint Technical Coordinating Group for Munitions Effectiveness: "Evaluation of Wound Data and Effectiveness of Munitions." Report No. 61JTCG/ME-75-11-3, 3, 1975.

38. Zaker, T.A., et al.: "Fragmentation Hazard Study." Phases I and II, final report, contract DAHC-04-69-C-0056, 1970.

39. Sperrazza, J., and Kolkanis, W.: "Criteria for Incapacitating Soldiers With Fragments and Fletchettes." Ballistics Research Laboratory report 1269, 1965.

40. Sperrazza, J., and Kolkanis, W.: "Ballistic Limits of Tissue and Clothing." Ballistics Research Laboratory technical note 1645, 1967.

41. Bryan, A.C., et al.: "Aircrew Oxygen Requirements in High Altitude Transport Aircraft." Aerospace Medicine, vol. 31, 1961, pp. 30–34.

42. Ernsting, et al.: "Hypoxia Induced by Rapid Decompression—The Influence of Rate of Decompression." Royal Air Force Institute of Aviation Medicine, report AD-A009-006, 1973.

43. Bowen, I.G., et al.: "Estimate of Man's Tolerance to the Direct Effect of Air Blast." NASA report No. 2113, 1968.

44. Severin, et al.: "A Study of Photostress and Flash Blindness." TDR-62-144, USAF School of Aviation Medicine, San Antonio, TX, 1962.

45. Isbell, D.: "Space Debris Growth a Concern for Space Station." Space News, June 1991.

46. Concepcion, J.C.: "Space Station Module Blowdown From Debris Puncture." Boeing Memo 2-8285-JCC-085, 1985.

47. Concha, S.R.: "Manual Versus Powered Hatch Considerations: Safety Implications and Trade Study." Boeing report No. 2-H881, 1988.

48. Dickinson, R.L.: "Space Station *Freedom* Program Element Volumes." Boeing Memo 2-H8HD-RBP/RD-91099, 1991.

49. NASA: "Space Station *Freedom* Contingency Operations Scenarios." Johnson Space Center Operations Integration Office, preliminary, 1990.

50. Smylie, E.: "Request for Improved Orbital Debris Data." Grumman Memo GSS-011-LR92, 1992.

51. Chipman, R., et al.: "Space Station *Freedom* Program Meteoroid and Orbital Debris Forward Action Plan." Grumman Space Station Engineering and Integration Contractor (SSEIC), 1992.

52. NASA Level 2 Forward Action Team: "Integrated Meteoroid and Orbital Debris Assessment—Task One Report." Grumman SSEIC activity report GSS-310-M093-001, 1992.

53. NASA Level 2 Forward Action Team: "Integrated Meteoroid and Orbital Debris Assessment—Interim Report." Grumman SSEIC activity report GSS-310-M093-084, 1993.

54. Sokolnikoff, I.S., and Redhoffer, R.M.: "Mathematics of Physics and Modern Engineering." McGraw-Hill, NY, 1958.

55. Boeing Aerospace Corporation promotional literature, 1992.

56. NASA Space Station *Freedom* Utilization and Operations Office. Space Station *Freedom* Program Utilization Sequence Databook. Revision 1, October, 1991.

57. Boeing Aerospace Corporation: "General Arrangement, X2 Standoff, Lab." Boeing drawing No. SK683-55535, 1990.

58. Boeing Aerospace Corporation promotional literature, 1993.

59. Williamsen, J., et al.: Meeting Notes, MSFC/SSEIC Review of Forward Action Plan Results. April 30, 1993.

60. Peace, G.S.: "Hands-On Taguchi." Wesley-Addison Publishing, 1993, p. 236.

APPENDIX A

MSCSurv™ Computer Program Listing

```
C        PROGRAM TO COMPUTE PROBABILITY OF CREW INJURY
C                JOEL WILLIAMSEN
C             DOCTORAL DISSERTATION 1993
C         INDUSTRIAL AND SYSTEMS ENGNEERING DEPARTMENT
C
C DIMENSION ALL VARIABLE ARRAYS
C
    1 DIMENSION PROBDIA(110), PROBVEL(37), PROBELEM(8,100,37)
      DIMENSION ANGELEM(8,100,37), PROBSTA(8,12)
      DIMENSION NUMPEN(8,100), NCRIT(8), NUMINJ(8,100), PROBMOD(8,37)
      DIMENSION NSTATION(8,100), NSHLDTYP(8,100)
      DIMENSION NPENIN(8), NPENAT(8), NPENOUT(8), AREALDEN(8,100)
      DIMENSION NPENNOCR(8), NUMHOLE1(8), NUMHOLE2(8)
      DIMENSION NUMHOLE4(8), NUMHOLE5(8), NUMHOLE6(8), NUMPENS(8)
      DIMENSION NUMHOLE7(8), NUMHOLE8(8), NUMHOLE9(8), NUMHOL10(8)
      DIMENSION NUMHOL11(8), NUMHOL12(8), NUMHOL20(8)
      DIMENSION NUMHO1(8), NUMHO2(8), NUMHO3(8)
      DIMENSION NUMHO4(8), NUMHO5(8), NUMHO6(8)
      DIMENSION NUMHO7(8), NUMHO8(8), NUMHO9(8), NUMHO10(8)
      DIMENSION NUMHO11(8), NUMHO12(8), NUMHO20(8)
      DIMENSION NUMHOLE3(8), VELPART(37), DIAPART(110), NUMIMPS(8)
      DIMENSION NPEN1CRW(8), NPEN2CRW(8), NPEN3CRW(8), NPEN4CRW(8)
      DIMENSION NUMODULE(24,4), NCREWSTA(4), ESCTIME(4), NINJCRIT(8)
      DIMENSION CRITTIME(4), NUMCRIT(8,100), NINJ(8), VOLAVAIL(8)
      DIMENSION NPENCRIT(8), NPENCRAC(8), NPENINJ(8), PHOUR(24)
      DIMENSION RATTOT(8), RATDEP(8), RATINJ(8), RATCRAC(8)
C
C PROBDIA = CUMULATIVE PROBABILITY OF DIAMETER (CM) HITTING STATION (.3 TO 3 CM)
C PROBVEL = CUMULATIVE PROBABILITY OF VELOCITY (K/S) OF IMPACT (2 TO 14.5 K/S)
C VELPART = ANGLE (1 THROUGH 37) THAT PARTICLE IS COMING FROM
C PROBMOD = CUMULATIVE PROBABILITY OF MODULE X BEING IMPACTED GIVEN ANGLE Y
C ANGELEM = ANGLE OF IMPACT FOR GIVEN (MODULE, ELEMENT, ANGLE)
C PROBELEM = CUMULATIVE PROBABILITY OF ELEMENT X BEING IMPACTED
C          GIVEN (MODULE, ANGLE)
C PROBSTA = CUMULATVE PROBABILITY THAT CREWMAN IS AT STATION X IN MODULE Y
C NSTATION = CREW "STATION NUMBER" (1 - 12) WITHIN MODULE X FOR ELEMENT Y
C NSHLDTYP = TYPE OF SHIELD FOR MODULE X AND ELEMENT Y
C AREALDEN = AREAL DENSITY OF RACK MATERIAL BEHIND MODULE X AND ELEMENT Y
C NUMPEN = NUMBER OF PENETRATIONS AT MODULE X AND ELEMENT Y
C NUMINJ = NUMBER OF INJURY LOSSES OCCURRING DUE TO PENETRATION
C       "AT" MODULE I AND STATION J
C NUMCRIT = NUMBER OF DEPRESS LOSSES OCCURRING DUE TO PENETRATION OF MODULE I
C        AND STATION J
C NUMPENS = NUMBER OF PENETRATIONS IN MODULE I
C NCRIT = NUMBER OF CRITICAL DEPRESS LOSSES OCURRING IN MODULE I
C NINJ = NUMBER OF INJURIES OCCURRING IN MODULE I
C NPENIN = NUMBER OF PENETRATIONS FOR MODULE X WHERE PENETRATION WAS NEAR
HATCH
C NPENAT = NUMBER OF PENETRATIONS FOR MODULE X WHERE PENETRATION WAS NEAR
CREW
C NPENOUT = NUMBER OF PENETRATIONS FOR MODULE X WHERE CREW WAS NEARER
HATCH
C NPENNOCR = NUMBER OF PENETRATIONS OCCURRING IN MODULE WITH NO CREW
C NUMHOLE1 = NUMBER OF HOLES IN MODULE I 0 TO 1 INCHES IN DIAMETER
```

```
C NUMHOLE2 = NUMBER OF HOLES IN MODULE I 1 TO 2 INCHES IN DIAMETER
C NUMHOLE3 = NUMBER OF HOLES IN MODULE I 2 TO 3 INCHES IN DIAMETER
C NUMHOLE4 = NUMBER OF HOLES IN MODULE I 3 TO 4 INCHES IN DIAMETER
C NUMHOLE5 = NUMBER OF HOLES IN MODULE I 4 TO 5 INCHES IN DIAMETER
C NUMHOLE6 = NUMBER OF HOLES IN MODULE I 5 TO 6 INCHES IN DIAMETER
C NUMHOLE7 = NUMBER OF HOLES IN MODULE I 6 TO 7 INCHES IN DIAMETER
C NUMHOLE8 = NUMBER OF HOLES IN MODULE I 7 TO 8 INCHES IN DIAMETER
C NUMHOLE9 = NUMBER OF HOLES IN MODULE I 8 TO 9 INCHES IN DIAMETER
C NUMHO1 = NUMBER OF CRACKS IN MODULE I 0 TO 1 INCHES IN DIAMETER
C NUMHO2 = NUMBER OF CRACKS IN MODULE I 1 TO 2 INCHES IN DIAMETER
C NUMHO3 = NUMBER OF CRACKS IN MODULE I 2 TO 3 INCHES IN DIAMETER
C NUMHO4 = NUMBER OF CRACKS IN MODULE I 3 TO 4 INCHES IN DIAMETER
C NUMHO5 = NUMBER OF CRACKS IN MODULE I 4 TO 5 INCHES IN DIAMETER
C NUMHO6 = NUMBER OF CRACKS IN MODULE I 5 TO 6 INCHES IN DIAMETER
C NUMHO7 = NUMBER OF CRACKS IN MODULE I 6 TO 7 INCHES IN DIAMETER
C NUMHO8 = NUMBER OF CRACKS IN MODULE I 7 TO 8 INCHES IN DIAMETER
C NUMHO9 = NUMBER OF CRACKS IN MODULE I 8 TO 9 INCHES IN DIAMETER
C NUMIMPS = NUMBER OF IMPACTS FOR MODULE I
C NUMODULE = MODULE THAT CREWMAN J IS IN DURING HOUR I
C PHOUR = PROBABILITY THAT DEBRIS HITS DURING HOUR I
C NCREWSTA = STATION THAT CREWMAN I IS AT
C ESCTIME = REQUIRED ESCAPE TIME FOR CREWMAN I FROM MODULE HE IS IN
C CRITTIME = TIME ALLOWABLE BEFORE LOSS OF CONSCIOUSNESS
C VOLAVAIL = VOLUME AVAILABLE TO CREW IN MODULE I
C NPENCRAC = NUMBER OF PENETRATIONS IN MODULE I WHERE ENERGY EXCEEDS
CRITICAL
C NPENCRIT = NUMBER OF PENETRATIONS WHERE ONE OR MORE DEPRESSURIZATION
LOSSES
C        OCCUR
C NPENINJ = NUMBER OF PENETRATIONS WHERE ONE OR MORE INJURIES OCCUR
C NINJCRIT = NUMBER OF PENETRATIONS WHERE ONE OR MORE INJURIES OR DEPRESSES
C        OCCUR
C RATCRAC = RATIO OF CRITICAL CRACKS WITHIN MODULE TO TOTAL PENETRATIONS
C RATINJ = RATIO OF CRITICAL INJURIES WITHIN MODULE TO TOTAL PENETRATIONS
C RATDEP = RATIO OF CRITCAL DEPRESSURIZATIONS WITHIN MODULE TO PENETRATIONS
C RATTOT = RATIO OF TOTAL CRITICAL LOSSES WITHIN MODULE TO PENETRATIONS
C
C SET INTEGER VALUES
C
    5 INTEGER SEEDVAL, ANGLE, ELEMENT
      REAL INJTIME
      REAL INJRATE
C
C OPEN DATA FILE VELSTA.DAT
C
     WRITE (*,*) 'READING IN VELSTA.DAT'
C
    6 OPEN (21, FILE='VELSTA.DAT')
C
C READ DATA FROM VELSTA.DAT
C
    7 DO 10 I = 1, 37
    8 READ (21, '( 2F9.4)' ) VELPART(I), PROBVEL(I)
   10 CONTINUE
```

```
C
C OPEN DATA FILE PROBDIA.DAT
C
      WRITE(*, *) 'READING IN PROBDIA.DAT'
C
   11  OPEN (22, FILE='PROBDIA.DAT' )
C
C READ DATA FROM PROBDIA.DAT
C
   12  DO 20 I = 1, 110
   13  READ (22, '( 2F9.4)' ) PROBDIA(I), DIAPART(I)
   20  CONTINUE
C
C OPEN DATA FILE LAB.DAT
C
      WRITE(*, *) 'READING IN LAB.DAT'
C
   21  OPEN (23, FILE='LAB.DAT' )
C
C READ DATA FROM LAB.DAT
C
   22  DO 40 J = 1, 37
   23  DO 30 I = 1, 100
   24  READ (23, '( 2F9.4)' ) ANGELEM(1,I,J), PROBELEM(1,I,J)
       NUMPEN(1,I)=0
       NUMINJ(1,I)=0
   30  CONTINUE
   40  CONTINUE
C
C OPEN DATA FILE HAB.DAT
C
      WRITE(*, *) 'READING IN HAB.DAT'

   41  OPEN (24, FILE='HAB.DAT' )
C
C READ DATA FROM HAB.DAT
C
   42  DO 60 J = 1, 37
   43  DO 50 I = 1, 100
   44  READ (24, '( 2F9.4)' ) ANGELEM(2,I,J), PROBELEM(2,I,J)
       NUMPEN(2,I)=0
       NUMINJ(2,I)=0
   50  CONTINUE
   60  CONTINUE
C
C OPEN DATA FILE JLAB.DAT
C
      WRITE(*, *) 'READING IN JLAB.DAT'
C
   61  OPEN (25, FILE='JLAB.DAT' )
C
C READ DATA FROM JLAB.DAT
C
       62DO 70 J = 1, 18
```

```
   63  DO 65 I = 1, 48
   64  READ (25, '( 2F9.4)' ) ANGELEM(3,I,J), PROBELEM(3,I,J)
       NUMPEN(3,I)=0
       NUMINJ(3,I)=0
   65  CONTINUE
   70  CONTINUE
C
C READ IN JLAB ANGLES 19 THROUGH 37
C
   71  DO 80 J = 19, 37
   72  DO 75 I = 1, 48
   73  ANGELEM(3,I,J)=0.0
   74  PROBELEM(3,I,J)=0.0
       NUMPEN(3,I)=0
       NUMINJ(3,I)=0
   75  CONTINUE
   80  CONTINUE
C
C OPEN DATA FILE ESA.DAT
C
    WRITE(*, *) 'READING IN ESA.DAT'
C
   81  OPEN (26, FILE='ESA.DAT' )
C
C READ IN DATA FROM ESA.DAT
C
   82  DO 100 J = 1, 37
   83  DO 90 I = 1, 100
   84  READ (26, '( 2F9.4)' ) ANGELEM(4,I,J), PROBELEM(4,I,J)
       NUMPEN(4,I)=0
       NUMINJ(4,I)=0
   90  CONTINUE
  100  CONTINUE
C
C OPEN DATA FILE NODE2.DAT
C
    WRITE(*, *) 'READING IN NODE2.DAT'
C
  101  OPEN (27, FILE='NODE2.DAT' )
C
C READ IN DATA FROM NODE2.DAT
C
  102  DO 120 J = 1, 37
  103  DO 110 I = 1, 39
  104  READ (27, '( 2F9.4)' ) ANGELEM(5,I,J), PROBELEM(5,I,J)
       NUMPEN(5,I)=0
       NUMINJ(5,I)=0
  110  CONTINUE
  120  CONTINUE
C
C OPEN DATA FILE NODE1.DAT
C
    WRITE(*, *) 'READING IN NODE1.DAT'
C
```

```
  121  OPEN (28, FILE='NODE1.DAT' )
C
C READ IN DATA FROM NODE1.DAT
C
  122  DO 140 J = 1, 37
  123  DO 130 I = 1, 39
  124  READ (28, '( 2F9.4)' ) ANGELEM(6,I,J), PROBELEM(6,I,J)
       NUMPEN(6,I)=0
       NUMINJ(6,I)=0
  130  CONTINUE
  140  CONTINUE
C
C OPEN DATA FILE PLOG.DAT
C
    WRITE(*, *) 'READING IN PLOG.DAT'
C
  141  OPEN (29, FILE='PLOG.DAT' )
C
C READ IN DATA FROM PLOG.DAT
C
  142  DO 160 J = 1, 37
  143  DO 150 I = 1, 72
  144  READ (29, '( 2F9.4)' ) ANGELEM(7,I,J), PROBELEM(7,I,J)
       NUMPEN(7,I)=0
       NUMINJ(7,I)=0
  150  CONTINUE
  160  CONTINUE
C
C OPEN DATA FILE ALOCK.DAT
C
    WRITE(*, *) 'READING IN ALOCK.DAT'
C
  161  OPEN (30, FILE='ALOCK.DAT' )
C
C READ IN DATA FROM ALOCK.DAT
C
  162  DO 180 J = 1, 37
  163  DO 170 I = 1, 36
  164  READ (30, '( 2F9.4)' ) ANGELEM(8,I,J), PROBELEM(8,I,J)
       NUMPEN(8,I)=0
       NUMINJ(8,I)=0
  170  CONTINUE
  180  CONTINUE
C
C OPEN DATA FILE PROBMOD.DAT
C
    WRITE(*, *) 'READING IN PROBMOD.DAT'
C
  181  OPEN (31, FILE='PROBMOD.DAT' )
C
C READ DATA FROM FILE PROBMOD.DAT
C
  182  DO 186 J = 1, 37
  183  DO 185 I = 1, 8
```

```
  184  READ (31, '( F9.4)' ) PROBMOD(I,J)
  185  CONTINUE
  186  CONTINUE
C
C OPEN DATA FILE SHIELD.DAT
C
       WRITE(*, *) 'READING IN SHIELD.DAT'
C
  187  OPEN (32, FILE='SHIELD.DAT' )
C
C READ IN CREW STATION-TO-ELEMENT AND SHIELD TYPE-TO-ELEMENT CORRELATION
C
  188  DO 193 I= 1, 530
  189  READ (32, '( 4I9, F9.4)' ) NMOD, NELEM, NSTA, NSTYP, DENS
  190  NSTATION(NMOD, NELEM)=NSTA
  191  NSHLDTYP(NMOD, NELEM)=NSTYP
  192  AREALDEN(NMOD, NELEM)=DENS
  193  CONTINUE
C
C OPEN DATA FILE POSITION.DAT
C
       WRITE(*, *) 'READING IN POSITION.DAT'
C
  194  OPEN (33, FILE='POSITION.DAT' )
C
C READ IN PROBABILITY OF CREW BEING AT THIS STATION
C
  195  DO 198 I = 1, 55
  196  READ (33, '( 2I9, F9.4)' ) NMOD, NSTA, STAPROB
  197  PROBSTA(NMOD,NSTA)=STAPROB
  198  CONTINUE
C
C OPEN DATA FILE PCREWMOD.DAT
C
       WRITE(*, *) 'READING IN PCREWMOD.DAT'
C
  199  OPEN (34, FILE="PCREWMOD.DAT" )
C
C READ IN PROBABILITY OF HOUR I AND NUMBER OF CREW IN MODULE J AT HOUR I
C
  200  DO 203 I = 1, 24
  201  READ (34, '( F9.4, 4I9)' ) P,M1,M2,M3,M4
  202  PHOUR(I)=P
       NUMODULE(I,1)=M1
       NUMODULE(I,2)=M2
       NUMODULE(I,3)=M3
       NUMODULE(I,4)=M4
  203  CONTINUE
C
C SET ALL NEEDED VARIABLES TO ZERO
C
  204  WRITE (*,*) ' INITIALIZING'
       WRITE (*,*) ' '
       WRITE (*,*) ' HOW MANY PENETRATIONS IN THIS MODEL RUN ? '
```

```
      READ  (*, '(I8)') NEND
207   NPEN=0
      NTRY=0
      NNN=1000
208   RANVAL=0.
      CALL GETTIM (IHR, IMIN, ISEC, I100TH)
      SEEDVAL=ISEC
      DO 210 I = 1,8
      NPEN1CRW(I)=0
      NPEN2CRW(I)=0
      NPEN3CRW(I)=0
      NPEN4CRW(I)=0
      NPENINJ(I)=0
      NPENCRAC(I)=0
      NPENIN(I)=0
      NPENOUT(I)=0
      NPENAT(I)=0
      NPENNOCR(I)=0
      NUMPENS(I)=0
      NPENCRIT(I)=0
      NINJCRIT(I)=0
      NCRIT(I)=0
      NINJ(I)=0
      NUMIMPS(I)=0
      NUMHOLE1(I)=0
      NUMHOLE2(I)=0
      NUMHOLE3(I)=0
      NUMHOLE4(I)=0
      NUMHOLE5(I)=0
      NUMHOLE6(I)=0
      NUMHOLE7(I)=0
      NUMHOLE8(I)=0
      NUMHOLE9(I)=0
      NUMHOL10(I)=0
      NUMHOL11(I)=0
      NUMHOL12(I)=0
      NUMHOL20(I)=0
      NUMHO1(I)=0
      NUMHO2(I)=0
      NUMHO3(I)=0
      NUMHO4(I)=0
      NUMHO5(I)=0
      NUMHO6(I)=0
      NUMHO7(I)=0
      NUMHO8(I)=0
      NUMHO9(I)=0
      NUMHO10(I)=0
      NUMHO11(I)=0
      NUMHO12(I)=0
      NUMHO20(I)=0
      IHSM=0
      RATCRAC(I)=0
      RATINJ(I)=0
      RATDEP(I)=0
```

```
      RATTOT(I)=0
      HACHTIME=30.
  210 CONTINUE
C
C SET A NEW SEED FOR ALL RANDOM VARIABLES TO BE DRAWN
C
  211 CALL  SEED(SEEDVAL)
C
C DRAW RANDOM NUMBER FOR "ANGLE" AND "VELOCITY"
C
C QUERY FOR CRITICAL VALUES
C
      WRITE (*,*) ' '
      WRITE (*,*) ' INPUT CRITICAL LENGTH OF CRACK OR "0." FOR ENERGY MO
      CDEL.'
      WRITE (*,*) ' '
      READ (*, '(F10.4)') CRITCRAC
      IF (CRITCRAC .NE. 0.) THEN
      ENERCRIT=0.
      WRITE (*,*) ' '
      WRITE (*,*) ' INPUT HOLE SIZE CRACK MULTIPLIER, 0.3 FOR AVERAGE.'
      WRITE (*,*) ' '
      READ (*, '(F10.4)') HMULT
      END IF
C
      IF (CRITCRAC .EQ. 0.) THEN
      WRITE (*,*) ' '
      WRITE (*,*) ' INPUT CRITICAL IMPACT ENERGY.'
      WRITE (*,*) ' '
      WRITE (*,*) '   NOTE: THIS CRITICAL CRACK RELATION IS MORE APPLICACBLE TO '
      WRITE (*,*) '        ADVANCED (B2) SHIELD.'
      WRITE (*,*) ' '
      READ (*, '(F14.6)') ENERCRIT
      WRITE (*,*) ' '
      WRITE (*,*) ' TYPE "1" FOR TOTAL ENERGY MODEL, "2" FOR OBLIQUE.'
      WRITE (*,*) ' '
      READ (*, '(I4)') NOB
      END IF
C
  213 WRITE (*,*) ' '
      WRITE (*,*) ' INPUT "1." FOR BASELINE SHIELD OR "2." FOR ADVANCED
      CSHIELD.'
      WRITE (*,*) ' '
      READ (*, '(F10.4)') SHIELD
C
      WRITE (*,*) ' '
      WRITE (*,*) ' INPUT MINIMUM CREW ESCAPE TIME (SECS) OR "0." FOR RA
      CTE-BASED ESCAPE RELATION.'
      WRITE (*,*) ' '
      READ (*, '(F10.4)') ET
      WRITE (*,*) ' '
      WRITE (*,*) ' INPUT DELAY PRIOR TO INITIATING MOVEMENT IF AWAKE.'
      WRITE (*,*) ' '
      READ (*, '(F10.4)') WAITTIME
```

```
WRITE (*,*) ' '
WRITE (*,*) ' INPUT DELAY TO WAKE AND EXIT RESTRAINTS IF ASLEEP.'
WRITE (*,*) ' '
READ (*, '(F10.4)') WAKETIME
IF (ET .NE. 0.) THEN
WRITE (*,*) ' '
WRITE (*,*) ' "1" TO MODEL HINDERED/INJURED TIMES; "2" FOR NO.'
WRITE (*,*) ' '
READ (*, '(I10)') INJHIND
IF (INJHIND .EQ. 1) THEN
WRITE (*,*) ' '
WRITE (*,*) ' INPUT HINDERED CREW ESCAPE TIME FROM MODULE.'
WRITE (*,*) ' '
READ (*, '(F10.4)') HINDTIME
WRITE (*,*) ' '
WRITE (*,*) ' INPUT (CONSCIOUS) INJURED CREW ESCAPE TIME FROM MODU
CLE.'
WRITE (*,*) ' '
READ (*, '(F10.4)') INJTIME
END IF
IF (INJHIND .EQ. 2) THEN
HINDTIME=ET
INJTIME=ET
END IF
END IF
IF (ET .EQ. 0.) THEN
WRITE (*,*) ' '
WRITE (*,*) ' INPUT UNHINDERED CREW ESCAPE RATE IN FT/SEC.'
WRITE (*,*) ' '
READ (*, '(F10.4)') GOODRATE
WRITE (*,*) ' '
WRITE (*,*) ' INPUT HINDERED CREW ESCAPE RATE IN FT/SEC.'
WRITE (*,*) ' '
READ (*, '(F10.4)') HINDRATE
WRITE (*,*) ' '
WRITE (*,*) ' INPUT (CONSCIOUS) INJURED CREW ESCAPE RATE IN FT/SEC
C.'
WRITE (*,*) ' '
READ (*, '(F10.4)') INJRATE
END IF
WRITE (*,*) ' '
WRITE (*,*) ' INPUT PROBABILITY THAT INJURED PERSON IS IMMEDIATELY
C LOST.'
WRITE (*,*) ' '
READ (*, '(F10.4)') PROBLOST
IF (PROBLOST .NE. 1.0) THEN
WRITE (*,*) ' '
WRITE (*,*) ' INPUT PROBABILITY THAT INJURED PERSON, IF SAVED, IS
CLATER LOST.'
WRITE (*,*) ' '
READ (*, '(F10.4)') PBADINJ
END IF
IF (PROBLOST .EQ. 1.0) THEN
PROBSTOP=1.0
```

```
        PBADINJ=1.0
        END IF
        WRITE (*,*) ' '
        WRITE (*,*) ' TYPE "1" IF CREW SLEEPS NEAR HATCH, "2" IF NO.'
        WRITE (*,*) ' '
        READ (*, '(I10)') ISLEEP
        WRITE (*,*) ' '
        WRITE (*,*) ' INCLUDE RACK FACTORS? TYPE 1 FOR YES, 2 FOR NO.'
        WRITE (*,*) ' '
        READ (*, '(I10)') IPEN
        WRITE (*,*) ' '
        WRITE (*,*) ' TYPE 1 FOR WIDE DEBRIS CLOUD, 2 FOR NARROW.'
        WRITE (*,*) ' '
        READ (*, '(I10)') IWIDE
        WRITE (*,*) ' '
        WRITE (*,*) ' INPUT CRITICAL DEPRESSURIZATION LIMIT (PSI).'
        WRITE (*,*) ' '
        READ (*, '(F10.4)') CRITPRES
        WRITE (*,*) ' '
        WRITE (*,*) ' INPUT PERCENTAGE OF MODULE FREE AIR (0. TO 1.0).'
        WRITE (*,*) ' '
        READ (*, '(F10.4)') FREE
C
C VOLUME DESIGNATION
C
    WRITE (*,*) ' '
    WRITE (*,*) ' TYPE "1" FOR OPEN HATCHES, "2" FOR CLOSED HATCHES,'
    WRITE (*,*) '  "3" FOR HATCHES CLOSED AT NIGHT.'
    WRITE (*,*) ' '
    READ (*, '(I10)') IVOLUME
    IF (IVOLUME.EQ.1) THEN
     VOLAVAIL(1)=22469*FREE
     VOLAVAIL(2)=22469*FREE
     VOLAVAIL(3)=22469*FREE
     VOLAVAIL(4)=22469*FREE
     VOLAVAIL(5)=22469*FREE
     VOLAVAIL(6)=22469*FREE
     VOLAVAIL(7)=22469*FREE
     VOLAVAIL(8)=22469*FREE
    WRITE (*,*) ' '
    WRITE (*,*) '    NOTE: HATCH CLOSURE TIME IS ASSUMED TO BE 30 SECO
   CNDS.'
    END IF
    IF (IVOLUME .EQ. 2) THEN
     VOLAVAIL(1)=3882*FREE
     VOLAVAIL(2)=3882*FREE
     VOLAVAIL(3)=5127*FREE
     VOLAVAIL(4)=5170*FREE
     VOLAVAIL(5)=2206*FREE
     VOLAVAIL(6)=2097*FREE
     VOLAVAIL(7)=2991*FREE
     VOLAVAIL(8)=1165*FREE
    HACHTIME=60.
    WRITE (*,*) ' '
```

```
      WRITE (*,*) '    NOTE: HATCH OPENING AND CLOSURE TIME IS ASSUMED T
     CO BE 60 SECONDS (TOTAL).'
      END IF
      IF (IVOLUME .EQ. 3) THEN
       VOLAVAIL(1)=22469*FREE
       VOLAVAIL(2)=22469*FREE
       VOLAVAIL(3)=22469*FREE
       VOLAVAIL(4)=22469*FREE
       VOLAVAIL(5)=22469*FREE
       VOLAVAIL(6)=22469*FREE
       VOLAVAIL(7)=22469*FREE
       VOLAVAIL(8)=22469*FREE
      WRITE (*,*) ' '
      WRITE (*,*) '    NOTE: HATCH CLOSURE TIME IS ASSUMED TO BE 30 SECO
     CNDS DURING DAY,'
      WRITE (*,*) '          AND 60 SECONDS AT NIGHT (OPENING AND CLOSUR
     CE).'
      END IF
C
      WRITE (*,*) ' '
      WRITE (*,*) ' INPUT CD, 0.9 OR 0.7. '
      WRITE (*,*) ' '
       READ (*, ' (F10.4)') CD
C
      WRITE (*,*) ' '
      WRITE (*,*) ' TYPE "1" FOR OBLIQUE HOLE MODEL, "2" FOR BURCH.'
      WRITE (*,*) ' '
       READ (*, '(I10)') IHSM
      WRITE (*,*) ' '
C
C     ALTERNATE CREW SLEEP AND INTERNAL MODULE POSITION DISTRIBUTION
C
      WRITE (*,*) ' '
       WRITE (*,*) ' TYPE "1" FOR SSEIC CREW MODEL, "2" IF CREW SLEEPS IN
     C NODE 2.'
      WRITE (*,*) ' '
       READ (*, '(I10)') INODE
C
       IF (INODE .EQ. 2) THEN
C
C      OPEN DATA FILE PCREWMO2.DAT
C
       WRITE(*, *) 'READING IN PCREWMO2.DAT'
C
       OPEN (35, FILE="PCREWMO2.DAT" )
C
C     READ IN PROBABILITY OF HOUR I AND NUMBER OF CREW IN MODULE J AT HOUR I
C
      DO 703 I = 1, 24
       READ (35, '( F9.4, 4I9)' ) P,M1,M2,M3,M4
      PHOUR(I)=P
       NUMODULE(I,1)=M1
       NUMODULE(I,2)=M2
       NUMODULE(I,3)=M3
```

```
      NUMODULE(I,4)=M4
  703 CONTINUE
      END IF
C
      WRITE (*,*) ' '
      WRITE (*,*) ' TYPE "1" FOR UNIFORM CREW DISTRIBUTION BETWEEN MODUL
     CE STATIONS, '
      WRITE (*,*) '  TYPE "2" FOR TRIANGULAR DISTRIBUTION.'
      WRITE (*,*) ' '
      READ (*, '(I10)') ITRI
C
      IF (ITRI .EQ. 2) THEN
C
C      OPEN DATA FILE POSIT2.DAT
C
      WRITE(*, *) 'READING IN POSIT2.DAT'
C
      OPEN (36, FILE='POSIT2.DAT' )
C
C      READ IN PROBABILITY OF CREW BEING AT THIS STATION
C
     DO 798 I = 1, 55
      READ (36, '( 2I9, F9.4)' ) NMOD, NSTA, STAPROB
      PROBSTA(NMOD,NSTA)=STAPROB
  798 CONTINUE
C
      END IF
      WRITE (*,*) ' '
C
C
C START SIMULATION BY DRAWING RANDOM NUMBER FOR DEBRIS DIRECTION
C
C
  220 CALL RANDOM(RANVAL)
  221 ANGLE=1
  222 IF (RANVAL .LT. PROBVEL(ANGLE)) GO TO 225
  223 ANGLE=ANGLE+1
  224 GO TO 222
  225 VELOCITY=VELPART(ANGLE)
C
C DRAW RANDOM NUMBER FOR "DIAMETER"
C
  230 CALL RANDOM(RANVAL)
  231 NDIA=1
  232 IF (RANVAL .LT. PROBDIA(NDIA)) GO TO 235
  233 NDIA=NDIA+1
  234 GO TO 232
  235 DIAMETER=DIAPART(NDIA)
C
C NOW COMPARE TO LOWEST BLC IN HIGH VELOCITY REGIME FOR A FIRST SCREEN
C
  240 IF (DIAMETER .LE. 0.55) THEN
      IF (VELOCITY .GE. 7.0) THEN
C     WRITE (*,241) NTRY
```


a-2.

```
C 241  FORMAT (' NO HV PENETRATION OCCURRED ON DRAW NUMBER ', I10)
       NTRY=NTRY+1
  242  GO TO 220
       END IF
       END IF
C
C
C
       IF (NPEN .EQ. NNN) THEN
       WRITE (*,*) ' '
       WRITE (*,431) NPEN
  431  FORMAT (I10, ' PENETRATIONS')
       NNN=NNN+20000
       END IF
C
C NOW SELECT "MODULE" THAT IS IMPACTED
C
  250  CALL RANDOM(RANVAL)
  251  MODULE=1
  252  IF (RANVAL .LT. PROBMOD(MODULE,ANGLE)) GO TO 259
  253  MODULE=MODULE+1
  254  GO TO 252
  259  NUMIMPS(MODULE)=NUMIMPS(MODULE)+1
C
C SELECT "ELEMENT" IMPACTED WITHIN MODULE AND "OBLIQITY"
C
  260  CALL RANDOM(RANVAL)
  261  ELEMENT=1
  262  IF (RANVAL .LT. PROBELEM(MODULE,ELEMENT,ANGLE)) GO TO 265
  263  ELEMENT=ELEMENT+1
  264  GO TO 262
  265  OBLIQITY=ANGELEM(MODULE,ELEMENT,ANGLE)
C
C INSTALLING THE 60 DEGREE CUTOFF ASSUMPTION
C
  266  IF (OBLIQITY .GT. 60.) THEN
  267  OBLIQITY=60.
  268  END IF
       OBL=OBLIQITY*3.14/180.
C      WRITE (*,271) OBLIQITY, MODULE, ELEMENT, ANGLE
C 271  FORMAT (' OBLIQUITY = ', F9.4, I8, I8, I8)
C
C NOW SEE IF THE CHOSEN OBLIQITY, VELOCITY, AND DIAMETER PENETRATE THE MODULE
C
    IF (VELOCITY .GE. 7.0) THEN
     DCRIT=1.0523*(VELOCITY*COS(OBL))**(-.25)
    END IF
C
C BOEING INTERPOLATION VALUES FOR VELOCITIES LESS THAN 7.0 KM/SEC
C NOTE: ONLY WORKS WITH 60 DEGREE CUTOFF ASSUMPTION!
C
    IF (VELOCITY .EQ. 2.67) THEN
    IF (OBLIQITY .LE. 45.) THEN
      DCRIT=.383+(.563-.383)*((1-COS(OBL))/(1-.7071))
```

```
      END IF
      IF (OBLIQITY .GT. 45.) THEN
        DCRIT=.563+(.620-.563)*((.7071-COS(OBL))/(.7071-.4226))
      END IF
      END IF
      IF (VELOCITY .EQ. 4.00) THEN
      IF (OBLIQITY .LE. 45.) THEN
        DCRIT=.452+(.563-.452)*((1-COS(OBL))/(1-.7071))
      END IF
      IF (OBLIQITY .GT. 45.) THEN
        DCRIT=.563+(.622-.563)*((.7071-COS(OBL))/(.7071-.4226))
      END IF
      END IF
      IF (VELOCITY .EQ. 5.25) THEN
      IF (OBLIQITY .LE. 45.) THEN
        DCRIT=.491+(.563-.491)*((1-COS(OBL))/(1-.7071))
      END IF
      IF (OBLIQITY .GT. 45.) THEN
        DCRIT=.563+(.684-.563)*((.7071-COS(OBL))/(.7071-.4226))
      END IF
      END IF
      IF (VELOCITY .EQ. 6.5) THEN
      IF (OBLIQITY .LE. 45.) THEN
        DCRIT=.593+(.584-.593)*((1-COS(OBL))/(1-.7071))
      END IF
      IF (OBLIQITY .GT. 45.) THEN
        DCRIT=.584+(.786-.584)*((.7071-COS(OBL))/(.7071-.4226))
      END IF
      END IF
C
C THE ORIGINAL INTERPOLATION EQUATION I USED FOR VELOCITIES < 7 KM/SEC.
C
C       DCRIT=0.6729+(.03494*VELOCITY)-.359*COS(OBL)
C
C
C FOR B2 SHIELDS, THE BALLISTIC LIMIT IS APPROXIMATELY TWICE AS HIGH
C
      DCRIT=DCRIT*SHIELD
C
C
C CHECK TO SEE IF DIAMETER EXCEEDS DCRIT
C
C
  272 IF (DIAMETER .LE. DCRIT) THEN
  285 NTRY=NTRY+1
C     WRITE (*,286) NTRY
C 286 FORMAT (' NO PENETRATION HAS OCCURRED ON DRAW ', I8)
  287 GO TO 220
      END IF
C
C
      IF (DIAMETER .GT. DCRIT) THEN
  280 NPEN=NPEN+1
  281 NUMPEN(MODULE,ELEMENT)=NUMPEN(MODULE,ELEMENT)+1
```

```
        NUMPENS(MODULE)=NUMPENS(MODULE)+1
        NTRY=NTRY
C       WRITE (*,289) NTRY
C 289   FORMAT (' PENETRATION HAS OCCURRED ON DRAW ', I8)
     END IF
C
C
C FIND THE HOLE DIAMETER USING "MODIFIED GOODWIN"
C
C  NORMAL ASSUMPTION
C     DIA=DIAMETER
C
  290 IF (IHSM .EQ. 1) THEN
C
  291 IF (VELOCITY .EQ. 2.67) THEN
      DIA=DIAMETER-DCRIT+.383
      HOLE=2.57387658
     *-4.20884931E1*DIA
     *+1.86661675E2*DIA**2.
     *-3.45057685E2*DIA**3.
     *+2.63809498E2*DIA**4.
     *+3.66829688E1*DIA**5.
     *-2.08245025E2*DIA**6.
     *+1.28594043E2*DIA**7.
     *-7.93818497*DIA**8.
     *-2.01099825E1*DIA**9.
     *+4.58038075*DIA**10.
     *+2.20788123*DIA**11.
     *-9.60467073E-1*DIA**12.
     *+2.17589538E-2*DIA**13.
     *+3.38436888E-2*DIA**14.
     *+3.28086909E-3*DIA**15.
     *-5.53900357E-3*DIA**16.
     *+5.80017150E-4*DIA**17.
     *-5.52943824E-5*DIA**18.
     *+2.23013284E-4*DIA**19.
     *+2.68222388E-5*DIA**20.
     *-2.35994882E-5*DIA**21.
     *-3.36683013E-6*DIA**22.
     *-1.02402698E-6*DIA**23.
     *+3.23097004E-7*DIA**24.
     *-2.08222373E-8*DIA**25.
     *-7.69741812E-8*DIA**26.
     *+6.08010755E-8*DIA**27.
     *+1.88267383E-8*DIA**28.
     *-7.01177885E-9*DIA**29.
     *-6.08360969E-10*DIA**30.
     *-6.27388429E-11*DIA**31
     *-1.26888528E-10*DIA**32.
     *+5.90442523E-11*DIA**33.
     *-1.35954610E-11*DIA**34.
     *+3.55958018E-12*DIA**35.
     *+1.70799452E-13*DIA**36.
     *-9.37784118E-14*DIA**37.
```

```
     *+2.08928715E-13*DIA**38.
     *-4.81879371E-14*DIA**39.
     *-7.74699537E-15*DIA**40.
     *-1.52101706E-15*DIA**41.
     *+8.23421407E-16*DIA**42.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  292 IF (VELOCITY .EQ. 4.0) THEN
      DIA=DIAMETER-DCRIT+.452
      HOLE=-4.75950138E1
     *+4.10900448E2*DIA
     *-1.51994125E3*DIA**2.
     *+3.09322566E3*DIA**3.
     *-3.72775989E3*DIA**4.
     *+2.71796055E3*DIA**5.
     *-1.14516088E3*DIA**6.
     *+2.15394383E2*DIA**7.
     *+1.28504688E1*DIA**8.
     *-4.22489232E-1*DIA**9.
     *-1.19297884E1*DIA**10.
     *+6.35987112*DIA**11.
     *-1.54945845*DIA**12.
     *+1.92565376E-1*DIA**13.
     *-9.93817150E-3*DIA**14.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  293 IF (VELOCITY .EQ. 5.25) THEN
      DIA=DIAMETER-DCRIT+.491
      HOLE=-5.96488093E1
     *+4.79489455E2*DIA
     *-1.69690114E3*DIA**2.
     *+3.39700029E3*DIA**3.
     *-4.17436362E3*DIA**4.
     *+3.29518338E3*DIA**5.
     *-1.70412960E3*DIA**6.
     *+5.74206585E2*DIA**7.
```

```
     *-1.21382539E2*DIA**8.
     *+1.46094536E1*DIA**9.
     *-7.63370717E-1*DIA**10.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  294 IF (VELOCITY .EQ. 6.5) THEN
      DIA=DIAMETER-DCRIT+.593
      HOLE=-3.46235980E1
     *+2.63836076E2*DIA
     *-1.09938748E3*DIA**2.
     *+2.93222256E3*DIA**3.
     *-5.07574942E3*DIA**4.
     *+5.69149648E3*DIA**5.
     *-3.93364886E3*DIA**6.
     *+1.38906444E3*DIA**7.
     *+1.30719100E1*DIA**8.
     *-1.86550361E2*DIA**9.
     *+3.22096671E1*DIA**10.
     *+1.74840804E1*DIA**11.
     *-5.67089732*DIA**12.
     *-5.44113789E-1*DIA**13.
     *+1.07608079E-1*DIA**14.
     *+1.99524760E-1*DIA**15.
     *-7.60855698E-2*DIA**16.
     *+1.04142358E-2*DIA**17.
     *-4.93898019E-4*DIA**18.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  295 IF (VELOCITY .EQ. 7.7) THEN
      DIA=(DIAMETER-DCRIT+.632)
      HOLE=+5.22918089E1
     *-2.39257296E2*DIA
     *+1.32038009E2*DIA**2.
     *+1.18040264E3*DIA**3.
     *-3.34306638E3*DIA**4.
     *+4.36277626E3*DIA**5.
```

```
     *-3.16959888E3*DIA**6.
     *+1.13165036E3*DIA**7.
     *+1.31664781E1*DIA**8.
     *-1.49737846E2*DIA**9.
     *+2.25330600E1*DIA**10.
     *+1.54623419E1*DIA**11.
     *-4.49773717*DIA**12.
     *-5.23952561E-1*DIA**13.
     *+5.86830826E-2*DIA**14.
     *+1.72688480E-1*DIA**15.
     *-5.89833872E-2*DIA**16.
     *+7.05050230E-3*DIA**17.
     *-2.56042679E-4*DIA**18.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  296 IF (VELOCITY .EQ. 8.83) THEN
      DIA=DIAMETER-DCRIT+.610
      HOLE=8.11895940E1
     *-5.48453870E2*DIA
     *+1.47717597E3*DIA**2.
     *-2.20407921E3*DIA**3.
     *+2.21610856E3*DIA**4.
     *-1.68462888E3*DIA**5.
     *+9.57500728E2*DIA**6.
     *-3.28300768E2*DIA**7.
     *+6.61456248*DIA**8.
     *+4.54816621E1*DIA**9.
     *-1.30438251E1*DIA**10.
     *-2.38433091*DIA**11.
     *+1.46956258*DIA**12.
     *+6.61543310E-2*DIA**13.
     *-6.68227276E-2*DIA**14.
     *-3.85086059E-2*DIA**15.
     *+2.18913523E-2*DIA**16.
     *-3.85192100E-3*DIA**17.
     *+2.38511457E-4*DIA**18.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
```

```
C
    END IF
 297 IF (VELOCITY .EQ. 9.9) THEN
    DIA=DIAMETER-DCRIT+.593
    HOLE=7.371453E2
    *-5.43012431E3*DIA
   *+1.69881424E4*DIA**2.
    *-2.99361596E4*DIA**3.
   *+3.31895031E4*DIA**4.
    *-2.43296508E4*DIA**5.
   *+1.19926412E4*DIA**6.
    *-3.93783485E3*DIA**7.
   *+8.26494804E2*DIA**8.
    *-1.00349605E2*DIA**9.
   *+5.36255763*DIA**10.
    HOLEMAJ=HOLE/COS(OBL)
C
C    THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
     HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C    HOLE=HOLE/COS(OBL)
C
    END IF
 298 IF (VELOCITY .EQ. 10.9) THEN
    DIA=DIAMETER-DCRIT+.579
    HOLE=6.23580373E2
    *-4.79852921E3*DIA
   *+1.55503020E4*DIA**2.
    *-2.81659773E4*DIA**3.
   *+3.18970189E4*DIA**4.
    *-2.37655861E4*DIA**5.
   *+1.18610628E4*DIA**6.
    *-3.93194396E3*DIA**7.
   *+8.31398354E2*DIA**8.
    *-1.01541662E2*DIA**9.
   *+5.452594*DIA**10.
    HOLEMAJ=HOLE/COS(OBL)
C
C    THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
     HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C    HOLE=HOLE/COS(OBL)
C
    END IF
 299  IF (VELOCITY .EQ. 11.8) THEN
    DIA=DIAMETER-DCRIT+.568
    HOLE=4.30261674E2
    *-3.58366461E3*DIA
```

```
     *+1.23391038E4*DIA**2.
     *-2.34547792E4*DIA**3.
     *+2.76599824E4*DIA**4.
     *-2.13459369E4*DIA**5.
     *+1.09903177E4*DIA**6.
     *-3.74645752E3*DIA**7.
     *+8.12420833E2*DIA**8.
     *-1.01521985E2*DIA**9.
     *+5.56624705*DIA**10.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
 300  IF (VELOCITY .EQ. 12.61) THEN
      DIA=DIAMETER-DCRIT+.558
      HOLE=1.52954665E1
     *-6.80677076E2*DIA
     *+3.61072700E3*DIA**2.
     *-8.52322071E3*DIA**3.
     *+1.14977623E4*DIA**4.
     *-9.73910272E3*DIA**5.
     *+5.37300884E3*DIA**6.
     *-1.93277029E3*DIA**7.
     *+4.37697829E2*DIA**8.
     *-5.66979239E1*DIA**9.
     *+3.20479012*DIA**10.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
 301  IF (VELOCITY .EQ. 13.34) THEN
      DIA=DIAMETER-DCRIT+.558
      HOLE=4.19935057E2
     *-3.41255760E3*DIA
     *+1.12177754E4*DIA**2.
     *-1.93407257E4*DIA**3.
     *+1.85717187E4*DIA**4.
     *-8.82601180E3*DIA**5.
     *+1.17017417E2*DIA**6.
     *+2.02939046E3*DIA**7.
```

```
     *-8.29205903E2*DIA**8.
     *+6.42408328*DIA**9.
     *+5.13641047E1*DIA**10.
     *+6.56674327*DIA**11.
     *-6.29038429*DIA**12.
     *-1.11772779*DIA**13.
     *+1.16672455*DIA**14.
     *-2.47704197E-1*DIA**15.
     *+1.77586595E-02*DIA**16.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  302 IF (VELOCITY .EQ. 13.95) THEN
      DIA=DIAMETER-DCRIT+.544
      HOLE=6.09863183E2
     *-5.10483012E3*DIA
     *+1.78856376E4*DIA**2.
     *-3.48097873E4*DIA**3.
     *+4.21131642E4*DIA**4.
     *-3.33397339E4*DIA**5.
     *+1.75916811E4*DIA**6.
     *-6.13689147E3*DIA**7.
     *+1.35973999E3*DIA**8.
     *-1.73342154E2*DIA**9.
     *+9.68141004*DIA**10.
      HOLEMAJ=HOLE/COS(OBL)
C
C     THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
      HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C     HOLE=HOLE/COS(OBL)
C
      END IF
  303 IF (VELOCITY .EQ. 14.47) THEN
      DIA=DIAMETER-DCRIT+.54
      HOLE=5.67578377E2
     *-4.82168904E3*DIA
     *+1.70936351E4*DIA**2.
     *-3.35891200E4*DIA**3.
     *+4.09682872E4*DIA**4.
     *-3.26629411E4*DIA**5.
     *+1.73415791E4*DIA**6.
     *-6.08276881E3*DIA**7.
```

```
   *+1.35426814E3*DIA**8.
   *-1.73382631E2*DIA**9.
   *+9.72024231*DIA**10.
    HOLEMAJ=HOLE/COS(OBL)
C
C    THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
     HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C    HOLE=HOLE/COS(OBL)
C
    END IF
 304 IF (VELOCITY .EQ. 14.87) THEN
     DIA=DIAMETER-DCRIT+.536
    HOLE=4.25065119E2
   *-3.76861667E3*DIA
   *+1.37632775E4*DIA**2.
   *-2.76189904E4*DIA**3.
   *+3.42193227E4*DIA**4.
   *-2.76165053E4*DIA**5.
   *+1.48055951E4*DIA**6.
   *-5.23461714E3*DIA**7.
   *+1.17313770E3*DIA**8.
   *-1.51028170E2*DIA**9.
   *+8.50707621*DIA**10.
    HOLEMAJ=HOLE/COS(OBL)
C
C    THIS EQUATION CALCULATES THE EFFECTIVE HOLE DIAMETER
C
     HOLE=((HOLE/COS(OBL))*HOLE)**.5
C
C THIS EQUATION CALCULATES THE MAJOR HOLE DIAMETER
C
C    HOLE=HOLE/COS(OBL)
C
    END IF
C
C IF THE PENETRATION OCCURS AT THE CUPOLA, THERE IS A 20 INCH HOLE
C
 305 IF (MODULE .EQ. 5) THEN
     IF (ELEMENT .EQ. 39) THEN
    HOLE=20.
    HOLEMAJ=20.
    END IF
    END IF
C
    END IF
C
C ALTERNATE HOLE SIZE EQUATION (BURCH)
C
 306 IF (IHSM .EQ. 2) THEN
C
```

```
      IF (VELOCITY .LT. 5.00) THEN
  307  HOLE=((.127/DIAMETER)**.25)*((10.668/DIAMETER)**.5)*DIAMETER*(5.55
       **VELOCITY/5.076-2.53)/2.54
       END IF
c
      IF (VELOCITY .GT. 5.00) THEN
  308  HOLE=((.127/DIAMETER)**.25)*((10.668/DIAMETER)**.5)*DIAMETER*(1.56
       **VELOCITY/5.076+1.66)/2.54
       END IF
       HOLEMAJ=HOLE
C
C IF THE PENETRATION OCCURS AT THE CUPOLA, THERE IS A 20 INCH HOLE
C
  309  IF (MODULE .EQ. 5) THEN
       IF (ELEMENT .EQ. 39) THEN
       HOLE=20.
       HOLEMAJ=20.
       END IF
       END IF
C
  310  END IF
C
C COUNT UP THE NUMBER OF HOLES FROM 0-1, 1-2, ETC., FOR EACH MODULE
C
C    HOL=HOLE
C    IF (HOL .LT. 1.0) THEN
C    NUMHOLE1(MODULE)=NUMHOLE1(MODULE)+1
C    END IF
C    IF (HOL .GE. 1.0) THEN
C    IF (HOL .LT. 2.0) THEN
C    NUMHOLE2(MODULE)=NUMHOLE2(MODULE)+1
C    END IF
C    END IF
C    IF (HOL .GE. 2.0) THEN
C    IF (HOL .LT. 3.0) THEN
C    NUMHOLE3(MODULE)=NUMHOLE3(MODULE)+1
C    END IF
C    END IF
C    IF (HOL .GE. 3.0) THEN
C    IF (HOL .LT. 4.0) THEN
C    NUMHOLE4(MODULE)=NUMHOLE4(MODULE)+1
C    END IF
C    END IF
C    IF (HOL .GE. 4.0) THEN
C    IF (HOL .LT. 5.0) THEN
C    NUMHOLE5(MODULE)=NUMHOLE5(MODULE)+1
C    END IF
C    END IF
C    IF (HOL .GE. 5.0) THEN
C    IF (HOL .LT. 6.0) THEN
C    NUMHOLE6(MODULE)=NUMHOLE6(MODULE)+1
C    END IF
C    END IF
C    IF (HOL .GE. 6.0) THEN
```

```
C   IF (HOL .LT. 7.0) THEN
C   NUMHOLE7(MODULE)=NUMHOLE7(MODULE)+1
C   END IF
C   END IF
C   IF (HOL .GE. 7.0) THEN
C   IF (HOL .LT. 8.0) THEN
C   NUMHOLE8(MODULE)=NUMHOLE8(MODULE)+1
C   END IF
C   END IF
C   IF (HOL .GE. 8.0) THEN
C   IF (HOL .LT. 9.0) THEN
C   NUMHOLE9(MODULE)=NUMHOLE9(MODULE)+1
C   END IF
C   END IF
C   IF (HOL .GE. 9.0) THEN
C   IF (HOL .LT. 10.) THEN
C   NUMHOL10(MODULE)=NUMHOL10(MODULE)+1
C   END IF
C   END IF
C   IF (HOL .GE. 10.) THEN
C   IF (HOL .LT. 11.) THEN
C   NUMHOL11(MODULE)=NUMHOL11(MODULE)+1
C   END IF
C   END IF
C   IF (HOL .GE. 11.) THEN
C   IF (HOL .LT. 12.) THEN
C   NUMHOL12(MODULE)=NUMHOL12(MODULE)+1
C   END IF
C   END IF
C   IF (HOL .GE. 12.) THEN
C   NUMHOL20(MODULE)=NUMHOL20(MODULE)+1
C   END IF
C
C
C IF ENERGY OR CRACK EXCEEDS CRITICAL LEVEL, COUNT AS NPENCRAC
C
    ENERGY=540.*(DIAMETER**3.)*(VELOCITY**2.)
    IF (NOB .EQ. 2) THEN
    ENERGY=COS(OBL)**2.*ENERGY
    END IF
    IF (ENERCRIT .GT. 0.) THEN
    IF (ENERGY .GT. ENERCRIT) THEN
    NPENCRAC(MODULE)=NPENCRAC(MODULE)+1
    IF (NPEN .EQ. NEND) GO TO 465
    GO TO 220
    END IF
    END IF
C
C
C CALCULATE SIZE OF CRACK FOR THIS PENETRATION
C
    CRACK=HOLEMAJ*HMULT
    IF (HMULT .EQ. .3) THEN
    HMIN=(1.48*HOLEMAJ)-.88
```

```
      IF (HMIN .LE. 0.) THEN
      HMIN=0.
      END IF
      HMAX=(1.94*HOLEMAJ)+5.5
      CALL RANDOM(RANVAL)
      CRACK=(HMAX-HMIN)*RANVAL+HMIN
      END IF
C
C COUNT UP THE NUMBER OF CRACKS FROM 0-1, 1-2, ETC., FOR EACH MODULE
C
C     HO=CRACK
C     IF (HO .LT. 1.0) THEN
C     NUMHO1(MODULE)=NUMHO1(MODULE)+1
C     END IF
C     IF (HO .GE. 1.0) THEN
C     IF (HO .LT. 2.0) THEN
C     NUMHO2(MODULE)=NUMHO2(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 2.0) THEN
C     IF (HO .LT. 3.0) THEN
C     NUMHO3(MODULE)=NUMHO3(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 3.0) THEN
C     IF (HO .LT. 4.0) THEN
C     NUMHO4(MODULE)=NUMHO4(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 4.0) THEN
C     IF (HO .LT. 5.0) THEN
C     NUMHO5(MODULE)=NUMHO5(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 5.0) THEN
C     IF (HO .LT. 6.0) THEN
C     NUMHO6(MODULE)=NUMHO6(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 6.0) THEN
C     IF (HO .LT. 7.0) THEN
C     NUMHO7(MODULE)=NUMHO7(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 7.0) THEN
C     IF (HO .LT. 8.0) THEN
C     NUMHO8(MODULE)=NUMHO8(MODULE)+1
C     END IF
C     END IF
C     IF (HO .GE. 8.0) THEN
C     IF (HO .LT. 9.0) THEN
C     NUMHO9(MODULE)=NUMHO9(MODULE)+1
C     END IF
C     END IF
```

```
C    IF (HO .GE. 9.0) THEN
C    IF (HO .LT. 10.) THEN
C    NUMHO10(MODULE)=NUMHO10(MODULE)+1
C    END IF
C    END IF
C    IF (HO .GE. 10.) THEN
C    IF (HO .LT. 11.) THEN
C    NUMHO11(MODULE)=NUMHO11(MODULE)+1
C    END IF
C    END IF
C    IF (HO .GE. 11.) THEN
C    IF (HO .LT. 12.) THEN
C    NUMHO12(MODULE)=NUMHO12(MODULE)+1
C    END IF
C    END IF
C    IF (HO .GE. 12.) THEN
C    NUMHO20(MODULE)=NUMHO20(MODULE)+1
C    END IF
C
C
C COMPARE CRACK SIZE TO CRITICAL CRACK SIZE
C
      IF (CRITCRAC .GT. 0.) THEN
      IF (CRACK .GT. CRITCRAC) THEN
      NPENCRAC(MODULE)=NPENCRAC(MODULE)+1
      IF (NPEN .EQ. NEND) GO TO 465
      GO TO 220
      END IF
      END IF
C
C
C COMPUTE THE DEPTH OF PENETRATION (NUMBER OF .125" EQUIVALENT PLATES)
C
      IF (IPEN .EQ. 1) THEN
      CHI=(TAN(OBL)-.5)
      F1=(0.5-1.87*.05*2.54/DIAMETER)+(5*.05*2.54/DIAMETER)*CHI**3.
      F2=(1.7-12*.05*2.54/DIAMETER)*CHI
      F=F1+F2
      EFF=2.42*(2.54*.05/DIAMETER)**(-.333)
      EFF=EFF+(4.26*(2.54*.05/DIAMETER)**.333)-4.18
      P=(EFF+0.63*F)*(VELOCITY/5.076)**(-1.333)
      PENDEPTH=P*(2.54*.125/DIAMETER)**(-.583)*(11.43/DIAMETER)**(-.416)
      END IF
C
      IF (IPEN .EQ. 2) THEN
      PENDEPTH=10.
      END IF
C
C FIND THE HOUR OF THE "DAY" THAT THE PENETRATION OCCURS IN
C
  390 CALL RANDOM(RANVAL)
  391 NHOUR=1
  392 IF (RANVAL .LT. PHOUR(NHOUR)) GO TO 395
  393 NHOUR=NHOUR+1
```

```
  394  GO TO 392
C
C FIND THE NUMBER AND POSITION OF CREW IN THE PENETRATED MODULE (NCREW)
C
  395  NCR=0
       NIN=0
       WAKETIM=0.
       IF (NHOUR .GE. 17) THEN
       WAKETIM=WAKETIME
C
C NODE 2 ALTERNATIVE CREW MODEL
C
       IF (IVOLUME .EQ. 3) THEN
       VOLAVAIL(1)=3882*FREE
       VOLAVAIL(2)=3882*FREE
       VOLAVAIL(3)=5127*FREE
       VOLAVAIL(4)=5170*FREE
       VOLAVAIL(5)=2206*FREE
       VOLAVAIL(6)=2097*FREE
       VOLAVAIL(7)=2991*FREE
       VOLAVAIL(8)=1165*FREE
       HACHTIME=60.
       END IF
C
       END IF
C
       IF (NHOUR .LT. 17) THEN
       IF (IVOLUME .EQ. 3) THEN
       VOLAVAIL(1)=22469*FREE
       VOLAVAIL(2)=22469*FREE
       VOLAVAIL(3)=22469*FREE
       VOLAVAIL(4)=22469*FREE
       VOLAVAIL(5)=22469*FREE
       VOLAVAIL(6)=22469*FREE
       VOLAVAIL(7)=22469*FREE
       VOLAVAIL(8)=22469*FREE
       HACHTIME=30.
       END IF
       END IF
C
C SURVIVABILITY "DO LOOP"
C
   DO 410 I = 1, 4
    NMOD=NUMODULE(NHOUR,I)
C
C FIND STATION NUMBER FOR EACH CREW MEMBER
C
   NSTA=1
    CALL RANDOM(RANVAL)
  399 IF(RANVAL .LT. PROBSTA(NMOD,NSTA)) GO TO 400
   NSTA=NSTA+1
   GO TO 399
  400 NCREWSTA(I)=NSTA
C
```

```
C FOR 'SLEEP NEAR HATCH' MODEL:
C
      IF (ISLEEP .EQ. 1) THEN
      IF (NHOUR .GE. 17) THEN
      NCREWSTA(1)=1
      NCREWSTA(2)=1
      NCREWSTA(3)=1
      NCREWSTA(4)=1
      END IF
      END IF
C
C THIS SECTION CALCULATES CREW LOSSES WITHIN PENETRATED MODULE
C
  405 IF(NMOD .EQ. MODULE) THEN
      NH=NSTA+1
      NL=NSTA-1
      IF(IWIDE .EQ. 2) THEN
      NH=NSTA
      NL=NSTA
      END IF
C
C
C  THIS SECTION INVOLVES CREW BEYOND THE IMPACT REGION
C
      IF (NL .GT. NSTATION(MODULE,ELEMENT)) THEN
      NPENIN(MODULE)=NPENIN(MODULE)+1
      IF (PENDEPTH .GE. AREALDEN(MODULE,ELEMENT)) THEN
      IF (ET .EQ. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+(HINDRATE*REAL(NSTA))
      END IF
      IF (ET .NE. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+HINDTIME
      END IF
      END IF
      IF(PENDEPTH .LT. AREALDEN(MODULE,ELEMENT)) THEN
      IF (ET .EQ. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+(GOODRATE*REAL(NSTA))
      END IF
      IF (ET .NE. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+ET
      END IF
      END IF
      END IF
      IF(NH .LT. NSTATION(MODULE,ELEMENT)) THEN
      NPENOUT(MODULE)=NPENOUT(MODULE)+1
      IF (ET .EQ. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+(GOODRATE*REAL(NSTA))
      END IF
      IF (ET .NE. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+ET
      END IF
      END IF
C
   NN=0
```

```
C
C
C
      DO 9882 III = NL, NH
      IF(III .EQ. NSTATION(MODULE,ELEMENT)) THEN
      NPENAT(MODULE)=NPENAT(MODULE)+1
      IF(PENDEPTH .GE. AREALDEN(MODULE,ELEMENT)) THEN
      CALL RANDOM(RANVAL)
      IF(RANVAL .LT. PROBLOST) THEN
      NUMINJ(NMOD,NSTA)=NUMINJ(NMOD,NSTA)+1
      NINJ(NMOD)=NINJ(NMOD)+1
      NIN=1
      NN=1
      END IF
      IF(RANVAL .GE. PROBLOST) THEN
      CALL RANDOM(RAN)
      IF (RAN .LT. PBADINJ) THEN
      NUMINJ(NMOD,NSTA)=NUMINJ(NMOD,NSTA)+1
      NINJ(NMOD)=NINJ(NMOD)+1
      NIN=1
      NN=1
      END IF
      IF (RAN .GT. PBADINJ) THEN
      IF (ET .EQ. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+(INJRATE*REAL(NSTA))
      END IF
      IF (ET .NE. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+INJTIME
      END IF
      END IF
      END IF
      END IF
      IF(PENDEPTH .LT. AREALDEN(MODULE,ELEMENT)) THEN
      IF (ET .EQ. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+(GOODRATE*REAL(NSTA))
      END IF
      IF (ET .NE. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+ET
      END IF
      END IF
      END IF
9882  CONTINUE
      END IF
C
C THIS SECTION CALCULATES CREW ESCAPE TIME IN NON-PENETRATED MODULES
C
    IF (NMOD .NE. MODULE) THEN
    IF (IVOLUME .EQ. 2) THEN
    GO TO 410
    END IF
    IF (IVOLUME .EQ. 3) THEN
    IF (NHOUR .GE. 17) THEN
    GO TO 410
    END IF
```

```
      END IF
      IF (ET .EQ. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+(GOODRATE*REAL(NSTA))
      END IF
      IF (ET .NE. 0.) THEN
      ESCTIME(I)=WAITTIME+WAKETIM+HACHTIME+ET
      END IF
      END IF
C
C
C CALCULATE CRITICAL DEPRESSURIZATION LIMIT
C
      ELAMBDA=(((CRITPRES/14.7)**(-.143))-1)*144/5.676
  407 CRITTIME(I)=ELAMBDA*VOLAVAIL(NMOD)/(CD*HOLE*HOLE*3.14159*.25*23.)
C
C CALCULATE CREW DEPRESSURIZATION LOSSES
C
      IF(ESCTIME(I) .GT. CRITTIME(I)) THEN
      NUMCRIT(NMOD,NSTA)=NUMCRIT(NMOD,NSTA)+1
      IF (NMOD .NE. MODULE) THEN
      NCRIT(NMOD)=NCRIT(NMOD)+1
      END IF
      IF (NMOD .EQ. MODULE) THEN
      IF (NN .EQ. 0) THEN
      NCRIT(NMOD)=NCRIT(NMOD)+1
      END IF
      END IF
      NCR=1
      END IF
C
  410 CONTINUE
C
C
C
      IF (NCR .EQ. 0) THEN
      IF (NIN .EQ. 0) THEN
      GO TO 430
C     WRITE (*,*) ' NONE '
      END IF
      END IF
      IF (NCR .EQ. 1) THEN
      NPENCRIT(MODULE)=NPENCRIT(MODULE)+1
      NINJCRIT(MODULE)=NINJCRIT(MODULE)+1
C     WRITE (*,*) ' CR '
      IF (NIN .EQ. 1) THEN
      NPENINJ(MODULE)=NPENINJ(MODULE)+1
C     WRITE (*,*) ' CRINJ '
      GO TO 430
      END IF
      END IF
      IF (NCR .EQ. 0) THEN
      IF (NIN .EQ. 1) THEN
      NPENINJ(MODULE)=NPENINJ(MODULE)+1
      NINJCRIT(MODULE)=NINJCRIT(MODULE)+1
```

```
C    WRITE (*,*) ' INJ'
     END IF
     END IF
C
C
C
 430 MODULE=MODULE
C    WRITE (*, 440) DIAMETER, VELOCITY, OBLIQITY, HOLE, NPEN, MODULE, E
C    *LEMENT, ANGLE
C 440 FORMAT (' DIAMETER = ', F7.4,' VELOCITY = ', F7.4, ' OBLIQUITY = '
C    *, F7.4, ' HOLE SIZE = ', F7.4, '     FOR PENETRATION NUMBER ', I8,
C    * '   MODULE =', I3, '   ELEMENT =', I3, '   ANGLE =', I3)
C    WRITE (*,*) ' '
 450 IF (NPEN .EQ. NEND) GO TO 465
     NTRY=NTRY+1
     GO TO 220
C
C PRINT OUT RESULTS
C
 465 NSUM1=0
     NSUM2=0
     NSUM3=0
     NSUM4=0
     NSUM5=0
C
C
C
     DO 485 I = 1, 8
C
C THIS SECTION CALCULATES RATIO FOR TOTAL OF SIX MODULES
C
      IF (I .LE. 6) THEN
       NSUM1=NPENCRAC(I)+NINJCRIT(I)+NSUM1
       NSUM2=NUMPENS(I)+NSUM2
       NSUM3=NPENCRAC(I)+NSUM3
       NSUM4=NPENINJ(I)+NSUM4
       NSUM5=NINJCRIT(I)-NPENINJ(I)+NSUM5
      END IF
C
C THIS SECTION CALCULATES RATIO FOR EACH MODULE
C
        RATCRAC(I)=REAL(NPENCRAC(I))/REAL(NUMPENS(I))
        RATINJ(I)=REAL(NPENINJ(I))/REAL(NUMPENS(I))
        RATTOT(I)=(REAL(NINJCRIT(I))+REAL(NPENCRAC(I)))/REAL(NUMPENS(I))
        RATDEP(I)=RATTOT(I)-RATCRAC(I)-RATINJ(I)
      WRITE (*,*) ' '
C
      WRITE (*,*) ' '
      WRITE (*,*) ' '
      WRITE (*, 466) I, NUMPENS(I)
 466  FORMAT ('  FOR MODULE ', I8, '  PENS = ', I8)
      WRITE (*,*) ' '
      WRITE (*, 467) NUMIMPS(I)
 467  FORMAT (' NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = ', I8)
```

```
      WRITE (*,*) ' '
       WRITE (*,468) NINJ(I),NCRIT(I),NPENCRAC(I)
 468 FORMAT (' INJURIES = ', I8, ' DEPRESS = ', I8, ' CRACKS = ', I8)
      WRITE (*,*) ' '
       WRITE (*,469) NPENINJ(I), NPENCRIT(I)
 469 FORMAT (' PENS WITH INJURIES = ', I8, ' PENS WITH DEPRESS = ', I8)
      WRITE (*,*) ' '
      WRITE (*,1470) NINJCRIT(I)
 1470 FORMAT (' PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = ', I8)
      WRITE (*,*) ' '
C 470 WRITE (*, 471) NPENIN(I)
C 471 FORMAT (' NUMBER OF PENETRATIONS NEARER TO HATCH THAN CREW = ', I8
C    *)
C     WRITE(*,*) ' '
C     WRITE (*, 472) NPENOUT(I)
C 472 FORMAT (' NUMBER OF PENETRATIONS FARTHER FROM HATCH THAN CREW = ',
C    * I8)
C     WRITE (*,*) ' '
C     WRITE (*, 473) NPENAT(I)
C 473 FORMAT (' NUMBER OF PENETRATIONS AT CREW LOCATION = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 474) NPENNOCR(I)
C 474 FORMAT (' NUMBER OF PENETRATIONS WITH NO CREW IN MODULE = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 475) NPEN1CRW(I)
C 475 FORMAT (' NUMBER OF PENETRATIONS WITH ONE CREW IN MODULE = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1475) NPEN2CRW(I)
C1475 FORMAT (' NUMBER OF PENETRATIONS WITH TWO CREW IN MODULE = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1476) NPEN3CRW(I)
C1476 FORMAT (' NUMBER OF PENETRATIONS WITH 3 CREW IN MODULE = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1477) NPEN4CRW(I)
C1477 FORMAT (' NUMBER OF PENETRATIONS WITH 4 CREW IN MODULE = ', I8)
C     WRITE (*,*) ' '
C 476 WRITE (*, 477) NUMHOLE1(I)
C 477 FORMAT (' NUMBER OF HOLES 0 TO 1 INCH IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 478) NUMHOLE2(I)
C 478 FORMAT (' NUMBER OF HOLES 1 TO 2 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 479) NUMHOLE3(I)
C 479 FORMAT (' NUMBER OF HOLES 2 TO 3 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 480) NUMHOLE4(I)
C 480 FORMAT (' NUMBER OF HOLES 3 TO 4 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 481) NUMHOLE5(I)
C 481 FORMAT (' NUMBER OF HOLES 4 TO 5 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 482) NUMHOLE6(I)
C 482 FORMAT (' NUMBER OF HOLES 5 TO 6 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
```

```
C     WRITE (*, 483) NUMHOLE7(I)
C 483 FORMAT (' NUMBER OF HOLES 6 TO 7 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 484) NUMHOLE8(I)
C 484 FORMAT (' NUMBER OF HOLES 7 TO 8 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1484) NUMHOLE9(I)
C1484 FORMAT (' NUMBER OF HOLES 8 TO 9 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1483) NUMHOL10(I)
C1483 FORMAT (' NUMBER OF HOLES 9 TO 10 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 2484) NUMHOL11(I)
C2484 FORMAT (' NUMBER OF HOLES 10 TO 11 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 3484) NUMHOL12(I)
C3484 FORMAT (' NUMBER OF HOLES 11 TO 12 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1485) NUMHOL20(I)
C1485 FORMAT (' NUMBER OF HOLES > 20 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C 676 WRITE (*, 677) NUMHO1(I)
C 677 FORMAT (' NUMBER OF CRACKS 0 TO 1 INCH IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 678) NUMHO2(I)
C 678 FORMAT (' NUMBER OF CRACKS 1 TO 2 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 679) NUMHO3(I)
C 679 FORMAT (' NUMBER OF CRACKS 2 TO 3 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 680) NUMHO4(I)
C 680 FORMAT (' NUMBER OF CRACKS 3 TO 4 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 681) NUMHO5(I)
C 681 FORMAT (' NUMBER OF CRACKS 4 TO 5 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 682) NUMHO6(I)
C 682 FORMAT (' NUMBER OF CRACKS 5 TO 6 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 683) NUMHO7(I)
C 683 FORMAT (' NUMBER OF CRACKS 6 TO 7 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 684) NUMHO8(I)
C 684 FORMAT (' NUMBER OF CRACKS 7 TO 8 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1684) NUMHO9(I)
C1684 FORMAT (' NUMBER OF CRACKS 8 TO 9 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 1683) NUMHO10(I)
C1683 FORMAT (' NUMBER OF CRACKS 9 TO 10 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
C     WRITE (*, 2684) NUMHO11(I)
C2684 FORMAT (' NUMBER OF CRACKS 10 TO 11 INCHES IN DIAMETER = ', I8)
C     WRITE (*,*) ' '
```

```
C    WRITE (*, 3684) NUMHO12(I)
C3684 FORMAT (' NUMBER OF CRACKS 11 TO 12 INCHES IN DIAMETER = ', I8)
C    WRITE (*,*) ''
C    WRITE (*, 1685) NUMHO20(I)
C1685 FORMAT (' NUMBER OF CRACKS > 12 INCHES IN DIAMETER = ', I8)
 485 CONTINUE
C
C
C
      RATIOTOT=REAL(NSUM1)/REAL(NSUM2)
      RATIOCRC=REAL(NSUM3)/REAL(NSUM2)
      RATIOINJ=REAL(NSUM4)/REAL(NSUM2)
      RATIODEP=REAL(NSUM5)/REAL(NSUM2)
C
      WRITE (*,*) ''
      WRITE (*,*) ' MODULE:  TOTAL RATIO = CRACK + INJURY + DEPRESS'
      IEEE=6
      IF (IVOLUME .EQ. 3) THEN
      IEEE=8
      END IF
      DO 9942 IE = 1, 8
      WRITE (*,*) ''
      WRITE (*,9943) IE, RATTOT(IE), RATCRAC(IE), RATINJ(IE), RATDEP(IE)
 9943 FORMAT (I8, F13.4, F8.4, F9.4, F10.4)
 9942 CONTINUE
      WRITE (*,*) ''
      WRITE (*,*) ''
      WRITE (*,9927) RATIOTOT, RATIOCRC, RATIOINJ, RATIODEP
 9927 FORMAT (' TOTAL =', F13.4, F8.4, F9.4, F10.4)
      WRITE (*,*) ' (1 TO 6)'
C
C
C
      WRITE (*,*) ''
      WRITE (*,*) ''
      WRITE (*,*) ' PERFORM ANOTHER ANALYSIS? TYPE 1 FOR YES, 2 FOR NO.'
      READ (*, '(I2)') NQUIT
      IF (INODE .EQ. 2) THEN
      NQUIT=2
      END IF
      IF (ITRI .EQ. 2) THEN
      NQUIT=2
      END IF
      IF (NQUIT .EQ. 1) GO TO 204
 500 END
```

APPENDIX B

PROBDIA.DAT Data File

Cum. Prob.	Dia. (cm)
0.0731	0.31
0.1392	0.32
0.1989	0.33
0.2531	0.34
0.3023	0.35
0.3472	0.36
0.3882	0.37
0.4257	0.38
0.4601	0.39
0.4916	0.4
0.5207	0.41
0.5475	0.42
0.5722	0.43
0.5951	0.44
0.6164	0.45
0.636	0.46
0.6544	0.47
0.6714	0.48
0.6873	0.49
0.7021	0.5
0.716	0.51
0.7289	0.52
0.7412	0.53
0.7525	0.54
0.7632	0.55
0.7733	0.56
0.7827	0.57
0.7917	0.58
0.8001	0.59
0.808	0.6
0.8156	0.61
0.8227	0.62
0.8294	0.63
0.8358	0.64
0.8418	0.65
0.8476	0.66
0.853	0.67
0.8582	0.68
0.8631	0.69
0.8678	0.7
0.8678	0.71
0.8766	0.72
0.8806	0.73
0.8845	0.74
0.8882	0.75
0.8918	0.76
0.8952	0.77
0.8984	0.78
0.9015	0.79
0.9045	0.8
0.9073	0.81
0.9101	0.82
0.9127	0.83
0.9152	0.84
0.9177	0.85
0.92	0.86
0.9222	0.87
0.9244	0.88
0.9265	0.89
0.9285	0.9
0.9304	0.91
0.9323	0.92
0.9341	0.93
0.9358	0.94
0.9374	0.95
0.9391	0.96
0.9406	0.97
0.9421	0.98
0.9436	0.99
0.945	1
0.9513	1.05
0.9567	1.1
0.9614	1.15
0.9654	1.2
0.969	1.25
0.972	1.3
0.9748	1.35
0.9772	1.4
0.9793	1.45
0.9812	1.5
0.9829	1.55
0.9845	1.6
0.9858	1.65
0.9871	1.7
0.9882	1.75
0.9893	1.8
0.9902	1.85
0.9911	1.9
0.9919	1.95
0.9926	2
0.9933	2.05
0.9939	2.1
0.9945	2.15
0.995	2.2
0.9955	2.25
0.996	2.3
0.9964	2.35
0.9968	2.4
0.9972	2.45
0.9975	2.5
0.9978	2.55
0.9982	2.6
0.9984	2.65
0.9987	2.7
0.999	2.75
0.9992	2.8
0.9994	2.85
0.9996	2.9
0.9998	2.95
1	3

APPENDIX C

VELSTA.DAT Data File

Velocity (km/s)	Cum. Prob.
0.3300	0.0000
1.3400	0.0000
2.6700	0.0040
4.0000	0.0143
5.2500	0.0369
6.5000	0.0756
7.7000	0.1271
8.8300	0.1809
9.9000	0.2378
10.9000	0.2897
11.8000	0.3433
12.6100	0.3991
13.3400	0.4465
13.9500	0.4734
14.4700	0.4769
14.8700	0.4778
15.1700	0.4778
15.3400	0.4778
15.4000	0.4778
15.3400	0.4778
15.1700	0.4778
14.8700	0.4789
14.4700	0.4826
13.9500	0.5113
13.3400	0.5625
12.6100	0.6230
11.8000	0.6818
10.9000	0.7389
9.9000	0.8020
8.8300	0.8619
7.7000	0.9188
6.5000	0.9609
5.2500	0.9850
4.0000	0.9959
2.6700	1.0000
1.3400	1.0000
0.3300	1.0000

APPENDIX D

PROBMOD.DAT Data File

Cum.	0.9011	1.0000	0.1409
Prob.	1.0000	0.2370	0.2819
	0.2745	0.4189	0.2819
0.2575	0.3635	0.5764	0.2819
0.2575	0.5985	0.5764	0.3690
0.5149	0.6103	0.6442	0.4561
0.6437	0.6947	0.6456	0.8187
0.7103	0.6947	0.8819	1.0000
0.7103	0.8982	1.0000	0.1586
0.9034	1.0000	0.2018	0.3171
1.0000	0.2725	0.3734	0.3171
0.2605	0.3809	0.4976	0.3720
0.2753	0.6072	0.4976	0.4563
0.5294	0.6072	0.5539	0.5293
0.6373	0.6904	0.5610	0.8431
0.7124	0.6904	0.7805	1.0000
0.7142	0.8968	1.0000	0.1778
0.9047	1.0000	0.2146	0.3556
1.0000	0.2684	0.4161	0.3556
0.2628	0.3919	0.5353	0.4561
0.2921	0.6076	0.5353	0.5236
0.5420	0.6076	0.5924	0.5724
0.6357	0.6881	0.6139	0.8575
0.7151	0.6881	0.8713	1.0000
0.7188	0.8960	1.0000	0.1889
0.9063	1.0000	0.1979	0.3778
1.0000	0.2641	0.3957	0.3778
0.2695	0.4017	0.4905	0.5135
0.3130	0.6062	0.4905	0.5731
0.5629	0.6062	0.5397	0.6201
0.6348	0.6858	0.6021	0.8734
0.7168	0.6858	0.8674	1.0000
0.7188	0.8953	1.0000	0.1901
0.9063	1.0000	0.1840	0.3927
1.0000	0.2554	0.3679	0.3927
0.2698	0.4075	0.4373	0.5614
0.3302	0.5971	0.4373	0.5817
0.5741	0.5971	0.4878	0.6356
0.6290	0.6732	0.5576	0.8785
0.7124	0.6732	0.8525	1.0000
0.7124	0.8911	1.0000	0.1803
0.9041	1.0000	0.1615	0.3921
1.0000	0.2453	0.3230	0.3921
0.2726	0.4159	0.3603	0.5877
0.3463	0.5892	0.3603	0.5952
0.5863	0.5892	0.4347	0.6543
0.6193	0.6615	0.5205	0.8848
0.7033	0.6615	0.8402	1.0000
0.7033	0.8872	1.0000	0.1686

0.3883
0.3883
0.6073
0.6086
0.6715
0.8905
1.0000
0.1570
0.3828
0.3828
0.6219
0.6219
0.6885
0.8962
1.0000
0.1389
0.3722
0.3722
0.6320
0.6320
0.7015
0.9005
1.0000
0.1249
0.3645
0.3645
0.6427
0.6427
0.7149
0.9050
1.0000
0.1115
0.3538
0.3538
0.6458
0.6458
0.7185
0.9062
1.0000
0.0973
0.3421
0.3421
0.6471
0.6471
0.7218
0.9073
1.0000
0.0805
0.3288
0.3288
0.6475
0.6475
0.7239
0.9080
1.0000
0.0678
0.3186
0.3186
0.6498
0.6498
0.7270
0.9090
1.0000
0.0566
0.3094
0.3094
0.6523
0.6523
0.7305
0.9102
1.0000
0.0413
0.2972
0.2972
0.6532
0.6551
0.7330
0.9110
1.0000
0.0284
0.2832
0.2832
0.6468
0.6503
0.7273
0.9091
1.0000
0.0146
0.2702
0.2702
0.6441
0.6459
0.7196
0.9065
1.0000
0.0000
0.2575
0.2575
0.6437
0.6437
0.7103
0.9034
1.0000

APPENDIX E

LAB.DAT Data File

Obliquity (degrees)	Cum. Prob.
74.9998	0.0084
44.9998	0.0312
14.9998	0.0625
15.0001	0.0937
45.0002	0.1166
75.0002	0.1250
74.9998	0.1334
44.9998	0.1562
14.9998	0.1875
15.0002	0.2187
45.0002	0.2416
75.0002	0.2500
74.9998	0.2584
44.9998	0.2812
14.9998	0.3125
15.0002	0.3437
45.0002	0.3666
75.0002	0.3750
74.9998	0.3834
44.9998	0.4062
14.9998	0.4375
15.0002	0.4687
45.0002	0.4916
75.0002	0.5000
74.9998	0.5084
44.9998	0.5312
14.9998	0.5625
15.0002	0.5937
45.0002	0.6166
75.0002	0.6250
74.9998	0.6334
44.9998	0.6562
14.9998	0.6875
15.0002	0.7187
45.0002	0.7416
75.0002	0.7500
74.9998	0.7584
44.9998	0.7812
14.9998	0.8125
15.0002	0.8437
45.0002	0.8666
75.0002	0.8750
74.9998	0.8834
44.9998	0.9062
14.9998	0.9375
15.0002	0.9687
45.0002	0.9916
75.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
90.0002	1.0000
90.0002	1.0000
90.0002	1.0000
90.0002	1.0000
75.0582	0.0082
45.2174	0.0305
15.7930	0.0609
15.7934	0.0914
45.2178	0.1137
75.0586	0.1219
75.0582	0.1301
45.2174	0.1524
15.7930	0.1828
15.7934	0.2133
45.2178	0.2356
75.0586	0.2438
75.0582	0.2519
45.2174	0.2742
15.7930	0.3047
15.7934	0.3352
45.2178	0.3575
75.0586	0.3657
75.0582	0.3738
45.2174	0.3961
15.7930	0.4266
15.7934	0.4571
45.2178	0.4794
75.0586	0.4876
75.0582	0.4957
45.2174	0.5180
15.7930	0.5485
15.7934	0.5790
45.2178	0.6013
75.0586	0.6094
75.0582	0.6176
45.2174	0.6399
15.7930	0.6704
15.7934	0.7009
45.2178	0.7232
75.0586	0.7313
75.0582	0.7395
45.2174	0.7618
15.7930	0.7923
15.7934	0.8228
45.2178	0.8451
75.0586	0.8532
75.0582	0.8614
45.2174	0.8837
15.7930	0.9142
15.7934	0.9446
45.2178	0.9669
75.0586	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
85.0002	0.9834
85.0002	0.9875
85.0002	0.9958
85.0002	1.0000
75.2329	0.0080
45.8638	0.0297
17.9637	0.0594
17.9641	0.0892
45.8642	0.1109
75.2333	0.1189
75.2329	0.1269
45.8638	0.1486
17.9637	0.1783
17.9640	0.2081
45.8642	0.2298
75.2333	0.2378
75.2329	0.2458
45.8638	0.2675
17.9637	0.2972
17.9640	0.3270
45.8642	0.3487
75.2333	0.3567
75.2329	0.3646
45.8638	0.3864
17.9637	0.4161
17.9640	0.4459
45.8642	0.4676
75.2333	0.4756
75.2329	0.4835
45.8638	0.5053
17.9637	0.5350
17.9640	0.5647
45.8642	0.5865
75.2333	0.5945
75.2329	0.6024
45.8638	0.6242
17.9637	0.6539
17.9640	0.6836
45.8642	0.7054
75.2333	0.7134
75.2329	0.7213
45.8638	0.7431
17.9637	0.7728
17.9640	0.8025
45.8642	0.8243
75.2333	0.8323
75.2329	0.8402
45.8638	0.8620
17.9637	0.8917
17.9640	0.9214
45.8642	0.9432
75.2333	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
80.0002	0.9674
80.0002	0.9756
80.0002	0.9919
80.0002	1.0000
75.5223	0.0078
46.9203	0.0290
21.0904	0.0580
21.0908	0.0870
46.9207	0.1082
75.5227	0.1159
75.5223	0.1237
46.9203	0.1449
21.0904	0.1739
21.0907	0.2029
46.9207	0.2241
75.5227	0.2319
75.5223	0.2397
46.9203	0.2609
21.0904	0.2899
21.0907	0.3188
46.9207	0.3401
75.5227	0.3478
75.5223	0.3556
46.9203	0.3768
21.0904	0.4058
21.0907	0.4348
46.9207	0.4560
75.5227	0.4638
75.5223	0.4715
46.9203	0.4928
21.0904	0.5217
21.0907	0.5507
46.9207	0.5720
75.5227	0.5797
75.5223	0.5875
46.9203	0.6087
21.0904	0.6377
21.0907	0.6667
46.9207	0.6879
75.5227	0.6957
75.5223	0.7034
46.9203	0.7246
21.0904	0.7536
21.0907	0.7826
46.9207	0.8038
75.5227	0.8116
75.5223	0.8194
46.9203	0.8406
21.0904	0.8696
21.0907	0.8986
46.9207	0.9198
75.5227	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
104.4772	0.9276
133.0792	0.9276
158.9092	0.9276
158.9095	0.9276
133.0796	0.9276
104.4777	0.9276
75.0002	0.9517
75.0002	0.9638
75.0002	0.9879
75.0002	1.0000
75.9237	0.0076
48.3586	0.0283
24.8141	0.0565
24.8145	0.0848
48.3590	0.1054
75.9241	0.1130
75.9237	0.1206
48.3586	0.1413
24.8141	0.1695
24.8143	0.1978
48.3590	0.2184
75.9241	0.2260
75.9237	0.2336
48.3586	0.2543
24.8141	0.2825
24.8143	0.3108
48.3590	0.3315
75.9241	0.3390
75.9237	0.3466
48.3586	0.3673
24.8141	0.3955
24.8143	0.4238
48.3590	0.4445
75.9241	0.4520
75.9237	0.4596
48.3586	0.4803
24.8141	0.5085
24.8143	0.5368
48.3590	0.5575
75.9241	0.5650
75.9237	0.5726
48.3586	0.5933
24.8141	0.6216
24.8143	0.6498
48.3590	0.6705
75.9241	0.6781
75.9237	0.6856
48.3586	0.7063
24.8141	0.7346
24.8143	0.7628
48.3590	0.7835
75.9241	0.7911
75.9237	0.7986
48.3586	0.8193
24.8141	0.8476
24.8143	0.8758
48.3590	0.8965
75.9241	0.9041
104.0758	0.9041
131.6409	0.9041
155.1856	0.9041
155.1858	0.9041
131.6413	0.9041
104.0762	0.9041
104.0758	0.9041
131.6409	0.9041
155.1856	0.9041
155.1858	0.9041
131.6413	0.9041
104.0762	0.9041
104.0758	0.9041
131.6409	0.9041
155.1856	0.9041
155.1858	0.9041
131.6413	0.9041
104.0762	0.9041
104.0758	0.9041
131.6409	0.9041
155.1856	0.9041
155.1858	0.9041
131.6413	0.9041
104.0762	0.9041
104.0758	0.9041
131.6409	0.9041
155.1856	0.9041
155.1858	0.9041
131.6413	0.9041
104.0762	0.9041
104.0758	0.9041
131.6409	0.9041
155.1856	0.9041
155.1858	0.9041
131.6413	0.9041

104.0762	0.9041	129.8558	0.8803	33.2261	0.8292	37.6984	0.4672	57.2021	0.1255	122.7978	0.8035
104.0758	0.9041	103.5664	0.8803	52.2389	0.8488	37.6986	0.4931	42.2735	0.1506	101.4357	0.8035
131.6409	0.9041	103.5660	0.8803	77.0476	0.8559	54.6039	0.5121	42.2736	0.1758	101.4353	0.8035
155.1856	0.9041	129.8554	0.8803	102.9522	0.8559	77.7599	0.5191	57.2024	0.1941	122.7974	0.8035
155.1858	0.9041	151.0952	0.8803	127.7609	0.8559	77.7595	0.5260	78.5646	0.2009	137.7263	0.8035
131.6413	0.9041	151.0955	0.8803	146.7738	0.8559	54.6036	0.5450	78.5641	0.2076	137.7264	0.8035
104.0762	0.9041	129.8558	0.8803	146.7740	0.8559	37.6984	0.5710	57.2021	0.2260	122.7978	0.8035
104.0758	0.9041	103.5664	0.8803	127.7613	0.8559	37.6986	0.5969	42.2735	0.2511	101.4357	0.8035
131.6409	0.9041	103.5660	0.8803	102.9527	0.8559	54.6039	0.6159	42.2736	0.2762	50.0001	0.8690
155.1856	0.9041	129.8554	0.8803	102.9522	0.8559	77.7599	0.6229	57.2024	0.2946	50.0001	0.9017
155.1858	0.9041	151.0952	0.8803	127.7609	0.8559	77.7595	0.6298	78.5646	0.3013	50.0001	0.9672
131.6413	0.9041	151.0955	0.8803	146.7738	0.8559	54.6036	0.6488	78.5641	0.3080	50.0001	1.0000
104.0762	0.9041	129.8558	0.8803	146.7740	0.8559	37.6984	0.6748	57.2021	0.3264	79.4545	0.0065
70.0001	0.9360	103.5664	0.8803	127.7613	0.8559	37.6986	0.7007	42.2735	0.3515	59.9999	0.0242
70.0001	0.9520	103.5660	0.8803	102.9527	0.8559	54.6039	0.7197	42.2736	0.3766	46.9205	0.0484
70.0001	0.9840	129.8554	0.8803	102.9522	0.8559	77.7599	0.7267	57.2024	0.3950	46.9207	0.0726
70.0001	1.0000	151.0952	0.8803	127.7609	0.8559	77.7595	0.7336	78.5646	0.4017	60.0002	0.0903
76.4335	0.0074	151.0955	0.8803	146.7738	0.8559	54.6036	0.7526	78.5641	0.4085	79.4549	0.0968
50.1441	0.0275	129.8558	0.8803	146.7740	0.8559	37.6984	0.7786	57.2021	0.4268	79.4545	0.1033
28.9044	0.0550	103.5664	0.8803	127.7613	0.8559	37.6986	0.8046	42.2735	0.4519	59.9999	0.1210
28.9048	0.0825	103.5660	0.8803	102.9527	0.8559	54.6039	0.8236	42.2736	0.4771	46.9205	0.1452
50.1445	0.1027	129.8554	0.8803	102.9522	0.8559	77.7599	0.8305	57.2024	0.4954	46.9206	0.1694
76.4339	0.1100	151.0952	0.8803	127.7609	0.8559	102.2400	0.8305	78.5646	0.5022	60.0002	0.1871
76.4335	0.1174	151.0955	0.8803	146.7738	0.8559	125.3960	0.8305	78.5641	0.5089	79.4549	0.1936
50.1441	0.1376	129.8558	0.8803	146.7740	0.8559	142.3013	0.8305	57.2021	0.5273	79.4545	0.2001
28.9044	0.1651	103.5664	0.8803	127.7613	0.8559	142.3015	0.8305	42.2735	0.5524	59.9999	0.2178
28.9047	0.1926	103.5660	0.8803	102.9527	0.8559	125.3963	0.8305	42.2736	0.5775	46.9205	0.2420
50.1445	0.2127	129.8554	0.8803	102.9522	0.8559	102.2404	0.8305	57.2024	0.5959	46.9206	0.2662
76.4339	0.2201	151.0952	0.8803	127.7609	0.8559	102.2400	0.8305	78.5646	0.6026	60.0002	0.2839
76.4335	0.2275	151.0955	0.8803	146.7738	0.8559	125.3960	0.8305	78.5641	0.6093	79.4549	0.2904
50.1441	0.2476	129.8558	0.8803	146.7740	0.8559	142.3013	0.8305	57.2021	0.6277	79.4545	0.2968
28.9044	0.2751	103.5664	0.8803	127.7613	0.8559	142.3015	0.8305	42.2735	0.6528	59.9999	0.3146
28.9047	0.3026	65.0001	0.9202	102.9527	0.8559	125.3963	0.8305	42.2736	0.6779	46.9205	0.3388
50.1445	0.3228	65.0001	0.9402	102.9522	0.8559	102.2404	0.8305	57.2024	0.6963	46.9206	0.3630
76.4339	0.3301	65.0001	0.9800	127.7609	0.8559	102.2400	0.8305	78.5646	0.7030	60.0002	0.3807
76.4335	0.3375	65.0001	1.0000	146.7738	0.8559	125.3960	0.8305	78.5641	0.7098	79.4549	0.3871
50.1441	0.3576	77.0472	0.0072	146.7740	0.8559	142.3013	0.8305	57.2021	0.7281	79.4545	0.3936
28.9044	0.3851	52.2386	0.0267	127.7613	0.8559	142.3015	0.8305	42.2735	0.7532	59.9999	0.4113
28.9047	0.4127	33.2259	0.0535	102.9527	0.8559	125.3963	0.8305	42.2736	0.7784	46.9205	0.4355
50.1445	0.4328	33.2262	0.0802	102.9522	0.8559	102.2404	0.8305	57.2024	0.7967	46.9206	0.4597
76.4339	0.4402	52.2389	0.0998	127.7609	0.8559	102.2400	0.8305	78.5646	0.8035	60.0002	0.4775
76.4335	0.4475	77.0476	0.1070	146.7738	0.8559	125.3960	0.8305	101.4353	0.8035	79.4549	0.4839
50.1441	0.4677	77.0472	0.1142	146.7740	0.8559	142.3013	0.8305	122.7974	0.8035	79.4545	0.4904
28.9044	0.4952	52.2386	0.1337	127.7613	0.8559	142.3015	0.8305	137.7263	0.8035	59.9999	0.5081
28.9047	0.5227	33.2259	0.1605	102.9527	0.8559	125.3963	0.8305	137.7264	0.8035	46.9205	0.5323
50.1445	0.5428	33.2261	0.1872	102.9522	0.8559	102.2404	0.8305	122.7978	0.8035	46.9206	0.5565
76.4339	0.5502	52.2389	0.2068	127.7609	0.8559	102.2400	0.8305	101.4357	0.8035	60.0002	0.5742
76.4335	0.5576	77.0476	0.2140	146.7738	0.8559	125.3960	0.8305	101.4353	0.8035	79.4549	0.5807
50.1441	0.5777	77.0472	0.2212	146.7740	0.8559	142.3013	0.8305	122.7974	0.8035	79.4545	0.5872
28.9044	0.6052	52.2386	0.2407	127.7613	0.8559	142.3015	0.8305	137.7263	0.8035	59.9999	0.6049
28.9047	0.6327	33.2259	0.2675	102.9527	0.8559	125.3963	0.8305	137.7264	0.8035	46.9205	0.6291
50.1445	0.6529	33.2261	0.2942	60.0001	0.9040	102.2404	0.8305	122.7978	0.8035	46.9206	0.6533
76.4339	0.6602	52.2389	0.3138	60.0001	0.9280	102.2400	0.8305	101.4357	0.8035	60.0002	0.6710
76.4335	0.6676	77.0476	0.3210	60.0001	0.9760	125.3960	0.8305	101.4353	0.8035	79.4549	0.6775
50.1441	0.6878	77.0472	0.3281	60.0001	1.0000	142.3013	0.8305	122.7974	0.8035	79.4545	0.6840
28.9044	0.7153	52.2386	0.3477	77.7595	0.0070	142.3015	0.8305	137.7263	0.8035	59.9999	0.7017
28.9047	0.7428	33.2259	0.3745	54.6036	0.0260	125.3963	0.8305	137.7264	0.8035	46.9205	0.7259
50.1445	0.7629	33.2261	0.4012	37.6984	0.0519	102.2404	0.8305	122.7978	0.8035	46.9206	0.7501
76.4339	0.7703	52.2389	0.4208	37.6987	0.0779	102.2400	0.8305	101.4357	0.8035	60.0002	0.7678
76.4335	0.7777	77.0476	0.4280	54.6039	0.0969	125.3960	0.8305	101.4353	0.8035	79.4549	0.7743
50.1441	0.7978	77.0472	0.4351	77.7599	0.1038	142.3013	0.8305	122.7974	0.8035	100.5450	0.7743
28.9044	0.8253	52.2386	0.4547	77.7595	0.1108	142.3015	0.8305	137.7263	0.8035	119.9997	0.7743
28.9047	0.8528	33.2259	0.4815	54.6036	0.1298	125.3963	0.8305	137.7264	0.8035	133.0793	0.7743
50.1445	0.8730	33.2261	0.5082	37.6984	0.1557	102.2404	0.8305	122.7978	0.8035	133.0794	0.7743
76.4339	0.8803	52.2389	0.5278	37.6986	0.1817	102.2400	0.8305	101.4357	0.8035	120.0000	0.7743
103.5660	0.8803	77.0476	0.5350	54.6039	0.2007	125.3960	0.8305	101.4353	0.8035	100.5454	0.7743
129.8554	0.8803	77.0472	0.5421	77.7599	0.2076	142.3013	0.8305	122.7974	0.8035	100.5450	0.7743
151.0952	0.8803	52.2386	0.5617	77.7595	0.2146	142.3015	0.8305	137.7263	0.8035	119.9997	0.7743
151.0955	0.8803	33.2259	0.5885	54.6036	0.2336	125.3963	0.8305	137.7264	0.8035	133.0793	0.7743
129.8558	0.8803	33.2261	0.6152	37.6984	0.2595	102.2404	0.8305	122.7978	0.8035	133.0794	0.7743
103.5664	0.8803	52.2389	0.6348	37.6986	0.2855	55.0001	0.8870	101.4357	0.8035	120.0000	0.7743
103.5660	0.8803	77.0476	0.6420	54.6039	0.3045	55.0001	0.9153	101.4353	0.8035	100.5454	0.7743
129.8554	0.8803	77.0472	0.6491	77.7599	0.3114	55.0001	0.9718	122.7974	0.8035	100.5450	0.7743
151.0952	0.8803	52.2386	0.6687	77.7595	0.3184	55.0001	1.0000	137.7263	0.8035	119.9997	0.7743
151.0955	0.8803	33.2259	0.6955	54.6036	0.3374	78.5641	0.0067	137.7264	0.8035	133.0793	0.7743
129.8558	0.8803	33.2261	0.7222	37.6984	0.3633	57.2021	0.0251	122.7978	0.8035	133.0794	0.7743
103.5664	0.8803	52.2389	0.7418	37.6986	0.3893	42.2735	0.0502	101.4357	0.8035	120.0000	0.7743
103.5660	0.8803	77.0476	0.7490	54.6039	0.4083	42.2738	0.0753	101.4353	0.8035	100.5454	0.7743
129.8554	0.8803	77.0472	0.7561	77.7599	0.4153	57.2024	0.0937	122.7974	0.8035	100.5450	0.7743
151.0952	0.8803	52.2386	0.7757	77.7595	0.4222	78.5646	0.1004	137.7263	0.8035	119.9997	0.7743
151.0955	0.8803	33.2259	0.8025	54.6036	0.4412	78.5641	0.1072	137.7264	0.8035	133.0793	0.7743

133.0794	0.7743	128.3806	0.7422	66.0724	0.4634	82.5643	0.1717	118.8790	0.6645	114.0927	0.6154
120.0000	0.7743	128.3807	0.7422	56.3559	0.4854	69.2951	0.1869	110.7048	0.6645	114.0928	0.6154
100.5454	0.7743	117.0340	0.7422	56.3561	0.5075	61.1210	0.2077	97.4356	0.6645	107.3877	0.6154
100.5450	0.7743	99.5767	0.7422	66.0728	0.5237	61.1211	0.2284	30.0000	0.7763	96.2798	0.6154
119.9997	0.7743	99.5763	0.7422	81.4629	0.5296	69.2954	0.2436	30.0000	0.8323	96.2794	0.6154
133.0793	0.7743	117.0337	0.7422	81.4625	0.5355	82.5647	0.2492	30.0000	0.9441	107.3874	0.6154
133.0794	0.7743	128.3806	0.7422	66.0724	0.5516	82.5643	0.2548	30.0000	1.0000	114.0927	0.6154
120.0000	0.7743	128.3807	0.7422	56.3559	0.5737	69.2951	0.2700	83.7201	0.0052	114.0928	0.6154
100.5454	0.7743	117.0340	0.7422	56.3561	0.5958	61.1210	0.2907	72.6122	0.0192	107.3877	0.6154
100.5450	0.7743	99.5767	0.7422	66.0728	0.6119	61.1211	0.3115	65.9071	0.0385	96.2798	0.6154
119.9997	0.7743	99.5763	0.7422	81.4629	0.6178	69.2954	0.3267	65.9073	0.0577	96.2794	0.6154
133.0793	0.7743	117.0337	0.7422	81.4625	0.6238	82.5647	0.3323	72.6125	0.0718	107.3874	0.6154
133.0794	0.7743	128.3806	0.7422	66.0724	0.6399	82.5643	0.3378	83.7205	0.0769	114.0927	0.6154
120.0000	0.7743	128.3807	0.7422	56.3559	0.6620	69.2951	0.3530	83.7201	0.0821	114.0928	0.6154
100.5454	0.7743	117.0340	0.7422	56.3561	0.6840	61.1210	0.3738	72.6122	0.0962	107.3877	0.6154
100.5450	0.7743	99.5767	0.7422	66.0728	0.7002	61.1211	0.3946	65.9071	0.1154	96.2798	0.6154
119.9997	0.7743	99.5763	0.7422	81.4629	0.7061	69.2954	0.4098	65.9072	0.1346	96.2794	0.6154
133.0793	0.7743	117.0337	0.7422	98.5370	0.7061	82.5647	0.4153	72.6125	0.1487	107.3874	0.6154
133.0794	0.7743	128.3806	0.7422	113.9271	0.7061	82.5643	0.4209	83.7205	0.1538	114.0927	0.6154
120.0000	0.7743	128.3807	0.7422	123.6439	0.7061	69.2951	0.4361	83.7201	0.1590	114.0928	0.6154
100.5454	0.7743	117.0340	0.7422	123.6440	0.7061	61.1210	0.4569	72.6122	0.1731	107.3877	0.6154
100.5450	0.7743	99.5767	0.7422	113.9275	0.7061	61.1211	0.4776	65.9071	0.1923	96.2798	0.6154
119.9997	0.7743	99.5763	0.7422	98.5374	0.7061	69.2954	0.4928	65.9072	0.2115	25.0000	0.7436
133.0793	0.7743	117.0337	0.7422	98.5370	0.7061	82.5647	0.4984	72.6125	0.2256	25.0000	0.8077
133.0794	0.7743	128.3806	0.7422	113.9271	0.7061	82.5643	0.5040	83.7205	0.2308	25.0000	0.9359
120.0000	0.7743	128.3807	0.7422	123.6439	0.7061	69.2951	0.5192	83.7201	0.2359	25.0000	1.0000
100.5454	0.7743	117.0340	0.7422	123.6440	0.7061	61.1210	0.5399	72.6122	0.2500	84.9213	0.0047
45.0001	0.8495	99.5767	0.7422	113.9275	0.7061	61.1211	0.5607	65.9071	0.2692	76.0045	0.0174
45.0001	0.8871	99.5763	0.7422	98.5374	0.7061	69.2954	0.5759	65.9072	0.2885	70.7091	0.0347
45.0001	0.9624	117.0337	0.7422	98.5370	0.7061	82.5647	0.5815	72.6125	0.3025	70.7093	0.0521
45.0001	1.0000	128.3806	0.7422	113.9271	0.7061	82.5643	0.5870	83.7205	0.3077	76.0048	0.0648
80.4232	0.0062	128.3807	0.7422	123.6439	0.7061	69.2951	0.6022	83.7201	0.3128	84.9217	0.0694
62.9659	0.0232	117.0340	0.7422	123.6440	0.7061	61.1210	0.6230	72.6122	0.3269	84.9213	0.0741
51.6192	0.0464	99.5767	0.7422	113.9275	0.7061	61.1211	0.6438	65.9071	0.3461	76.0045	0.0868
51.6195	0.0696	99.5763	0.7422	98.5374	0.7061	69.2954	0.6590	65.9072	0.3654	70.7091	0.1041
62.9662	0.0866	117.0337	0.7422	98.5370	0.7061	82.5647	0.6645	72.6125	0.3795	70.7092	0.1215
80.4236	0.0928	128.3806	0.7422	113.9271	0.7061	97.4352	0.6645	83.7205	0.3846	76.0048	0.1342
80.4232	0.0990	128.3807	0.7422	123.6439	0.7061	110.7045	0.6645	83.7201	0.3898	84.9217	0.1388
62.9659	0.1160	117.0340	0.7422	123.6440	0.7061	118.8789	0.6645	72.6122	0.4038	84.9213	0.1435
51.6192	0.1392	99.5767	0.7422	113.9275	0.7061	118.8790	0.6645	65.9071	0.4231	76.0045	0.1562
51.6193	0.1624	99.5763	0.7422	98.5374	0.7061	110.7048	0.6645	65.9072	0.4423	70.7091	0.1735
62.9662	0.1793	117.0337	0.7422	98.5370	0.7061	97.4356	0.6645	72.6125	0.4564	70.7092	0.1909
80.4236	0.1856	128.3806	0.7422	113.9271	0.7061	97.4352	0.6645	83.7205	0.4615	76.0048	0.2036
80.4232	0.1918	128.3807	0.7422	123.6439	0.7061	110.7045	0.6645	83.7201	0.4667	84.9217	0.2082
62.9659	0.2087	117.0340	0.7422	123.6440	0.7061	118.8789	0.6645	72.6122	0.4808	84.9213	0.2129
51.6192	0.2319	99.5767	0.7422	113.9275	0.7061	118.8790	0.6645	65.9071	0.5000	76.0045	0.2256
51.6193	0.2551	40.0001	0.8281	98.5374	0.7061	110.7048	0.6645	65.9072	0.5192	70.7091	0.2429
62.9662	0.2721	40.0001	0.8711	98.5370	0.7061	97.4356	0.6645	72.6125	0.5333	70.7092	0.2603
80.4236	0.2783	40.0001	0.9571	113.9271	0.7061	97.4352	0.6645	83.7205	0.5384	76.0048	0.2730
80.4232	0.2845	40.0001	1.0000	123.6439	0.7061	110.7045	0.6645	83.7201	0.5436	84.9217	0.2777
62.9659	0.3015	81.4625	0.0059	123.6440	0.7061	118.8789	0.6645	72.6122	0.5577	84.9213	0.2823
51.6192	0.3247	66.0724	0.0221	113.9275	0.7061	118.8790	0.6645	65.9071	0.5769	76.0045	0.2950
51.6193	0.3479	56.3559	0.0441	98.5374	0.7061	110.7048	0.6645	65.9072	0.5961	70.7091	0.3124
62.9662	0.3649	56.3562	0.0662	98.5370	0.7061	97.4356	0.6645	72.6125	0.6102	70.7092	0.3297
80.4236	0.3711	66.0728	0.0824	113.9271	0.7061	97.4352	0.6645	83.7205	0.6154	76.0048	0.3424
80.4232	0.3773	81.4629	0.0883	123.6439	0.7061	110.7045	0.6645	96.2794	0.6154	84.9217	0.3471
62.9659	0.3943	81.4625	0.0942	123.6440	0.7061	118.8789	0.6645	107.3874	0.6154	84.9213	0.3517
51.6192	0.4175	66.0724	0.1103	113.9275	0.7061	118.8790	0.6645	114.0927	0.6154	76.0045	0.3644
51.6193	0.4407	56.3559	0.1324	98.5374	0.7061	110.7048	0.6645	114.0928	0.6154	70.7091	0.3818
62.9662	0.4577	56.3561	0.1545	98.5370	0.7061	97.4356	0.6645	107.3877	0.6154	70.7092	0.3991
80.4236	0.4639	66.0728	0.1706	113.9271	0.7061	97.4352	0.6645	96.2798	0.6154	76.0048	0.4118
80.4232	0.4701	81.4629	0.1765	123.6439	0.7061	110.7045	0.6645	96.2794	0.6154	84.9217	0.4165
62.9659	0.4871	81.4625	0.1824	123.6440	0.7061	118.8789	0.6645	107.3874	0.6154	84.9213	0.4211
51.6192	0.5103	66.0724	0.1986	113.9275	0.7061	118.8790	0.6645	114.0927	0.6154	76.0045	0.4338
51.6193	0.5335	56.3559	0.2207	98.5374	0.7061	110.7048	0.6645	114.0928	0.6154	70.7091	0.4512
62.9662	0.5504	56.3561	0.2427	35.0000	0.8041	97.4356	0.6645	107.3877	0.6154	70.7092	0.4685
80.4236	0.5567	66.0728	0.2589	35.0000	0.8531	97.4352	0.6645	96.2798	0.6154	76.0048	0.4812
80.4232	0.5629	81.4629	0.2648	35.0000	0.9510	110.7045	0.6645	96.2794	0.6154	84.9217	0.4859
62.9659	0.5798	81.4625	0.2707	35.0000	1.0000	118.8789	0.6645	107.3874	0.6154	84.9213	0.4905
51.6192	0.6030	66.0724	0.2869	82.5643	0.0056	118.8790	0.6645	114.0927	0.6154	76.0045	0.5032
51.6193	0.6262	56.3559	0.3089	69.2951	0.0208	110.7048	0.6645	114.0928	0.6154	70.7091	0.5206
62.9662	0.6432	56.3561	0.3310	61.1210	0.0415	97.4356	0.6645	107.3877	0.6154	70.7092	0.5380
80.4236	0.6494	66.0728	0.3471	61.1212	0.0623	97.4352	0.6645	96.2798	0.6154	76.0048	0.5507
80.4232	0.6556	81.4629	0.3531	69.2954	0.0775	110.7045	0.6645	96.2794	0.6154	84.9217	0.5553
62.9659	0.6726	81.4625	0.3590	82.5647	0.0831	118.8789	0.6645	107.3874	0.6154	95.0783	0.5553
51.6192	0.6958	66.0724	0.3751	82.5643	0.0886	118.8790	0.6645	114.0927	0.6154	103.9951	0.5553
51.6193	0.7190	56.3559	0.3972	69.2951	0.1038	110.7048	0.6645	114.0928	0.6154	109.2907	0.5553
62.9662	0.7360	56.3561	0.4193	61.1210	0.1246	97.4356	0.6645	107.3877	0.6154	109.2909	0.5553
80.4236	0.7422	66.0728	0.4354	61.1211	0.1454	97.4352	0.6645	96.2798	0.6154	103.9954	0.5553
99.5763	0.7422	81.4629	0.4413	69.2954	0.1606	110.7045	0.6645	96.2794	0.6154	95.0787	0.5553
117.0337	0.7422	81.4625	0.4472	82.5647	0.1661	118.8789	0.6645	107.3874	0.6154	95.0783	0.5553

103.9951	0.5553	86.1589	0.3633	87.4243	0.1413	10.0000	0.8961	93.5330	0.2308	89.9997	0.0000
109.2907	0.5553	79.4547	0.3742	87.4239	0.1445	10.0000	1.0000	94.8290	0.2308	89.9997	0.0000
109.2909	0.5553	75.5226	0.3892	82.9469	0.1531	88.7073	0.0019	94.8291	0.2308	89.9997	0.0000
103.9954	0.5553	75.5227	0.4041	80.3442	0.1649	86.4667	0.0072	93.5333	0.2308	89.9999	0.0000
95.0787	0.5553	79.4550	0.4151	80.3443	0.1767	85.1709	0.0144	91.2927	0.2308	90.0000	0.0000
95.0783	0.5553	86.1593	0.4191	82.9472	0.1853	85.1710	0.0216	91.2923	0.2308	90.0001	0.0000
103.9951	0.5553	86.1589	0.4231	87.4243	0.1884	86.4670	0.0269	93.5330	0.2308	89.9997	0.0000
109.2907	0.5553	79.4547	0.4341	87.4239	0.1916	88.7077	0.0288	94.8290	0.2308	89.9997	0.0000
109.2909	0.5553	75.5226	0.4490	82.9469	0.2002	88.7073	0.0308	94.8291	0.2308	89.9997	0.0000
103.9954	0.5553	75.5227	0.4640	80.3442	0.2120	86.4667	0.0361	93.5333	0.2308	89.9999	0.0000
95.0787	0.5553	79.4550	0.4750	80.3443	0.2238	85.1709	0.0433	91.2927	0.2308	90.0000	0.0000
95.0783	0.5553	86.1593	0.4790	82.9472	0.2324	85.1710	0.0505	91.2923	0.2308	90.0001	0.0000
103.9951	0.5553	93.8407	0.4790	87.4243	0.2356	86.4670	0.0558	93.5330	0.2308	89.9997	0.0000
109.2907	0.5553	100.5450	0.4790	87.4239	0.2387	88.7077	0.0577	94.8290	0.2308	89.9997	0.0000
109.2909	0.5553	104.4772	0.4790	82.9469	0.2473	88.7073	0.0596	94.8291	0.2308	89.9997	0.0000
103.9954	0.5553	104.4774	0.4790	80.3442	0.2591	86.4667	0.0649	93.5333	0.2308	89.9999	0.0000
95.0787	0.5553	100.5453	0.4790	80.3443	0.2709	85.1709	0.0721	91.2927	0.2308	90.0000	0.0000
95.0783	0.5553	93.8411	0.4790	82.9472	0.2795	85.1710	0.0793	4.9999	0.4872	90.0001	0.0000
103.9951	0.5553	93.8407	0.4790	87.4243	0.2827	86.4670	0.0846	4.9999	0.6153	89.9997	0.0000
109.2907	0.5553	100.5450	0.4790	87.4239	0.2858	88.7077	0.0865	4.9999	0.8717	89.9997	0.0000
109.2909	0.5553	104.4772	0.4790	82.9469	0.2945	88.7073	0.0885	4.9999	0.9999	89.9997	0.0000
103.9954	0.5553	104.4774	0.4790	80.3442	0.3062	86.4667	0.0938	89.9999	0.0000	89.9999	0.0000
95.0787	0.5553	100.5453	0.4790	80.3443	0.3180	85.1709	0.1010	90.0000	0.0000	90.0000	0.0000
95.0783	0.5553	93.8411	0.4790	82.9472	0.3266	85.1710	0.1082	90.0001	0.0000	90.0001	0.0000
103.9951	0.5553	93.8407	0.4790	87.4243	0.3298	86.4670	0.1135	90.0003	0.0000	89.9997	0.0000
109.2907	0.5553	100.5450	0.4790	87.4239	0.3329	88.7077	0.1154	90.0003	0.0000	89.9997	0.0000
109.2909	0.5553	104.4772	0.4790	82.9469	0.3416	88.7073	0.1173	90.0003	0.0000	89.9997	0.0000
103.9954	0.5553	104.4774	0.4790	80.3442	0.3533	86.4667	0.1226	89.9999	0.0000	89.9999	0.0000
95.0787	0.5553	100.5453	0.4790	80.3443	0.3651	85.1709	0.1298	90.0000	0.0000	90.0000	0.0000
95.0783	0.5553	93.8411	0.4790	82.9472	0.3737	85.1710	0.1370	90.0001	0.0000	90.0001	0.0000
103.9951	0.5553	93.8407	0.4790	87.4243	0.3769	86.4670	0.1423	90.0003	0.0000	89.9997	0.0000
109.2907	0.5553	100.5450	0.4790	92.5757	0.3769	88.7077	0.1442	90.0003	0.0000	89.9997	0.0000
109.2909	0.5553	104.4772	0.4790	97.0527	0.3769	88.7073	0.1462	90.0003	0.0000	89.9997	0.0000
103.9954	0.5553	104.4774	0.4790	99.6557	0.3769	86.4667	0.1514	89.9999	0.0000	89.9999	0.0000
95.0787	0.5553	100.5453	0.4790	99.6558	0.3769	85.1709	0.1587	90.0000	0.0000	90.0000	0.0000
95.0783	0.5553	93.8411	0.4790	97.0530	0.3769	85.1710	0.1659	90.0001	0.0000	90.0001	0.0000
103.9951	0.5553	93.8407	0.4790	92.5761	0.3769	86.4670	0.1712	90.0003	0.0000	0.0003	0.3333
109.2907	0.5553	100.5450	0.4790	92.5757	0.3769	88.7077	0.1731	90.0003	0.0000	0.0003	0.5000
109.2909	0.5553	104.4772	0.4790	97.0527	0.3769	88.7073	0.1750	90.0003	0.0000	0.0003	0.8333
103.9954	0.5553	104.4774	0.4790	99.6557	0.3769	86.4667	0.1803	89.9999	0.0000	0.0003	1.0000
95.0787	0.5553	100.5453	0.4790	99.6558	0.3769	85.1709	0.1875	90.0000	0.0000	91.2924	0.0000
20.0000	0.7035	93.8411	0.4790	97.0530	0.3769	85.1710	0.1947	90.0001	0.0000	93.5333	0.0000
20.0000	0.7777	93.8407	0.4790	92.5761	0.3769	86.4670	0.2000	90.0003	0.0000	94.8294	0.0000
20.0000	0.9259	100.5450	0.4790	92.5757	0.3769	88.7077	0.2019	90.0003	0.0000	94.8295	0.0000
20.0000	1.0000	104.4772	0.4790	97.0527	0.3769	88.7073	0.2039	90.0003	0.0000	93.5336	0.0000
86.1589	0.0040	104.4774	0.4790	99.6557	0.3769	86.4667	0.2091	89.9999	0.0000	91.2928	0.0000
79.4547	0.0150	100.5453	0.4790	99.6558	0.3769	85.1709	0.2164	90.0000	0.0000	91.2924	0.0000
75.5226	0.0299	93.8411	0.4790	97.0530	0.3769	85.1710	0.2236	90.0001	0.0000	93.5333	0.0000
75.5227	0.0449	93.8407	0.4790	92.5761	0.3769	86.4670	0.2288	90.0003	0.0000	94.8294	0.0000
79.4550	0.0559	100.5450	0.4790	92.5757	0.3769	88.7077	0.2308	90.0003	0.0000	94.8295	0.0000
86.1593	0.0599	104.4772	0.4790	97.0527	0.3769	91.2923	0.2308	90.0003	0.0000	93.5336	0.0000
86.1589	0.0639	104.4774	0.4790	99.6557	0.3769	93.5330	0.2308	89.9999	0.0000	91.2928	0.0000
79.4547	0.0748	100.5453	0.4790	99.6558	0.3769	94.8290	0.2308	90.0000	0.0000	91.2924	0.0000
75.5226	0.0898	93.8411	0.4790	97.0530	0.3769	94.8291	0.2308	90.0001	0.0000	93.5333	0.0000
75.5227	0.1048	93.8407	0.4790	92.5761	0.3769	93.5333	0.2308	90.0003	0.0000	94.8294	0.0000
79.4550	0.1157	100.5450	0.4790	92.5757	0.3769	91.2927	0.2308	90.0003	0.0000	94.8295	0.0000
86.1593	0.1197	104.4772	0.4790	97.0527	0.3769	91.2923	0.2308	90.0003	0.0000	93.5336	0.0000
86.1589	0.1238	104.4774	0.4790	99.6557	0.3769	93.5330	0.2308	89.9999	0.0000	91.2928	0.0000
79.4547	0.1347	100.5453	0.4790	99.6558	0.3769	94.8290	0.2308	90.0000	0.0000	91.2924	0.0000
75.5226	0.1497	93.8411	0.4790	97.0530	0.3769	94.8291	0.2308	90.0001	0.0000	93.5333	0.0000
75.5227	0.1647	15.0000	0.6527	92.5761	0.3769	93.5333	0.2308	90.0003	0.0000	94.8294	0.0000
79.4550	0.1756	15.0000	0.7395	92.5757	0.3769	91.2927	0.2308	90.0003	0.0000	94.8295	0.0000
86.1593	0.1796	15.0000	0.9132	97.0527	0.3769	91.2923	0.2308	90.0003	0.0000	93.5336	0.0000
86.1589	0.1836	15.0000	1.0000	99.6557	0.3769	93.5330	0.2308	89.9999	0.0000	91.2928	0.0000
79.4547	0.1946	87.4239	0.0032	99.6558	0.3769	94.8290	0.2308	90.0000	0.0000	91.2924	0.0000
75.5226	0.2096	82.9469	0.0118	97.0530	0.3769	94.8291	0.2308	90.0001	0.0000	93.5333	0.0000
75.5227	0.2245	80.3442	0.0236	92.5761	0.3769	93.5333	0.2308	90.0003	0.0000	94.8294	0.0000
79.4550	0.2355	80.3443	0.0353	92.5757	0.3769	91.2927	0.2308	90.0003	0.0000	94.8295	0.0000
86.1593	0.2395	82.9472	0.0440	97.0527	0.3769	91.2923	0.2308	90.0003	0.0000	93.5336	0.0000
86.1589	0.2435	87.4243	0.0471	99.6557	0.3769	93.5330	0.2308	89.9999	0.0000	91.2928	0.0000
79.4547	0.2545	87.4239	0.0503	99.6558	0.3769	94.8290	0.2308	89.9997	0.0000	91.2924	0.0000
75.5226	0.2694	82.9469	0.0589	97.0530	0.3769	94.8291	0.2308	89.9997	0.0000	93.5333	0.0000
75.5227	0.2844	80.3442	0.0707	92.5761	0.3769	93.5333	0.2308	89.9999	0.0000	94.8294	0.0000
79.4550	0.2954	80.3443	0.0824	92.5757	0.3769	91.2927	0.2308	90.0000	0.0000	94.8295	0.0000
86.1593	0.2994	82.9472	0.0911	97.0527	0.3769	91.2923	0.2308	90.0001	0.0000	93.5336	0.0000
86.1589	0.3034	87.4243	0.0942	99.6557	0.3769	93.5330	0.2308	89.9997	0.0000	91.2928	0.0000
79.4547	0.3143	87.4239	0.0974	99.6558	0.3769	94.8290	0.2308	89.9997	0.0000	91.2924	0.0000
75.5226	0.3293	82.9469	0.1060	97.0530	0.3769	94.8291	0.2308	89.9997	0.0000	93.5333	0.0000
75.5227	0.3443	80.3442	0.1178	92.5761	0.3769	93.5333	0.2308	89.9999	0.0000	94.8294	0.0000
79.4550	0.3552	80.3443	0.1296	10.0000	0.5846	91.2927	0.2308	90.0000	0.0000	94.8295	0.0000
86.1593	0.3592	82.9472	0.1382	10.0000	0.6884	91.2923	0.2308	90.0001	0.0000	93.5336	0.0000

91.2928	0.0000	97.0533	0.0000	104.4777	0.0000	86.1588	0.3632	84.9216	0.2219	107.3880	0.0000
91.2924	0.0000	92.5762	0.0000	100.5456	0.0000	79.4544	0.3742	84.9212	0.2268	96.2800	0.0000
93.5333	0.0000	92.5758	0.0000	93.8413	0.0000	75.5222	0.3892	76.0042	0.2404	83.7201	0.0061
94.8294	0.0000	97.0530	0.0000	93.8408	0.0000	75.5223	0.4041	70.7087	0.2589	72.6120	0.0226
94.8295	0.0000	99.6561	0.0000	100.5453	0.0000	79.4547	0.4151	70.7088	0.2774	65.9067	0.0452
93.5336	0.0000	99.6562	0.0000	104.4777	0.0000	86.1592	0.4191	76.0046	0.2909	65.9069	0.0678
91.2928	0.0000	97.0533	0.0000	104.4778	0.0000	86.1588	0.4231	84.9216	0.2959	72.6123	0.0844
88.7072	0.0019	92.5762	0.0000	100.5456	0.0000	79.4544	0.4341	84.9212	0.3008	83.7205	0.0904
86.4664	0.0072	92.5758	0.0000	93.8413	0.0000	75.5222	0.4490	76.0042	0.3143	83.7201	0.0965
85.1705	0.0144	97.0530	0.0000	93.8408	0.0000	75.5223	0.4640	70.7087	0.3328	72.6120	0.1130
85.1706	0.0216	99.6561	0.0000	100.5453	0.0000	79.4547	0.4750	70.7088	0.3513	65.9067	0.1356
86.4667	0.0269	99.6562	0.0000	104.4777	0.0000	86.1592	0.4790	76.0046	0.3649	65.9069	0.1582
88.7076	0.0289	97.0533	0.0000	104.4778	0.0000	15.0001	0.6527	84.9216	0.3698	72.6123	0.1748
88.7072	0.0308	92.5762	0.0000	100.5456	0.0000	15.0001	0.7395	84.9212	0.3748	83.7205	0.1808
86.4664	0.0361	92.5758	0.0000	93.8413	0.0000	15.0001	0.9132	76.0042	0.3883	83.7201	0.1869
85.1705	0.0433	97.0530	0.0000	93.8408	0.0000	15.0001	1.0000	70.7087	0.4050	72.6120	0.2034
85.1706	0.0505	99.6561	0.0000	100.5453	0.0000	95.0784	0.0000	70.7088	0.4216	65.9067	0.2260
86.4667	0.0558	99.6562	0.0000	104.4777	0.0000	103.9954	0.0000	76.0046	0.4351	65.9069	0.2486
88.7076	0.0577	97.0533	0.0000	104.4778	0.0000	109.2912	0.0000	84.9216	0.4401	72.6123	0.2652
88.7072	0.0596	92.5762	0.0000	100.5456	0.0000	109.2912	0.0000	84.9212	0.4450	83.7205	0.2712
86.4664	0.0649	92.5758	0.0000	93.8413	0.0000	103.9957	0.0000	76.0042	0.4586	83.7201	0.2773
85.1705	0.0721	97.0530	0.0000	93.8408	0.0000	95.0788	0.0000	70.7087	0.4660	72.6120	0.2938
85.1706	0.0794	99.6561	0.0000	100.5453	0.0000	95.0784	0.0000	70.7088	0.4734	65.9067	0.3164
86.4667	0.0846	99.6562	0.0000	104.4777	0.0000	103.9954	0.0000	76.0046	0.4869	65.9069	0.3390
88.7076	0.0866	97.0533	0.0000	104.4778	0.0000	109.2912	0.0000	84.9216	0.4919	72.6123	0.3556
88.7072	0.0885	92.5762	0.0000	100.5456	0.0000	109.2913	0.0000	84.9212	0.4968	83.7205	0.3616
86.4664	0.0938	87.4238	0.0032	93.8413	0.0000	103.9957	0.0000	76.0042	0.5090	83.7201	0.3677
85.1705	0.1010	82.9467	0.0118	93.8408	0.0000	95.0788	0.0000	70.7087	0.5090	72.6120	0.3842
85.1706	0.1082	80.3438	0.0236	100.5453	0.0000	95.0784	0.0000	70.7088	0.5090	65.9067	0.4068
86.4667	0.1135	80.3439	0.0353	104.4777	0.0000	103.9954	0.0000	76.0046	0.5212	65.9069	0.4294
88.7076	0.1154	82.9470	0.0440	104.4778	0.0000	109.2912	0.0000	84.9216	0.5261	72.6123	0.4460
88.7072	0.1174	87.4242	0.0471	100.5456	0.0000	109.2913	0.0000	20.0001	0.6841	83.7205	0.4520
86.4664	0.1226	87.4238	0.0503	93.8413	0.0000	103.9957	0.0000	20.0001	0.7631	83.7201	0.4581
85.1705	0.1298	82.9467	0.0589	93.8408	0.0000	95.0788	0.0000	20.0001	0.9210	72.6120	0.4730
85.1706	0.1371	80.3438	0.0707	100.5453	0.0000	95.0784	0.0000	20.0001	1.0000	65.9067	0.4730
86.4667	0.1423	80.3439	0.0824	104.4777	0.0000	103.9954	0.0000	96.2796	0.0000	65.9069	0.4730
88.7076	0.1443	82.9470	0.0911	104.4778	0.0000	109.2912	0.0000	107.3877	0.0000	72.6123	0.4879
88.7072	0.1462	87.4242	0.0942	100.5456	0.0000	109.2913	0.0000	114.0931	0.0000	83.7205	0.4939
86.4664	0.1515	87.4238	0.0974	93.8413	0.0000	103.9957	0.0000	114.0932	0.0000	83.7201	0.5000
85.1705	0.1587	82.9467	0.1060	93.8408	0.0000	95.0788	0.0000	107.3880	0.0000	72.6120	0.5099
85.1706	0.1659	80.3438	0.1178	100.5453	0.0000	95.0784	0.0000	96.2800	0.0000	65.9067	0.5099
86.4667	0.1712	80.3439	0.1296	104.4777	0.0000	103.9954	0.0000	96.2796	0.0000	65.9069	0.5099
88.7076	0.1731	82.9470	0.1382	104.4778	0.0000	109.2912	0.0000	107.3877	0.0000	72.6123	0.5198
88.7072	0.1751	87.4242	0.1413	100.5456	0.0000	109.2913	0.0000	114.0931	0.0000	83.7205	0.5259
86.4664	0.1803	87.4238	0.1445	93.8413	0.0000	103.9957	0.0000	114.0932	0.0000	83.7201	0.5319
85.1705	0.1876	82.9467	0.1531	86.1588	0.0040	95.0788	0.0000	107.3880	0.0000	72.6120	0.5369
85.1706	0.1948	80.3438	0.1649	79.4544	0.0150	95.0784	0.0000	96.2800	0.0000	65.9067	0.5369
86.4667	0.2000	80.3439	0.1767	75.5222	0.0299	103.9954	0.0000	96.2796	0.0000	65.9069	0.5369
88.7076	0.2020	82.9470	0.1853	75.5223	0.0449	109.2912	0.0000	107.3877	0.0000	72.6123	0.5419
88.7072	0.2039	87.4242	0.1884	79.4547	0.0559	109.2913	0.0000	114.0931	0.0000	83.7205	0.5479
86.4664	0.2092	87.4238	0.1916	86.1592	0.0599	103.9957	0.0000	114.0932	0.0000	25.0002	0.6986
85.1705	0.2164	82.9467	0.2002	86.1588	0.0639	95.0788	0.0000	107.3880	0.0000	25.0002	0.7740
85.1706	0.2236	80.3438	0.2120	79.4544	0.0748	95.0784	0.0000	96.2800	0.0000	25.0002	0.9246
86.4667	0.2289	80.3439	0.2238	75.5222	0.0898	103.9954	0.0000	96.2796	0.0000	25.0002	1.0000
88.7076	0.2308	82.9470	0.2324	75.5223	0.1048	109.2912	0.0000	107.3877	0.0000	97.4354	0.0000
5.0001	0.4872	87.4242	0.2356	79.4547	0.1157	109.2913	0.0000	114.0931	0.0000	110.7048	0.0000
5.0001	0.6154	87.4238	0.2387	86.1592	0.1197	103.9957	0.0000	114.0932	0.0000	118.8793	0.0000
5.0001	0.8718	82.9467	0.2473	86.1588	0.1238	95.0788	0.0000	107.3880	0.0000	118.8793	0.0000
5.0001	1.0000	80.3438	0.2591	79.4544	0.1347	95.0784	0.0000	96.2800	0.0000	110.7051	0.0000
92.5758	0.0000	80.3439	0.2709	75.5222	0.1497	103.9954	0.0000	96.2796	0.0000	97.4358	0.0000
97.0530	0.0000	82.9470	0.2795	75.5223	0.1646	109.2912	0.0000	107.3877	0.0000	97.4354	0.0000
99.6561	0.0000	87.4242	0.2827	79.4547	0.1756	109.2913	0.0000	114.0931	0.0000	110.7048	0.0000
99.6562	0.0000	87.4238	0.2858	86.1592	0.1796	103.9957	0.0000	114.0932	0.0000	118.8793	0.0000
97.0533	0.0000	82.9467	0.2944	86.1588	0.1836	95.0788	0.0000	107.3880	0.0000	118.8794	0.0000
92.5762	0.0000	80.3438	0.3062	79.4544	0.1946	84.9212	0.0050	96.2800	0.0000	110.7051	0.0000
92.5758	0.0000	80.3439	0.3180	75.5222	0.2096	76.0042	0.0185	96.2796	0.0000	97.4358	0.0000
97.0530	0.0000	82.9470	0.3266	75.5223	0.2245	70.7087	0.0370	107.3877	0.0000	97.4354	0.0000
99.6561	0.0000	87.4242	0.3298	79.4547	0.2355	70.7088	0.0555	114.0931	0.0000	110.7048	0.0000
99.6562	0.0000	87.4238	0.3329	86.1592	0.2395	76.0046	0.0690	114.0932	0.0000	118.8793	0.0000
97.0533	0.0000	82.9467	0.3416	86.1588	0.2435	84.9216	0.0740	107.3880	0.0000	118.8794	0.0000
92.5762	0.0000	80.3438	0.3533	79.4544	0.2545	84.9212	0.0789	96.2800	0.0000	110.7051	0.0000
92.5758	0.0000	80.3439	0.3651	75.5222	0.2694	76.0042	0.0925	96.2796	0.0000	97.4358	0.0000
97.0530	0.0000	82.9470	0.3737	75.5223	0.2844	70.7087	0.1109	107.3877	0.0000	97.4354	0.0000
99.6561	0.0000	87.4242	0.3769	79.4547	0.2954	70.7088	0.1294	114.0931	0.0000	110.7048	0.0000
99.6562	0.0000	10.0001	0.5846	86.1592	0.2994	76.0046	0.1430	114.0932	0.0000	118.8793	0.0000
97.0533	0.0000	10.0001	0.6884	86.1588	0.3034	84.9216	0.1479	107.3880	0.0000	118.8794	0.0000
92.5762	0.0000	10.0001	0.8961	79.4544	0.3143	84.9212	0.1529	96.2800	0.0000	110.7051	0.0000
92.5758	0.0000	10.0001	1.0000	75.5222	0.3293	76.0042	0.1664	96.2796	0.0000	97.4358	0.0000
97.0530	0.0000	93.8408	0.0000	75.5223	0.3443	70.7087	0.1849	107.3877	0.0000	97.4354	0.0000
99.6561	0.0000	100.5453	0.0000	79.4547	0.3552	70.7088	0.2034	114.0931	0.0000	110.7048	0.0000
99.6562	0.0000	104.4777	0.0000	86.1592	0.3592	76.0046	0.2169	114.0932	0.0000	118.8793	0.0000

118.8794	0.0000	123.6443	0.0000	81.4629	0.5688	62.9660	0.4945	46.9203	0.1392	137.7267	0.0000
110.7051	0.0000	123.6444	0.0000	81.4625	0.5731	80.4236	0.5049	60.0000	0.1732	137.7269	0.0000
97.4358	0.0000	113.9278	0.0000	66.0722	0.5731	80.4232	0.5154	79.4549	0.1857	122.7981	0.0000
97.4354	0.0000	98.5376	0.0000	56.3556	0.5731	62.9657	0.5239	79.4545	0.1981	101.4359	0.0000
110.7048	0.0000	98.5372	0.0000	56.3557	0.5731	51.6188	0.5239	59.9997	0.2321	101.4355	0.0000
118.8793	0.0000	113.9275	0.0000	66.0726	0.5731	51.6190	0.5239	46.9201	0.2785	122.7978	0.0000
118.8794	0.0000	123.6443	0.0000	81.4629	0.5773	62.9660	0.5325	46.9203	0.3249	137.7267	0.0000
110.7051	0.0000	123.6444	0.0000	35.0002	0.7182	80.4236	0.5429	60.0000	0.3589	137.7269	0.0000
97.4358	0.0000	113.9278	0.0000	35.0002	0.7887	80.4232	0.5502	79.4549	0.3713	122.7981	0.0000
97.4354	0.0000	98.5376	0.0000	35.0002	0.9296	62.9657	0.5502	79.4545	0.3837	101.4359	0.0000
110.7048	0.0000	98.5372	0.0000	35.0002	1.0000	51.6188	0.5502	59.9997	0.4143	101.4355	0.0000
118.8793	0.0000	113.9275	0.0000	99.5765	0.0000	51.6190	0.5502	46.9201	0.4282	122.7978	0.0000
118.8794	0.0000	123.6443	0.0000	117.0340	0.0000	62.9660	0.5502	46.9203	0.4422	137.7267	0.0000
110.7051	0.0000	123.6444	0.0000	128.3810	0.0000	80.4236	0.5575	60.0000	0.4727	137.7269	0.0000
97.4358	0.0000	113.9278	0.0000	128.3810	0.0000	80.4232	0.5596	79.4549	0.4852	122.7981	0.0000
97.4354	0.0000	98.5376	0.0000	117.0344	0.0000	62.9657	0.5596	79.4545	0.4976	101.4359	0.0000
110.7048	0.0000	98.5372	0.0000	99.5769	0.0000	51.6188	0.5596	59.9997	0.5112	78.5642	0.0146
118.8793	0.0000	113.9275	0.0000	99.5765	0.0000	51.6190	0.5596	46.9201	0.5112	57.2020	0.0545
118.8794	0.0000	123.6443	0.0000	117.0340	0.0000	62.9660	0.5596	46.9203	0.5112	42.2731	0.1091
110.7051	0.0000	123.6444	0.0000	128.3810	0.0000	80.4236	0.5617	60.0000	0.5248	42.2733	0.1636
97.4358	0.0000	113.9278	0.0000	128.3811	0.0000	80.4232	0.5617	79.4549	0.5372	57.2023	0.2035
82.5643	0.0072	98.5376	0.0000	117.0344	0.0000	62.9657	0.5617	79.4545	0.5472	78.5646	0.2181
69.2949	0.0271	98.5372	0.0000	99.5769	0.0000	51.6188	0.5617	59.9997	0.5472	78.5642	0.2327
61.1206	0.0541	113.9275	0.0000	99.5765	0.0000	51.6190	0.5617	46.9201	0.5472	57.2020	0.2727
61.1207	0.0812	123.6443	0.0000	117.0340	0.0000	62.9660	0.5617	46.9203	0.5472	42.2731	0.3272
69.2952	0.1010	123.6444	0.0000	128.3810	0.0000	80.4236	0.5669	60.0000	0.5472	42.2733	0.3817
82.5647	0.1083	113.9278	0.0000	128.3811	0.0000	40.0002	0.7113	79.4549	0.5571	57.2023	0.4216
82.5643	0.1155	98.5376	0.0000	117.0344	0.0000	40.0002	0.7835	79.4545	0.5621	78.5646	0.4363
69.2949	0.1353	98.5372	0.0000	99.5769	0.0000	40.0002	0.9278	59.9997	0.5621	78.5642	0.4509
61.1206	0.1624	113.9275	0.0000	99.5765	0.0000	40.0002	1.0000	46.9201	0.5621	57.2020	0.4788
61.1207	0.1895	123.6443	0.0000	117.0340	0.0000	100.5452	0.0000	46.9203	0.5621	42.2731	0.4788
69.2952	0.2093	123.6444	0.0000	128.3810	0.0000	120.0000	0.0000	60.0000	0.5621	42.2733	0.4788
82.5647	0.2165	113.9278	0.0000	128.3811	0.0000	133.0797	0.0000	79.4549	0.5671	57.2023	0.5068
82.5643	0.2238	98.5376	0.0000	117.0344	0.0000	133.0797	0.0000	79.4545	0.5671	78.5646	0.5214
69.2949	0.2436	98.5372	0.0000	99.5769	0.0000	120.0004	0.0000	59.9997	0.5671	78.5642	0.5360
61.1206	0.2706	113.9275	0.0000	99.5765	0.0000	100.5456	0.0000	46.9201	0.5671	57.2020	0.5400
61.1207	0.2977	123.6443	0.0000	117.0340	0.0000	100.5452	0.0000	46.9203	0.5671	42.2731	0.5400
69.2952	0.3175	123.6444	0.0000	128.3810	0.0000	120.0000	0.0000	60.0000	0.5671	42.2733	0.5400
82.5647	0.3248	113.9278	0.0000	128.3811	0.0000	133.0797	0.0000	79.4549	0.5671	57.2023	0.5440
82.5643	0.3320	98.5376	0.0000	117.0344	0.0000	133.0799	0.0000	79.4545	0.5671	78.5646	0.5586
69.2949	0.3518	81.4625	0.0085	99.5769	0.0000	120.0004	0.0000	59.9997	0.5671	78.5642	0.5659
61.1206	0.3789	66.0722	0.0317	99.5765	0.0000	100.5456	0.0000	46.9201	0.5671	57.2020	0.5659
61.1207	0.4060	56.3556	0.0635	117.0340	0.0000	100.5452	0.0000	46.9203	0.5671	42.2731	0.5659
69.2952	0.4258	56.3557	0.0952	128.3810	0.0000	120.0000	0.0000	60.0000	0.5671	42.2733	0.5659
82.5647	0.4330	66.0726	0.1184	128.3811	0.0000	133.0797	0.0000	79.4549	0.5671	57.2023	0.5659
82.5643	0.4403	81.4629	0.1269	117.0344	0.0000	133.0799	0.0000	45.0002	0.7114	78.5646	0.5732
69.2949	0.4601	81.4625	0.1354	99.5769	0.0000	120.0004	0.0000	45.0002	0.7835	78.5642	0.5732
61.1206	0.4601	66.0722	0.1587	99.5765	0.0000	100.5456	0.0000	45.0002	0.9278	57.2020	0.5732
61.1207	0.4601	56.3556	0.1904	117.0340	0.0000	100.5452	0.0000	45.0002	1.0000	42.2731	0.5732
69.2952	0.4799	56.3557	0.2221	128.3810	0.0000	120.0000	0.0000	101.4355	0.0000	42.2733	0.5732
82.5647	0.4872	66.0726	0.2454	128.3811	0.0000	133.0797	0.0000	122.7978	0.0000	57.2023	0.5732
82.5643	0.4944	81.4629	0.2539	117.0344	0.0000	133.0799	0.0000	137.7267	0.0000	78.5646	0.5732
69.2949	0.5063	81.4625	0.2624	99.5769	0.0000	120.0004	0.0000	137.7267	0.0000	78.5642	0.5732
61.1206	0.5063	66.0722	0.2856	99.5765	0.0000	100.5456	0.0000	122.7981	0.0000	57.2020	0.5732
61.1207	0.5063	56.3556	0.3173	117.0340	0.0000	100.5452	0.0000	101.4359	0.0000	42.2731	0.5732
69.2952	0.5182	56.3557	0.3491	128.3810	0.0000	120.0000	0.0000	101.4355	0.0000	42.2733	0.5732
82.5647	0.5254	66.0726	0.3723	128.3811	0.0000	133.0797	0.0000	122.7978	0.0000	57.2023	0.5732
82.5643	0.5327	81.4629	0.3808	117.0344	0.0000	133.0799	0.0000	137.7267	0.0000	78.5646	0.5732
69.2949	0.5386	81.4625	0.3893	99.5769	0.0000	120.0004	0.0000	137.7269	0.0000	78.5642	0.5732
61.1206	0.5386	66.0722	0.4125	80.4232	0.0104	100.5456	0.0000	122.7981	0.0000	57.2020	0.5732
61.1207	0.5386	56.3556	0.4284	62.9657	0.0390	100.5452	0.0000	101.4359	0.0000	42.2731	0.5732
69.2952	0.5446	56.3557	0.4443	51.6188	0.0779	120.0000	0.0000	101.4355	0.0000	42.2733	0.5732
82.5647	0.5518	66.0726	0.4675	51.6190	0.1169	133.0797	0.0000	122.7978	0.0000	57.2023	0.5732
82.5643	0.5591	81.4629	0.4760	62.9660	0.1454	133.0799	0.0000	137.7267	0.0000	78.5646	0.5732
69.2949	0.5591	81.4625	0.4845	80.4236	0.1558	120.0004	0.0000	137.7269	0.0000	50.0002	0.7155
61.1206	0.5591	66.0722	0.4984	80.4232	0.1663	100.5456	0.0000	122.7981	0.0000	50.0002	0.7866
61.1207	0.5591	56.3556	0.4984	62.9657	0.1948	100.5452	0.0000	101.4359	0.0000	50.0002	0.9289
69.2952	0.5591	56.3557	0.4984	51.6188	0.2338	120.0000	0.0000	101.4355	0.0000	50.0002	1.0000
82.5647	0.5663	66.0726	0.5124	51.6190	0.2727	133.0797	0.0000	122.7978	0.0000	102.2402	0.0000
30.0002	0.7121	81.4629	0.5209	62.9660	0.3012	133.0799	0.0000	137.7267	0.0000	125.3963	0.0000
30.0002	0.7849	81.4625	0.5294	80.4236	0.3117	120.0004	0.0000	137.7269	0.0000	142.3018	0.0000
30.0002	0.9307	66.0722	0.5363	80.4232	0.3221	100.5456	0.0000	122.7981	0.0000	142.3018	0.0000
30.0002	1.0036	56.3556	0.5363	62.9657	0.3506	100.5452	0.0000	101.4359	0.0000	125.3966	0.0000
98.5372	0.0000	56.3557	0.5363	51.6188	0.3779	120.0000	0.0000	101.4355	0.0000	102.2406	0.0000
113.9275	0.0000	66.0726	0.5433	51.6190	0.4052	133.0797	0.0000	122.7978	0.0000	102.2402	0.0000
123.6443	0.0000	81.4629	0.5518	62.9660	0.4337	133.0799	0.0000	137.7267	0.0000	125.3963	0.0000
123.6443	0.0000	81.4625	0.5603	80.4236	0.4441	120.0004	0.0000	137.7269	0.0000	142.3018	0.0000
113.9278	0.0000	66.0722	0.5603	80.4232	0.4546	100.5456	0.0000	122.7981	0.0000	142.3020	0.0000
98.5376	0.0000	56.3556	0.5603	62.9657	0.4745	79.4545	0.0124	101.4359	0.0000	125.3966	0.0000
98.5372	0.0000	56.3557	0.5603	51.6188	0.4745	59.9997	0.0464	101.4355	0.0000	102.2406	0.0000
113.9275	0.0000	66.0726	0.5603	51.6190	0.4745	46.9201	0.0928	122.7978	0.0000	102.2402	0.0000

125.3963	0.0000
142.3018	0.0000
142.3020	0.0000
125.3966	0.0000
102.2406	0.0000
102.2402	0.0000
125.3963	0.0000
142.3018	0.0000
142.3020	0.0000
125.3966	0.0000
102.2406	0.0000
102.2402	0.0000
125.3963	0.0000
142.3018	0.0000
142.3020	0.0000
125.3966	0.0000
102.2406	0.0000
102.2402	0.0000
125.3963	0.0000
142.3018	0.0000
142.3020	0.0000
125.3966	0.0000
102.2406	0.0000
102.2402	0.0000
125.3963	0.0000
142.3018	0.0000
142.3020	0.0000
125.3966	0.0000
102.2406	0.0000
102.2402	0.0000
125.3963	0.0000
142.3018	0.0000
142.3020	0.0000
125.3966	0.0000
102.2406	0.0000
77.7595	0.0175
54.6035	0.0653
37.6981	0.1305
37.6982	0.1958
54.6038	0.2436
77.7600	0.2611
77.7595	0.2786
54.6035	0.3264
37.6981	0.3721
37.6982	0.4177
54.6038	0.4655
77.7600	0.4830
77.7595	0.5005
54.6035	0.5196
37.6981	0.5196
37.6982	0.5196
54.6038	0.5387
77.7600	0.5562
77.7595	0.5650
54.6035	0.5650
37.6981	0.5650
37.6982	0.5650
54.6038	0.5650
77.7600	0.5737
77.7595	0.5737
54.6035	0.5737
37.6981	0.5737
37.6982	0.5737
54.6038	0.5737
77.7600	0.5737
77.7595	0.5737
54.6035	0.5737
37.6981	0.5737
37.6982	0.5737
54.6038	0.5737
77.7600	0.5737
77.7595	0.5737
54.6035	0.5737
37.6981	0.5737
37.6982	0.5737
54.6038	0.5737
77.7600	0.5737
77.7595	0.5737
54.6035	0.5737
37.6981	0.5737
37.6982	0.5737
54.6038	0.5737
77.7600	0.5737
55.0003	0.7158
55.0003	0.7869
55.0003	0.9290
55.0003	1.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7743	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
102.9524	0.0000
127.7613	0.0000
146.7743	0.0000
146.7745	0.0000
127.7616	0.0000
102.9528	0.0000
77.0473	0.0221
52.2385	0.0825
33.2255	0.1650
33.2257	0.2475
52.2389	0.3079
77.0477	0.3300
77.0473	0.3521
52.2385	0.3944
33.2255	0.4191
33.2257	0.4439
52.2389	0.4862
77.0477	0.5083
77.0473	0.5260
52.2385	0.5320
33.2255	0.5320
33.2257	0.5320
52.2389	0.5380
77.0477	0.5557
77.0473	0.5557
52.2385	0.5557
33.2255	0.5557
33.2257	0.5557
52.2389	0.5557
77.0477	0.5557
77.0473	0.5557
52.2385	0.5557
33.2255	0.5557
33.2257	0.5557
52.2389	0.5557
77.0477	0.5557
77.0473	0.5557
52.2385	0.5557
33.2255	0.5557
33.2257	0.5557
52.2389	0.5557
77.0477	0.5557
77.0473	0.5557
52.2385	0.5557
33.2255	0.5557
33.2257	0.5557
52.2389	0.5557
77.0477	0.5557
77.0473	0.5557
52.2385	0.5557
33.2255	0.5557
33.2257	0.5557
52.2389	0.5557
77.0477	0.5557
77.0473	0.5557
52.2385	0.5557
33.2255	0.5557
33.2257	0.5557
52.2389	0.5557
77.0477	0.5557
60.0003	0.7038
60.0003	0.7779
60.0003	0.9260
60.0003	1.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0957	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
103.5662	0.0000
129.8557	0.0000
151.0957	0.0000
151.0959	0.0000
129.8561	0.0000
103.5666	0.0000
76.4336	0.0273
50.1441	0.1017
28.9042	0.2034
28.9044	0.3051
50.1444	0.3796
76.4340	0.4068
76.4336	0.4341
50.1441	0.4713
28.9042	0.4713
28.9044	0.4713
50.1444	0.5086
76.4340	0.5358
76.4336	0.5467
50.1441	0.5467
28.9042	0.5467
28.9044	0.5467
50.1444	0.5467
76.4340	0.5576
76.4336	0.5576
50.1441	0.5576
28.9042	0.5576
28.9044	0.5576
50.1444	0.5576
76.4340	0.5576
76.4336	0.5576
50.1441	0.5576
28.9042	0.5576
28.9044	0.5576
50.1444	0.5576
76.4340	0.5576
76.4336	0.5576
50.1441	0.5576
28.9042	0.5576
28.9044	0.5576
50.1444	0.5576
76.4340	0.5576
76.4336	0.5576
50.1441	0.5576
28.9042	0.5576
28.9044	0.5576
50.1444	0.5576
76.4340	0.5576
76.4336	0.5576
50.1441	0.5576
28.9042	0.5576
28.9044	0.5576
50.1444	0.5576
76.4340	0.5576
65.0003	0.7051
65.0003	0.7788
65.0003	0.9263
65.0003	1.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1860	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
104.0760	0.0000
131.6411	0.0000
155.1860	0.0000
155.1862	0.0000
131.6415	0.0000
104.0764	0.0000
75.9238	0.0338
48.3586	0.1263
24.8138	0.2274
24.8141	0.3285
48.3590	0.4209
75.9242	0.4548
75.9238	0.4852
48.3586	0.5130
24.8138	0.5130
24.8141	0.5130
48.3590	0.5407
75.9242	0.5712
75.9238	0.5712
48.3586	0.5712
24.8138	0.5712
24.8141	0.5712
48.3590	0.5712
75.9242	0.5712
75.9238	0.5712
48.3586	0.5712
24.8138	0.5712
24.8141	0.5712
48.3590	0.5712
75.9242	0.5712
75.9238	0.5712
48.3586	0.5712
24.8138	0.5712
24.8141	0.5712
48.3590	0.5712
75.9242	0.5712
75.9238	0.5712
48.3586	0.5712
24.8138	0.5712
24.8141	0.5712
48.3590	0.5712
75.9242	0.5712
75.9238	0.5712
48.3586	0.5712
24.8138	0.5712
24.8141	0.5712
48.3590	0.5712
75.9242	0.5712
75.9238	0.5712
48.3586	0.5712
24.8138	0.5712
24.8141	0.5712
48.3590	0.5712
75.9242	0.5712
70.0003	0.7141
70.0003	0.7856
70.0003	0.9285
70.0003	1.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9096	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
104.4774	0.0000
133.0795	0.0000
158.9096	0.0000
158.9099	0.0000
133.0799	0.0000
104.4778	0.0000
75.5224	0.0481
46.9203	0.1533
21.0902	0.2611
21.0905	0.3689
46.9207	0.4741
75.5228	0.5222
75.5224	0.5366
46.9203	0.5366
21.0902	0.5366
21.0905	0.5366
46.9207	0.5366
75.5228	0.5511
75.5224	0.5511
46.9203	0.5511
21.0902	0.5511
21.0905	0.5511
46.9207	0.5511
75.5228	0.5511
75.5224	0.5511
46.9203	0.5511
21.0902	0.5511
21.0905	0.5511
46.9207	0.5511
75.5228	0.5511
75.5224	0.5511
46.9203	0.5511
21.0902	0.5511
21.0905	0.5511
46.9207	0.5511
75.5228	0.5511
75.5224	0.5511
46.9203	0.5511
21.0902	0.5511
21.0905	0.5511
46.9207	0.5511
75.5228	0.5511
75.5224	0.5511
46.9203	0.5511
21.0902	0.5511
21.0905	0.5511
46.9207	0.5511
75.5228	0.5511
75.5224	0.5511
46.9203	0.5511
21.0902	0.5511
21.0905	0.5511
46.9207	0.5511
75.5228	0.5511
75.0003	0.7007
75.0003	0.7755
75.0003	0.9252

75.0003	1.0000	17.9636	0.5616	45.2175	0.5636	0.0000	0.0000
104.7668	0.0000	17.9639	0.5616	15.7930	0.5636	0.0000	0.0000
134.1360	0.0000	45.8642	0.5616	15.7934	0.5636	0.0000	0.0000
162.0362	0.0000	75.2334	0.5616	45.2179	0.5636	0.0000	0.0000
162.0363	0.0000	75.2330	0.5616	75.0588	0.5636	0.0000	0.0000
134.1364	0.0000	45.8638	0.5616	75.0583	0.5636	0.0000	0.0000
104.7672	0.0000	17.9636	0.5616	45.2175	0.5636	0.0000	0.0000
104.7668	0.0000	17.9639	0.5616	15.7930	0.5636	0.0000	0.0000
134.1360	0.0000	45.8642	0.5616	15.7934	0.5636	0.0000	0.0000
162.0362	0.0000	75.2334	0.5616	45.2179	0.5636	0.0000	0.0000
162.0366	0.0000	75.2330	0.5616	75.0588	0.5636	0.0000	0.0000
134.1364	0.0000	45.8638	0.5616	75.0583	0.5636	0.0000	0.0000
104.7672	0.0000	17.9636	0.5616	45.2175	0.5636	0.0000	0.0000
104.7668	0.0000	17.9639	0.5616	15.7930	0.5636	0.0000	0.0000
134.1360	0.0000	45.8642	0.5616	15.7934	0.5636	0.0000	0.0000
162.0362	0.0000	75.2334	0.5616	45.2179	0.5636	0.0000	0.0000
162.0366	0.0000	80.0003	0.7078	75.0588	0.5636	0.0000	0.0000
134.1364	0.0000	80.0003	0.7808	75.0583	0.5636	0.0000	0.0000
104.7672	0.0000	80.0003	0.9269	45.2175	0.5636	0.0000	0.0000
104.7668	0.0000	80.0003	1.0000	15.7930	0.5636	0.0000	0.0000
134.1360	0.0000	104.9415	0.0000	15.7934	0.5636	0.0000	0.0000
162.0362	0.0000	134.7823	0.0000	45.2179	0.5636	0.0000	0.0000
162.0366	0.0000	164.2068	0.0000	75.0588	0.5636	0.0000	0.0000
134.1364	0.0000	164.2068	0.0000	75.0583	0.5636	0.0000	0.0000
104.7672	0.0000	134.7827	0.0000	45.2175	0.5636	0.0000	0.0000
104.7668	0.0000	104.9419	0.0000	15.7930	0.5636	0.0000	0.0000
134.1360	0.0000	104.9415	0.0000	15.7934	0.5636	0.0000	0.0000
162.0362	0.0000	134.7823	0.0000	45.2179	0.5636	0.0000	0.0000
162.0366	0.0000	164.2068	0.0000	75.0588	0.5636	0.0000	0.0000
134.1364	0.0000	164.2072	0.0000	75.0583	0.5636	0.0000	0.0000
104.7672	0.0000	134.7827	0.0000	45.2175	0.5636	0.0000	0.0000
104.7668	0.0000	104.9419	0.0000	15.7930	0.5636	0.0000	0.0000
134.1360	0.0000	104.9415	0.0000	15.7934	0.5636	0.0000	0.0000
162.0362	0.0000	134.7823	0.0000	45.2179	0.5636	0.0000	0.0000
162.0366	0.0000	164.2068	0.0000	75.0588	0.5636	0.0000	0.0000
134.1364	0.0000	164.2072	0.0000	85.0003	0.7091	0.0000	0.0000
104.7672	0.0000	134.7827	0.0000	85.0003	0.7819	0.0000	0.0000
104.7668	0.0000	104.9419	0.0000	85.0003	0.9273	0.0000	0.0000
134.1360	0.0000	104.9415	0.0000	85.0003	1.0001	0.0000	0.0000
162.0362	0.0000	134.7823	0.0000	0.0000	0.0000	0.0000	0.0000
162.0366	0.0000	164.2068	0.0000	0.0000	0.0000	0.0000	0.0000
134.1364	0.0000	164.2072	0.0000	0.0000	0.0000	0.0000	0.0000
104.7672	0.0000	134.7827	0.0000	0.0000	0.0000	0.0000	0.0000
104.7668	0.0000	104.9419	0.0000	0.0000	0.0000	0.0000	0.0000
134.1360	0.0000	104.9415	0.0000	0.0000	0.0000	0.0000	0.0000
162.0362	0.0000	134.7823	0.0000	0.0000	0.0000	0.0000	0.0000
162.0366	0.0000	164.2068	0.0000	0.0000	0.0000	0.0000	0.0000
134.1364	0.0000	164.2072	0.0000	0.0000	0.0000	0.0000	0.0000
104.7672	0.0000	134.7827	0.0000	0.0000	0.0000	0.0000	0.0000
75.2330	0.0571	104.9419	0.0000	0.0000	0.0000	0.0000	0.0000
45.8638	0.1742	104.9415	0.0000	0.0000	0.0000	0.0000	0.0000
17.9636	0.2808	134.7823	0.0000	0.0000	0.0000	0.0000	0.0000
17.9639	0.3874	164.2068	0.0000	0.0000	0.0000	0.0000	0.0000
45.8642	0.5045	164.2072	0.0000	0.0000	0.0000	0.0000	0.0000
75.2334	0.5616	134.7827	0.0000	0.0000	0.0000	0.0000	0.0000
75.2330	0.5616	104.9419	0.0000	0.0000	0.0000	0.0000	0.0000
45.8638	0.5616	104.9415	0.0000	0.0000	0.0000	0.0000	0.0000
17.9636	0.5616	134.7823	0.0000	0.0000	0.0000	0.0000	0.0000
17.9639	0.5616	164.2068	0.0000	0.0000	0.0000		
45.8642	0.5616	164.2072	0.0000	0.0000	0.0000		
75.2334	0.5616	134.7827	0.0000	0.0000	0.0000		
75.2330	0.5616	104.9419	0.0000	0.0000	0.0000		
45.8638	0.5616	104.9415	0.0000	0.0000	0.0000		
17.9636	0.5616	134.7823	0.0000	0.0000	0.0000		
17.9639	0.5616	164.2068	0.0000	0.0000	0.0000		
45.8642	0.5616	164.2072	0.0000	0.0000	0.0000		
75.2334	0.5616	134.7827	0.0000	0.0000	0.0000		
75.2330	0.5616	104.9419	0.0000	0.0000	0.0000		
45.8638	0.5616	75.0583	0.0573	0.0000	0.0000		
17.9636	0.5616	45.2175	0.1748	0.0000	0.0000		
17.9639	0.5616	15.7930	0.2818	0.0000	0.0000		
45.8642	0.5616	15.7934	0.3888	0.0000	0.0000		
75.2334	0.5616	45.2179	0.5063	0.0000	0.0000		
75.2330	0.5616	75.0588	0.5636	0.0000	0.0000		
45.8638	0.5616	75.0583	0.5636	0.0000	0.0000		
17.9636	0.5616	45.2175	0.5636	0.0000	0.0000		
17.9639	0.5616	15.7930	0.5636	0.0000	0.0000		
45.8642	0.5616	15.7934	0.5636	0.0000	0.0000		
75.2334	0.5616	45.2179	0.5636	0.0000	0.0000		
75.2330	0.5616	75.0588	0.5636	0.0000	0.0000		
45.8638	0.5616	75.0583	0.5636	0.0000	0.0000		

APPENDIX F

HAB.DAT Data File

Obliquity (degrees)	Cum. Prob.										
		0.0000	0.0000	75.0583	0.5636	75.2334	0.5616	133.0799	0.0000	155.1862	0.0000
		0.0000	0.0000	45.2175	0.5636	75.2330	0.5616	104.4778	0.0000	131.6415	0.0000
		0.0000	0.0000	15.7930	0.5636	45.8638	0.5616	104.4774	0.0000	104.0764	0.0000
0.0000	0.0000	104.9415	0.0000	15.7934	0.5636	17.9636	0.5616	133.0795	0.0000	104.0760	0.0000
0.0000	0.0000	134.7823	0.0000	45.2179	0.5636	17.9639	0.5616	158.9096	0.0000	131.6411	0.0000
0.0000	0.0000	164.2068	0.0000	75.0588	0.5636	45.8642	0.5616	158.9099	0.0000	155.1860	0.0000
0.0000	0.0000	164.2068	0.0000	75.0583	0.5636	75.2334	0.5616	133.0799	0.0000	155.1862	0.0000
0.0000	0.0000	134.7827	0.0000	45.2175	0.5636	75.2330	0.5616	104.4778	0.0000	131.6415	0.0000
0.0000	0.0000	104.9419	0.0000	15.7930	0.5636	45.8638	0.5616	75.5224	0.0481	104.0764	0.0000
0.0000	0.0000	104.9415	0.0000	15.7934	0.5636	17.9636	0.5616	46.9203	0.1533	104.0760	0.0000
0.0000	0.0000	134.7823	0.0000	45.2179	0.5636	17.9639	0.5616	21.0902	0.2611	131.6411	0.0000
0.0000	0.0000	164.2068	0.0000	75.0588	0.5636	45.8642	0.5616	21.0905	0.3689	155.1860	0.0000
0.0000	0.0000	164.2072	0.0000	75.0583	0.5636	75.2334	0.5616	46.9207	0.4741	155.1862	0.0000
0.0000	0.0000	134.7827	0.0000	45.2175	0.5636	75.2330	0.5616	75.5228	0.5222	131.6415	0.0000
0.0000	0.0000	104.9419	0.0000	15.7930	0.5636	45.8638	0.5616	75.5224	0.5366	104.0764	0.0000
0.0000	0.0000	104.9415	0.0000	15.7934	0.5636	17.9636	0.5616	46.9203	0.5366	104.0760	0.0000
0.0000	0.0000	134.7823	0.0000	45.2179	0.5636	17.9639	0.5616	21.0902	0.5366	131.6411	0.0000
0.0000	0.0000	164.2068	0.0000	75.0588	0.5636	45.8642	0.5616	21.0905	0.5366	155.1860	0.0000
0.0000	0.0000	164.2072	0.0000	85.0003	0.7091	75.2334	0.5616	46.9207	0.5366	155.1862	0.0000
0.0000	0.0000	134.7827	0.0000	85.0003	0.7819	75.2330	0.5616	75.5228	0.5511	131.6415	0.0000
0.0000	0.0000	104.9419	0.0000	85.0003	0.9273	45.8638	0.5616	75.5224	0.5511	104.0764	0.0000
0.0000	0.0000	104.9415	0.0000	85.0003	1.0001	17.9636	0.5616	46.9203	0.5511	104.0760	0.0000
0.0000	0.0000	134.7823	0.0000	104.7668	0.0000	17.9639	0.5616	21.0902	0.5511	131.6411	0.0000
0.0000	0.0000	164.2068	0.0000	134.1360	0.0000	45.8642	0.5616	21.0905	0.5511	155.1860	0.0000
0.0000	0.0000	164.2072	0.0000	162.0362	0.0000	75.2334	0.5616	46.9207	0.5511	155.1862	0.0000
0.0000	0.0000	134.7827	0.0000	162.0363	0.0000	75.2330	0.5616	75.5228	0.5511	131.6415	0.0000
0.0000	0.0000	104.9419	0.0000	134.1364	0.0000	45.8638	0.5616	75.5224	0.5511	104.0764	0.0000
0.0000	0.0000	104.9415	0.0000	104.7672	0.0000	17.9636	0.5616	46.9203	0.5511	75.9238	0.0338
0.0000	0.0000	134.7823	0.0000	104.7668	0.0000	17.9639	0.5616	21.0902	0.5511	48.3586	0.1263
0.0000	0.0000	164.2068	0.0000	134.1360	0.0000	45.8642	0.5616	21.0905	0.5511	24.8138	0.2274
0.0000	0.0000	164.2072	0.0000	162.0362	0.0000	75.2334	0.5616	46.9207	0.5511	24.8141	0.3285
0.0000	0.0000	134.7827	0.0000	162.0366	0.0000	75.2330	0.5616	75.5228	0.5511	48.3590	0.4209
0.0000	0.0000	104.9419	0.0000	134.1364	0.0000	45.8638	0.5616	75.5224	0.5511	75.9242	0.4548
0.0000	0.0000	104.9415	0.0000	104.7672	0.0000	17.9636	0.5616	46.9203	0.5511	75.9238	0.4852
0.0000	0.0000	134.7823	0.0000	104.7668	0.0000	17.9639	0.5616	21.0902	0.5511	48.3586	0.5130
0.0000	0.0000	164.2068	0.0000	134.1360	0.0000	45.8642	0.5616	21.0905	0.5511	24.8138	0.5130
0.0000	0.0000	164.2072	0.0000	162.0362	0.0000	75.2334	0.5616	46.9207	0.5511	24.8141	0.5130
0.0000	0.0000	134.7827	0.0000	162.0366	0.0000	80.0003	0.7078	75.5228	0.5511	48.3590	0.5407
0.0000	0.0000	104.9419	0.0000	134.1364	0.0000	80.0003	0.7808	75.5224	0.5511	75.9242	0.5712
0.0000	0.0000	104.9415	0.0000	104.7672	0.0000	80.0003	0.9269	46.9203	0.5511	75.9238	0.5712
0.0000	0.0000	134.7823	0.0000	104.7668	0.0000	80.0003	1.0000	21.0902	0.5511	48.3586	0.5712
0.0000	0.0000	164.2068	0.0000	134.1360	0.0000	104.4774	0.0000	21.0905	0.5511	24.8138	0.5712
0.0000	0.0000	164.2072	0.0000	162.0362	0.0000	133.0795	0.0000	46.9207	0.5511	24.8141	0.5712
0.0000	0.0000	134.7827	0.0000	162.0366	0.0000	158.9096	0.0000	75.5228	0.5511	48.3590	0.5712
0.0000	0.0000	104.9419	0.0000	134.1364	0.0000	158.9096	0.0000	75.5224	0.5511	75.9242	0.5712
0.0000	0.0000	104.9415	0.0000	104.7672	0.0000	133.0799	0.0000	46.9203	0.5511	75.9238	0.5712
0.0000	0.0000	134.7823	0.0000	104.7668	0.0000	104.4778	0.0000	21.0902	0.5511	48.3586	0.5712
0.0000	0.0000	164.2068	0.0000	134.1360	0.0000	104.4774	0.0000	21.0905	0.5511	24.8138	0.5712
0.0000	0.0000	164.2072	0.0000	162.0362	0.0000	133.0795	0.0000	46.9207	0.5511	24.8141	0.5712
0.0000	0.0000	134.7827	0.0000	162.0366	0.0000	158.9096	0.0000	75.5228	0.5511	48.3590	0.5712
0.0000	0.0000	104.9419	0.0000	134.1364	0.0000	158.9099	0.0000	75.5224	0.5511	75.9242	0.5712
0.0000	0.0000	75.0583	0.0573	104.7672	0.0000	133.0799	0.0000	46.9203	0.5511	75.9238	0.5712
0.0000	0.0000	45.2175	0.1748	104.7668	0.0000	104.4778	0.0000	21.0902	0.5511	48.3586	0.5712
0.0000	0.0000	15.7930	0.2818	134.1360	0.0000	104.4774	0.0000	21.0905	0.5511	24.8138	0.5712
0.0000	0.0000	15.7934	0.3888	162.0362	0.0000	133.0795	0.0000	46.9207	0.5511	24.8141	0.5712
0.0000	0.0000	45.2179	0.5063	162.0366	0.0000	158.9096	0.0000	75.5228	0.5511	48.3590	0.5712
0.0000	0.0000	75.0588	0.5636	134.1364	0.0000	158.9099	0.0000	75.0003	0.7007	75.9242	0.5712
0.0000	0.0000	75.0583	0.5636	104.7672	0.0000	133.0799	0.0000	75.0003	0.7755	75.9238	0.5712
0.0000	0.0000	45.2175	0.5636	104.7668	0.0000	104.4778	0.0000	75.0003	0.9252	48.3586	0.5712
0.0000	0.0000	15.7930	0.5636	134.1360	0.0000	104.4774	0.0000	75.0003	1.0000	24.8138	0.5712
0.0000	0.0000	15.7934	0.5636	162.0362	0.0000	133.0795	0.0000	104.0760	0.0000	24.8141	0.5712
0.0000	0.0000	45.2179	0.5636	162.0366	0.0000	158.9096	0.0000	131.6411	0.0000	48.3590	0.5712
0.0000	0.0000	75.0588	0.5636	134.1364	0.0000	158.9099	0.0000	155.1860	0.0000	75.9242	0.5712
0.0000	0.0000	75.0583	0.5636	104.7672	0.0000	133.0799	0.0000	155.1860	0.0000	75.9238	0.5712
0.0000	0.0000	45.2175	0.5636	104.7668	0.0000	104.4778	0.0000	131.6415	0.0000	48.3586	0.5712
0.0000	0.0000	15.7930	0.5636	134.1360	0.0000	104.4774	0.0000	104.0764	0.0000	24.8138	0.5712
0.0000	0.0000	15.7934	0.5636	162.0362	0.0000	133.0795	0.0000	104.0760	0.0000	24.8141	0.5712
0.0000	0.0000	45.2179	0.5636	162.0366	0.0000	158.9096	0.0000	131.6411	0.0000	48.3590	0.5712
0.0000	0.0000	75.0588	0.5636	134.1364	0.0000	158.9099	0.0000	155.1860	0.0000	75.9242	0.5712
0.0000	0.0000	75.0583	0.5636	104.7672	0.0000	133.0799	0.0000	155.1862	0.0000	75.9238	0.5712
0.0000	0.0000	45.2175	0.5636	75.2330	0.0571	104.4778	0.0000	131.6415	0.0000	48.3586	0.5712
0.0000	0.0000	15.7930	0.5636	45.8638	0.1742	104.4774	0.0000	104.0764	0.0000	24.8138	0.5712
0.0000	0.0000	15.7934	0.5636	17.9636	0.2808	133.0795	0.0000	104.0760	0.0000	24.8141	0.5712
0.0000	0.0000	45.2179	0.5636	17.9639	0.3874	158.9096	0.0000	131.6411	0.0000	48.3590	0.5712
0.0000	0.0000	75.0588	0.5636	45.8642	0.5045	158.9099	0.0000	155.1860	0.0000	75.9242	0.5712
0.0000	0.0000	75.0583	0.5636	75.2334	0.5616	133.0799	0.0000	155.1862	0.0000	70.0003	0.7141
0.0000	0.0000	45.2175	0.5636	75.2330	0.5616	104.4778	0.0000	131.6415	0.0000	70.0003	0.7856
0.0000	0.0000	15.7930	0.5636	45.8638	0.5616	104.4774	0.0000	104.0764	0.0000	70.0003	0.9285
0.0000	0.0000	15.7934	0.5636	17.9636	0.5616	133.0795	0.0000	104.0760	0.0000	70.0003	1.0000
0.0000	0.0000	45.2179	0.5636	17.9639	0.5616	158.9096	0.0000	131.6411	0.0000	103.5662	0.0000
0.0000	0.0000	75.0588	0.5636	45.8642	0.5616	158.9099	0.0000	155.1860	0.0000	129.8557	0.0000

151.0957	0.0000	76.4340	0.5576	52.2389	0.5380	142.3020	0.0000	137.7267	0.0000	120.0000	0.0000
151.0957	0.0000	76.4336	0.5576	77.0477	0.5557	125.3966	0.0000	137.7269	0.0000	133.0797	0.0000
129.8561	0.0000	50.1441	0.5576	77.0473	0.5557	102.2406	0.0000	122.7981	0.0000	133.0799	0.0000
103.5666	0.0000	28.9042	0.5576	52.2385	0.5557	77.7595	0.0175	101.4359	0.0000	120.0004	0.0000
103.5662	0.0000	28.9044	0.5576	33.2255	0.5557	54.6035	0.0653	101.4355	0.0000	100.5456	0.0000
129.8557	0.0000	50.1444	0.5576	33.2257	0.5557	37.6981	0.1305	122.7978	0.0000	100.5452	0.0000
151.0957	0.0000	76.4340	0.5576	52.2389	0.5557	37.6982	0.1958	137.7267	0.0000	120.0000	0.0000
151.0959	0.0000	76.4336	0.5576	77.0477	0.5557	54.6038	0.2436	137.7269	0.0000	133.0797	0.0000
129.8561	0.0000	50.1441	0.5576	77.0473	0.5557	77.7600	0.2611	122.7981	0.0000	133.0799	0.0000
103.5666	0.0000	28.9042	0.5576	52.2385	0.5557	77.7595	0.2786	101.4359	0.0000	120.0004	0.0000
103.5662	0.0000	28.9044	0.5576	33.2255	0.5557	54.6035	0.3264	101.4355	0.0000	100.5456	0.0000
129.8557	0.0000	50.1444	0.5576	33.2257	0.5557	37.6981	0.3721	122.7978	0.0000	100.5452	0.0000
151.0957	0.0000	76.4340	0.5576	52.2389	0.5557	37.6982	0.4177	137.7267	0.0000	120.0000	0.0000
151.0959	0.0000	65.0003	0.7051	77.0477	0.5557	54.6038	0.4655	137.7269	0.0000	133.0797	0.0000
129.8561	0.0000	65.0003	0.7788	77.0473	0.5557	77.7600	0.4830	122.7981	0.0000	133.0799	0.0000
103.5666	0.0000	65.0003	0.9263	52.2385	0.5557	77.7595	0.5005	101.4359	0.0000	120.0004	0.0000
103.5662	0.0000	65.0003	1.0000	33.2255	,0.5557	54.6035	0.5196	101.4355	0.0000	100.5456	0.0000
129.8557	0.0000	102.9524	0.0000	33.2257	0.5557	37.6981	0.5196	122.7978	0.0000	100.5452	0.0000
151.0957	0.0000	127.7613	0.0000	52.2389	0.5557	37.6982	0.5196	137.7267	0.0000	120.0000	0.0000
151.0959	0.0000	146.7743	0.0000	77.0477	0.5557	54.6038	0.5387	137.7269	0.0000	133.0797	0.0000
129.8561	0.0000	146.7743	0.0000	77.0473	0.5557	77.7600	0.5562	122.7981	0.0000	133.0799	0.0000
103.5666	0.0000	127.7616	0.0000	52.2385	0.5557	77.7595	0.5650	101.4359	0.0000	120.0004	0.0000
103.5662	0.0000	102.9528	0.0000	33.2255	0.5557	54.6035	0.5650	78.5642	0.0146	100.5456	0.0000
129.8557	0.0000	102.9524	0.0000	33.2257	0.5557	37.6981	0.5650	57.2020	0.0545	100.5452	0.0000
151.0957	0.0000	127.7613	0.0000	52.2389	0.5557	37.6982	0.5650	42.2731	0.1091	120.0000	0.0000
151.0959	0.0000	146.7743	0.0000	77.0477	0.5557	54.6038	0.5650	42.2733	0.1636	133.0797	0.0000
129.8561	0.0000	146.7745	0.0000	77.0473	0.5557	77.7600	0.5737	57.2023	0.2035	133.0799	0.0000
103.5666	0.0000	127.7616	0.0000	52.2385	0.5557	77.7595	0.5737	78.5646	0.2181	120.0004	0.0000
103.5662	0.0000	102.9528	0.0000	33.2255	0.5557	54.6035	0.5737	78.5642	0.2327	100.5456	0.0000
129.8557	0.0000	102.9524	0.0000	33.2257	0.5557	37.6981	0.5737	57.2020	0.2727	100.5452	0.0000
151.0957	0.0000	127.7613	0.0000	52.2389	0.5557	37.6982	0.5737	42.2731	0.3272	120.0000	0.0000
151.0959	0.0000	146.7743	0.0000	77.0477	0.5557	54.6038	0.5737	42.2733	0.3817	133.0797	0.0000
129.8561	0.0000	146.7745	0.0000	60.0003	0.7038	77.7600	0.5737	57.2023	0.4216	133.0799	0.0000
103.5666	0.0000	127.7616	0.0000	60.0003	0.7779	77.7595	0.5737	78.5646	0.4363	120.0004	0.0000
103.5662	0.0000	102.9528	0.0000	60.0003	0.9260	54.6035	0.5737	78.5642	0.4509	100.5456	0.0000
129.8557	0.0000	102.9524	0.0000	60.0003	1.0000	37.6981	0.5737	57.2020	0.4788	100.5452	0.0000
151.0957	0.0000	127.7613	0.0000	102.2402	0.0000	37.6982	0.5737	42.2731	0.4788	120.0000	0.0000
151.0959	0.0000	146.7743	0.0000	125.3963	0.0000	54.6038	0.5737	42.2733	0.4788	133.0797	0.0000
129.8561	0.0000	146.7745	0.0000	142.3018	0.0000	77.7600	0.5737	57.2023	0.5068	133.0799	0.0000
103.5666	0.0000	127.7616	0.0000	142.3018	0.0000	77.7595	0.5737	78.5646	0.5214	120.0004	0.0000
103.5662	0.0000	102.9528	0.0000	125.3966	0.0000	54.6035	0.5737	78.5642	0.5360	100.5456	0.0000
129.8557	0.0000	102.9524	0.0000	102.2406	0.0000	37.6981	0.5737	57.2020	0.5400	79.4545	0.0124
151.0957	0.0000	127.7613	0.0000	102.2402	0.0000	37.6982	0.5737	42.2731	0.5400	59.9997	0.0464
151.0959	0.0000	146.7743	0.0000	125.3963	0.0000	54.6038	0.5737	42.2733	0.5400	46.9201	0.0928
129.8561	0.0000	146.7745	0.0000	142.3018	0.0000	77.7600	0.5737	57.2023	0.5440	46.9203	0.1392
103.5666	0.0000	127.7616	0.0000	142.3020	0.0000	77.7595	0.5737	78.5646	0.5586	60.0000	0.1732
76.4336	0.0273	102.9528	0.0000	125.3966	0.0000	54.6035	0.5737	78.5642	0.5659	79.4549	0.1857
50.1441	0.1017	102.9524	0.0000	102.2406	0.0000	37.6981	0.5737	57.2020	0.5659	79.4545	0.1981
28.9042	0.2034	127.7613	0.0000	102.2402	0.0000	37.6982	0.5737	42.2731	0.5659	59.9997	0.2321
28.9044	0.3051	146.7743	0.0000	125.3963	0.0000	54.6038	0.5737	42.2733	0.5659	46.9201	0.2785
50.1444	0.3796	146.7745	0.0000	142.3018	0.0000	77.7600	0.5737	57.2023	0.5659	46.9203	0.3249
76.4340	0.4068	127.7616	0.0000	142.3020	0.0000	55.0003	0.7158	78.5646	0.5732	60.0000	0.3589
76.4336	0.4341	102.9528	0.0000	125.3966	0.0000	55.0003	0.7869	78.5642	0.5732	79.4549	0.3713
50.1441	0.4713	102.9524	0.0000	102.2406	0.0000	55.0003	0.9290	57.2020	0.5732	79.4545	0.3837
28.9042	0.4713	127.7613	0.0000	102.2402	0.0000	55.0003	1.0000	42.2731	0.5732	59.9997	0.4143
28.9044	0.4713	146.7743	0.0000	125.3963	0.0000	101.4355	0.0000	42.2733	0.5732	46.9201	0.4282
50.1444	0.5086	146.7745	0.0000	142.3018	0.0000	122.7978	0.0000	57.2023	0.5732	46.9203	0.4422
76.4340	0.5358	127.7616	0.0000	142.3020	0.0000	137.7267	0.0000	78.5646	0.5732	60.0000	0.4727
76.4336	0.5467	102.9528	0.0000	125.3966	0.0000	137.7267	0.0000	78.5642	0.5732	79.4549	0.4852
50.1441	0.5467	102.9524	0.0000	102.2406	0.0000	122.7981	0.0000	57.2020	0.5732	79.4545	0.4976
28.9042	0.5467	127.7613	0.0000	102.2402	0.0000	101.4359	0.0000	42.2731	0.5732	59.9997	0.5112
28.9044	0.5467	146.7743	0.0000	125.3963	0.0000	101.4355	0.0000	42.2733	0.5732	46.9201	0.5112
50.1444	0.5467	146.7745	0.0000	142.3018	0.0000	122.7978	0.0000	57.2023	0.5732	46.9203	0.5112
76.4340	0.5576	127.7616	0.0000	142.3020	0.0000	137.7267	0.0000	78.5646	0.5732	60.0000	0.5248
76.4336	0.5576	102.9528	0.0000	125.3966	0.0000	137.7269	0.0000	78.5642	0.5732	79.4549	0.5372
50.1441	0.5576	77.0473	0.0221	102.2406	0.0000	122.7981	0.0000	57.2020	0.5732	79.4545	0.5472
28.9042	0.5576	52.2385	0.0825	102.2402	0.0000	101.4359	0.0000	42.2731	0.5732	59.9997	0.5472
28.9044	0.5576	33.2255	0.1650	125.3963	0.0000	101.4355	0.0000	42.2733	0.5732	46.9201	0.5472
50.1444	0.5576	33.2257	0.2475	142.3018	0.0000	122.7978	0.0000	57.2023	0.5732	46.9203	0.5472
76.4340	0.5576	52.2389	0.3079	142.3020	0.0000	137.7267	0.0000	78.5646	0.5732	60.0000	0.5472
76.4336	0.5576	77.0477	0.3300	125.3966	0.0000	137.7269	0.0000	50.0002	0.7155	79.4549	0.5571
50.1441	0.5576	77.0473	0.3521	102.2406	0.0000	122.7981	0.0000	50.0002	0.7866	79.4545	0.5621
28.9042	0.5576	52.2385	0.3944	102.2402	0.0000	101.4359	0.0000	50.0002	0.9289	59.9997	0.5621
28.9044	0.5576	33.2255	0.4191	125.3963	0.0000	101.4355	0.0000	50.0002	1.0000	46.9201	0.5621
50.1444	0.5576	33.2257	0.4439	142.3018	0.0000	122.7978	0.0000	100.5452	0.0000	46.9203	0.5621
76.4340	0.5576	52.2389	0.4862	142.3020	0.0000	137.7267	0.0000	120.0000	0.0000	60.0000	0.5621
76.4336	0.5576	77.0477	0.5083	125.3966	0.0000	137.7269	0.0000	133.0797	0.0000	79.4549	0.5671
50.1441	0.5576	77.0473	0.5260	102.2406	0.0000	122.7981	0.0000	133.0797	0.0000	79.4545	0.5671
28.9042	0.5576	52.2385	0.5320	102.2402	0.0000	101.4359	0.0000	120.0004	0.0000	59.9997	0.5671
28.9044	0.5576	33.2255	0.5320	125.3963	0.0000	101.4355	0.0000	100.5456	0.0000	46.9201	0.5671
50.1444	0.5576	33.2257	0.5320	142.3018	0.0000	122.7978	0.0000	100.5452	0.0000	46.9203	0.5671

60.0000	0.5671	51.6190	0.4745	56.3556	0.0635	110.7048	0.0000	96.2796	0.0000	65.9069	0.5369
79.4549	0.5671	62.9660	0.4945	56.3557	0.0952	118.8793	0.0000	107.3877	0.0000	72.6123	0.5419
79.4545	0.5671	80.4236	0.5049	66.0726	0.1184	118.8794	0.0000	114.0931	0.0000	83.7205	0.5479
59.9997	0.5671	80.4232	0.5154	81.4629	0.1269	110.7051	0.0000	114.0932	0.0000	25.0002	0.6986
46.9201	0.5671	62.9657	0.5239	81.4625	0.1354	97.4358	0.0000	107.3880	0.0000	25.0002	0.7740
46.9203	0.5671	51.6188	0.5239	66.0722	0.1587	97.4354	0.0000	96.2800	0.0000	25.0002	0.9246
60.0000	0.5671	51.6190	0.5239	56.3556	0.1904	110.7048	0.0000	96.2796	0.0000	25.0002	1.0000
79.4549	0.5671	62.9660	0.5325	56.3557	0.2221	118.8793	0.0000	107.3877	0.0000	95.0784	0.0000
45.0002	0.7114	80.4236	0.5429	66.0726	0.2454	118.8794	0.0000	114.0931	0.0000	103.9954	0.0000
45.0002	0.7835	80.4232	0.5502	81.4629	0.2539	110.7051	0.0000	114.0932	0.0000	109.2912	0.0000
45.0002	0.9278	62.9657	0.5502	81.4625	0.2624	97.4358	0.0000	107.3880	0.0000	109.2912	0.0000
45.0002	1.0000	51.6188	0.5502	66.0722	0.2856	97.4354	0.0000	96.2800	0.0000	103.9957	0.0000
99.5765	0.0000	51.6190	0.5502	56.3556	0.3173	110.7048	0.0000	96.2796	0.0000	95.0788	0.0000
117.0340	0.0000	62.9660	0.5502	56.3557	0.3491	118.8793	0.0000	107.3877	0.0000	95.0784	0.0000
128.3810	0.0000	80.4236	0.5575	66.0726	0.3723	118.8794	0.0000	114.0931	0.0000	103.9954	0.0000
128.3810	0.0000	80.4232	0.5596	81.4629	0.3808	110.7051	0.0000	114.0932	0.0000	109.2912	0.0000
117.0344	0.0000	62.9657	0.5596	81.4625	0.3893	97.4358	0.0000	107.3880	0.0000	109.2913	0.0000
99.5769	0.0000	51.6188	0.5596	66.0722	0.4125	82.5643	0.0072	96.2800	0.0000	103.9957	0.0000
99.5765	0.0000	51.6190	0.5596	56.3556	0.4284	69.2949	0.0271	96.2796	0.0000	95.0788	0.0000
117.0340	0.0000	62.9660	0.5596	56.3557	0.4443	61.1206	0.0541	107.3877	0.0000	95.0784	0.0000
128.3810	0.0000	80.4236	0.5617	66.0726	0.4675	61.1207	0.0812	114.0931	0.0000	103.9954	0.0000
128.3811	0.0000	80.4232	0.5617	81.4629	0.4760	69.2952	0.1010	114.0932	0.0000	109.2912	0.0000
117.0344	0.0000	62.9657	0.5617	81.4625	0.4845	82.5647	0.1083	107.3880	0.0000	109.2913	0.0000
99.5769	0.0000	51.6188	0.5617	66.0722	0.4984	82.5643	0.1155	96.2800	0.0000	103.9957	0.0000
99.5765	0.0000	51.6190	0.5617	56.3556	0.4984	69.2949	0.1353	96.2796	0.0000	95.0788	0.0000
117.0340	0.0000	62.9660	0.5617	56.3557	0.4984	61.1206	0.1624	107.3877	0.0000	95.0784	0.0000
128.3810	0.0000	80.4236	0.5669	66.0726	0.5124	61.1207	0.1895	114.0931	0.0000	103.9954	0.0000
128.3811	0.0000	40.0002	0.7113	81.4629	0.5209	69.2952	0.2093	114.0932	0.0000	109.2912	0.0000
117.0344	0.0000	40.0002	0.7835	81.4625	0.5294	82.5647	0.2165	107.3880	0.0000	109.2913	0.0000
99.5769	0.0000	40.0002	0.9278	66.0722	0.5363	82.5643	0.2238	96.2800	0.0000	103.9957	0.0000
99.5765	0.0000	40.0002	1.0000	56.3556	0.5363	69.2949	0.2436	96.2796	0.0000	95.0788	0.0000
117.0340	0.0000	98.5372	0.0000	56.3557	0.5363	61.1206	0.2706	107.3877	0.0000	95.0784	0.0000
128.3810	0.0000	113.9275	0.0000	66.0726	0.5433	61.1207	0.2977	114.0931	0.0000	103.9954	0.0000
128.3811	0.0000	123.6443	0.0000	81.4629	0.5518	69.2952	0.3175	114.0932	0.0000	109.2912	0.0000
117.0344	0.0000	123.6443	0.0000	81.4625	0.5603	82.5647	0.3248	107.3880	0.0000	109.2913	0.0000
99.5769	0.0000	113.9278	0.0000	66.0722	0.5603	82.5643	0.3320	96.2800	0.0000	103.9957	0.0000
99.5765	0.0000	98.5376	0.0000	56.3556	0.5603	69.2949	0.3518	83.7201	0.0061	95.0788	0.0000
117.0340	0.0000	98.5372	0.0000	56.3557	0.5603	61.1206	0.3789	72.6120	0.0226	95.0784	0.0000
128.3810	0.0000	113.9275	0.0000	66.0726	0.5603	61.1207	0.4060	65.9067	0.0452	103.9954	0.0000
128.3811	0.0000	123.6443	0.0000	81.4629	0.5688	69.2952	0.4258	65.9069	0.0678	109.2912	0.0000
117.0344	0.0000	123.6444	0.0000	81.4625	0.5731	82.5647	0.4330	72.6123	0.0844	109.2913	0.0000
99.5769	0.0000	113.9278	0.0000	66.0722	0.5731	82.5643	0.4403	83.7205	0.0904	103.9957	0.0000
99.5765	0.0000	98.5376	0.0000	56.3556	0.5731	69.2949	0.4601	83.7201	0.0965	95.0788	0.0000
117.0340	0.0000	98.5372	0.0000	56.3557	0.5731	61.1206	0.4601	72.6120	0.1130	95.0784	0.0000
128.3810	0.0000	113.9275	0.0000	66.0726	0.5731	61.1207	0.4601	65.9067	0.1356	103.9954	0.0000
128.3811	0.0000	123.6443	0.0000	81.4629	0.5773	69.2952	0.4799	65.9069	0.1582	109.2912	0.0000
117.0344	0.0000	123.6444	0.0000	35.0002	0.7182	82.5647	0.4872	72.6123	0.1748	109.2913	0.0000
99.5769	0.0000	113.9278	0.0000	35.0002	0.7887	82.5643	0.4944	83.7205	0.1808	103.9957	0.0000
99.5765	0.0000	98.5376	0.0000	35.0002	0.9296	69.2949	0.5063	83.7201	0.1869	95.0788	0.0000
117.0340	0.0000	98.5372	0.0000	35.0002	1.0000	61.1206	0.5063	72.6120	0.2034	95.0784	0.0000
128.3810	0.0000	113.9275	0.0000	97.4354	0.0000	61.1207	0.5063	65.9067	0.2260	103.9954	0.0000
128.3811	0.0000	123.6443	0.0000	110.7048	0.0000	69.2952	0.5182	65.9069	0.2486	109.2912	0.0000
117.0344	0.0000	123.6444	0.0000	118.8793	0.0000	82.5647	0.5254	72.6123	0.2652	109.2913	0.0000
99.5769	0.0000	113.9278	0.0000	118.8793	0.0000	82.5643	0.5327	83.7205	0.2712	103.9957	0.0000
99.5765	0.0000	98.5376	0.0000	110.7051	0.0000	69.2949	0.5386	83.7201	0.2773	95.0788	0.0000
117.0340	0.0000	98.5372	0.0000	97.4358	0.0000	61.1206	0.5386	72.6120	0.2938	84.9212	0.0050
128.3810	0.0000	113.9275	0.0000	97.4354	0.0000	61.1207	0.5386	65.9067	0.3164	76.0042	0.0185
128.3811	0.0000	123.6443	0.0000	110.7048	0.0000	69.2952	0.5446	65.9069	0.3390	70.7087	0.0370
117.0344	0.0000	123.6444	0.0000	118.8793	0.0000	82.5647	0.5518	72.6123	0.3556	70.7088	0.0555
99.5769	0.0000	113.9278	0.0000	118.8794	0.0000	82.5643	0.5591	83.7205	0.3616	76.0046	0.0690
80.4232	0.0104	98.5376	0.0000	110.7051	0.0000	69.2949	0.5591	83.7201	0.3677	84.9216	0.0740
62.9657	0.0390	98.5372	0.0000	97.4358	0.0000	61.1206	0.5591	72.6120	0.3842	84.9212	0.0789
51.6188	0.0779	113.9275	0.0000	97.4354	0.0000	61.1207	0.5591	65.9067	0.4068	76.0042	0.0925
51.6190	0.1169	123.6443	0.0000	110.7048	0.0000	69.2952	0.5591	65.9069	0.4294	70.7087	0.1109
62.9660	0.1454	123.6444	0.0000	118.8793	0.0000	82.5647	0.5663	72.6123	0.4460	70.7088	0.1294
80.4236	0.1558	113.9278	0.0000	118.8794	0.0000	30.0002	0.7121	83.7205	0.4520	76.0046	0.1430
80.4232	0.1663	98.5376	0.0000	110.7051	0.0000	30.0002	0.7849	83.7201	0.4581	84.9216	0.1479
62.9657	0.1948	98.5372	0.0000	97.4358	0.0000	30.0002	0.9307	72.6120	0.4730	84.9212	0.1529
51.6188	0.2338	113.9275	0.0000	97.4354	0.0000	30.0002	1.0036	65.9067	0.4730	76.0042	0.1664
51.6190	0.2727	123.6443	0.0000	110.7048	0.0000	96.2796	0.0000	65.9069	0.4730	70.7087	0.1849
62.9660	0.3012	123.6444	0.0000	118.8793	0.0000	107.3877	0.0000	72.6123	0.4879	70.7088	0.2034
80.4236	0.3117	113.9278	0.0000	118.8794	0.0000	114.0931	0.0000	83.7205	0.4939	76.0046	0.2169
80.4232	0.3221	98.5376	0.0000	110.7051	0.0000	114.0932	0.0000	83.7201	0.5000	84.9216	0.2219
62.9657	0.3506	98.5372	0.0000	97.4358	0.0000	107.3880	0.0000	72.6120	0.5099	84.9212	0.2268
51.6188	0.3779	113.9275	0.0000	97.4354	0.0000	96.2800	0.0000	65.9067	0.5099	76.0042	0.2404
51.6190	0.4052	123.6443	0.0000	110.7048	0.0000	96.2796	0.0000	65.9069	0.5099	70.7087	0.2589
62.9660	0.4337	123.6444	0.0000	118.8793	0.0000	107.3877	0.0000	72.6123	0.5198	70.7088	0.2774
80.4236	0.4441	113.9278	0.0000	118.8794	0.0000	114.0931	0.0000	83.7205	0.5259	76.0046	0.2909
80.4232	0.4546	98.5376	0.0000	110.7051	0.0000	114.0932	0.0000	83.7201	0.5319	84.9216	0.2959
62.9657	0.4745	81.4625	0.0085	97.4358	0.0000	107.3880	0.0000	72.6120	0.5369	84.9212	0.3008
51.6188	0.4745	66.0722	0.0317	97.4354	0.0000	96.2800	0.0000	65.9067	0.5369	76.0042	0.3143

70.7087	0.3328	79.4544	0.0748	92.5758	0.0000	91.2928	0.0000	5.0001	0.8718	89.9997	0.0000
70.7088	0.3513	75.5222	0.0898	97.0530	0.0000	91.2924	0.0000	5.0001	1.0000	89.9997	0.0000
76.0046	0.3649	75.5223	0.1048	99.6561	0.0000	93.5333	0.0000	89.9999	0.0000	89.9999	0.0000
84.9216	0.3698	79.4547	0.1157	99.6562	0.0000	94.8294	0.0000	90.0000	0.0000	90.0000	0.0000
84.9212	0.3748	86.1592	0.1197	97.0533	0.0000	94.8295	0.0000	90.0001	0.0000	90.0001	0.0000
76.0042	0.3883	86.1588	0.1238	92.5762	0.0000	93.5336	0.0000	90.0003	0.0000	89.9997	0.0000
70.7087	0.4050	79.4544	0.1347	92.5758	0.0000	91.2928	0.0000	90.0003	0.0000	89.9997	0.0000
70.7088	0.4216	75.5222	0.1497	97.0530	0.0000	91.2924	0.0000	90.0003	0.0000	89.9997	0.0000
76.0046	0.4351	75.5223	0.1646	99.6561	0.0000	93.5333	0.0000	89.9999	0.0000	89.9999	0.0000
84.9216	0.4401	79.4547	0.1756	99.6562	0.0000	94.8294	0.0000	90.0000	0.0000	90.0000	0.0000
84.9212	0.4450	86.1592	0.1796	97.0533	0.0000	94.8295	0.0000	90.0001	0.0000	90.0001	0.0000
76.0042	0.4586	86.1588	0.1836	92.5762	0.0000	93.5336	0.0000	90.0003	0.0000	89.9997	0.0000
70.7087	0.4660	79.4544	0.1946	87.4238	0.0032	91.2928	0.0000	90.0003	0.0000	89.9997	0.0000
70.7088	0.4734	75.5222	0.2096	82.9467	0.0118	91.2924	0.0000	90.0003	0.0000	89.9997	0.0000
76.0046	0.4869	75.5223	0.2245	80.3438	0.0236	93.5333	0.0000	89.9999	0.0000	89.9999	0.0000
84.9216	0.4919	79.4547	0.2355	80.3439	0.0353	94.8294	0.0000	90.0000	0.0000	90.0000	0.0000
84.9212	0.4968	86.1592	0.2395	82.9470	0.0440	94.8295	0.0000	90.0001	0.0000	90.0001	0.0000
76.0042	0.5090	86.1588	0.2435	87.4242	0.0471	93.5336	0.0000	90.0003	0.0000	0.0003	0.3333
70.7087	0.5090	79.4544	0.2545	87.4238	0.0503	91.2928	0.0000	90.0003	0.0000	0.0003	0.5000
70.7088	0.5090	75.5222	0.2694	82.9467	0.0589	91.2924	0.0000	90.0003	0.0000	0.0003	0.8333
76.0046	0.5212	75.5223	0.2844	80.3438	0.0707	93.5333	0.0000	89.9999	0.0000	0.0003	1.0000
84.9216	0.5261	79.4547	0.2954	80.3439	0.0824	94.8294	0.0000	90.0000	0.0000	88.7073	0.0019
20.0001	0.6841	86.1592	0.2994	82.9470	0.0911	94.8295	0.0000	90.0001	0.0000	86.4667	0.0072
20.0001	0.7631	86.1588	0.3034	87.4242	0.0942	93.5336	0.0000	90.0003	0.0000	85.1709	0.0144
20.0001	0.9210	79.4544	0.3143	87.4238	0.0974	91.2928	0.0000	90.0003	0.0000	85.1710	0.0216
20.0001	1.0000	75.5222	0.3293	82.9467	0.1060	91.2924	0.0000	90.0003	0.0000	86.4670	0.0269
93.8408	0.0000	75.5223	0.3443	80.3438	0.1178	93.5333	0.0000	89.9999	0.0000	88.7077	0.0288
100.5453	0.0000	79.4547	0.3552	80.3439	0.1296	94.8294	0.0000	90.0000	0.0000	88.7073	0.0308
104.4777	0.0000	86.1592	0.3592	82.9470	0.1382	94.8295	0.0000	90.0001	0.0000	86.4667	0.0361
104.4777	0.0000	86.1588	0.3632	87.4242	0.1413	93.5336	0.0000	90.0003	0.0000	85.1709	0.0433
100.5456	0.0000	79.4544	0.3742	87.4238	0.1445	91.2928	0.0000	90.0003	0.0000	85.1710	0.0505
93.8413	0.0000	75.5222	0.3892	82.9467	0.1531	88.7072	0.0019	90.0003	0.0000	86.4670	0.0558
93.8408	0.0000	75.5223	0.4041	80.3438	0.1649	86.4664	0.0072	89.9999	0.0000	88.7077	0.0577
100.5453	0.0000	79.4547	0.4151	80.3439	0.1767	85.1705	0.0144	90.0000	0.0000	88.7073	0.0596
104.4777	0.0000	86.1592	0.4191	82.9470	0.1853	85.1706	0.0216	90.0001	0.0000	86.4667	0.0649
104.4778	0.0000	86.1588	0.4231	87.4242	0.1884	86.4667	0.0269	90.0003	0.0000	85.1709	0.0721
100.5456	0.0000	79.4544	0.4341	87.4238	0.1916	88.7076	0.0289	90.0003	0.0000	85.1710	0.0793
93.8413	0.0000	75.5222	0.4490	82.9467	0.2002	88.7072	0.0308	90.0003	0.0000	86.4670	0.0846
93.8408	0.0000	75.5223	0.4640	80.3438	0.2120	86.4664	0.0361	89.9999	0.0000	88.7077	0.0865
100.5453	0.0000	79.4547	0.4750	80.3439	0.2238	85.1705	0.0433	90.0000	0.0000	88.7073	0.0885
104.4777	0.0000	86.1592	0.4790	82.9470	0.2324	85.1706	0.0505	90.0001	0.0000	86.4667	0.0938
104.4778	0.0000	15.0001	0.6527	87.4242	0.2356	86.4667	0.0558	90.0003	0.0000	85.1709	0.1010
100.5456	0.0000	15.0001	0.7395	87.4238	0.2387	88.7076	0.0577	90.0003	0.0000	85.1710	0.1082
93.8413	0.0000	15.0001	0.9132	82.9467	0.2473	88.7072	0.0596	90.0003	0.0000	86.4670	0.1135
93.8408	0.0000	15.0001	1.0000	80.3438	0.2591	86.4664	0.0649	89.9999	0.0000	88.7077	0.1154
100.5453	0.0000	92.5758	0.0000	80.3439	0.2709	85.1705	0.0721	90.0000	0.0000	88.7073	0.1173
104.4777	0.0000	97.0530	0.0000	82.9470	0.2795	85.1706	0.0794	90.0001	0.0000	86.4667	0.1226
104.4778	0.0000	99.6561	0.0000	87.4242	0.2827	86.4667	0.0846	90.0003	0.0000	85.1709	0.1298
100.5456	0.0000	99.6562	0.0000	87.4238	0.2858	88.7076	0.0866	90.0003	0.0000	85.1710	0.1370
93.8413	0.0000	97.0533	0.0000	82.9467	0.2944	88.7072	0.0885	90.0003	0.0000	86.4670	0.1423
93.8408	0.0000	92.5762	0.0000	80.3438	0.3062	86.4664	0.0938	89.9997	0.0000	88.7077	0.1442
100.5453	0.0000	92.5758	0.0000	80.3439	0.3180	85.1705	0.1010	89.9997	0.0000	88.7073	0.1462
104.4777	0.0000	97.0530	0.0000	82.9470	0.3266	85.1706	0.1082	89.9997	0.0000	86.4667	0.1514
104.4778	0.0000	99.6561	0.0000	87.4242	0.3298	86.4667	0.1135	89.9999	0.0000	85.1709	0.1587
100.5456	0.0000	99.6562	0.0000	87.4238	0.3329	88.7076	0.1154	90.0000	0.0000	85.1710	0.1659
93.8413	0.0000	97.0533	0.0000	82.9467	0.3416	88.7072	0.1174	90.0001	0.0000	86.4670	0.1712
93.8408	0.0000	92.5762	0.0000	80.3438	0.3533	86.4664	0.1226	89.9997	0.0000	88.7077	0.1731
100.5453	0.0000	92.5758	0.0000	80.3439	0.3651	85.1705	0.1298	89.9997	0.0000	88.7073	0.1750
104.4777	0.0000	97.0530	0.0000	82.9470	0.3737	85.1706	0.1371	89.9997	0.0000	86.4667	0.1803
104.4778	0.0000	99.6561	0.0000	87.4242	0.3769	86.4667	0.1423	89.9999	0.0000	85.1709	0.1875
100.5456	0.0000	99.6562	0.0000	10.0001	0.5846	88.7076	0.1443	90.0000	0.0000	85.1710	0.1947
93.8413	0.0000	97.0533	0.0000	10.0001	0.6884	88.7072	0.1462	90.0001	0.0000	86.4670	0.2000
93.8408	0.0000	92.5762	0.0000	10.0001	0.8961	86.4664	0.1515	89.9997	0.0000	88.7077	0.2019
100.5453	0.0000	92.5758	0.0000	10.0001	1.0000	85.1705	0.1587	89.9997	0.0000	88.7073	0.2039
104.4777	0.0000	97.0530	0.0000	91.2924	0.0000	85.1706	0.1659	89.9997	0.0000	86.4667	0.2091
104.4778	0.0000	99.6561	0.0000	93.5333	0.0000	86.4667	0.1712	89.9999	0.0000	85.1709	0.2164
100.5456	0.0000	99.6562	0.0000	94.8294	0.0000	88.7076	0.1731	90.0000	0.0000	85.1710	0.2236
93.8413	0.0000	97.0533	0.0000	94.8295	0.0000	88.7072	0.1751	90.0001	0.0000	86.4670	0.2288
93.8408	0.0000	92.5762	0.0000	93.5336	0.0000	86.4664	0.1803	89.9997	0.0000	88.7077	0.2308
100.5453	0.0000	92.5758	0.0000	91.2928	0.0000	85.1705	0.1876	89.9997	0.0000	91.2923	0.2308
104.4777	0.0000	97.0530	0.0000	91.2924	0.0000	85.1706	0.1948	89.9997	0.0000	93.5330	0.2308
104.4778	0.0000	99.6561	0.0000	93.5333	0.0000	86.4667	0.2000	89.9999	0.0000	94.8290	0.2308
100.5456	0.0000	99.6562	0.0000	94.8294	0.0000	88.7076	0.2020	90.0000	0.0000	94.8291	0.2308
93.8413	0.0000	97.0533	0.0000	94.8295	0.0000	88.7072	0.2039	90.0001	0.0000	93.5333	0.2308
86.1588	0.0040	92.5762	0.0000	93.5336	0.0000	86.4664	0.2092	89.9997	0.0000	91.2927	0.2308
79.4544	0.0150	92.5758	0.0000	91.2928	0.0000	85.1705	0.2164	89.9997	0.0000	91.2923	0.2308
75.5222	0.0299	97.0530	0.0000	91.2924	0.0000	85.1706	0.2236	89.9997	0.0000	93.5330	0.2308
75.5223	0.0449	99.6561	0.0000	93.5333	0.0000	86.4667	0.2289	89.9999	0.0000	94.8290	0.2308
79.4547	0.0559	99.6562	0.0000	94.8294	0.0000	88.7076	0.2308	90.0000	0.0000	94.8291	0.2308
86.1592	0.0599	97.0533	0.0000	94.8295	0.0000	5.0001	0.4872	90.0001	0.0000	93.5333	0.2308
86.1588	0.0639	92.5762	0.0000	93.5336	0.0000	5.0001	0.6154	89.9997	0.0000	91.2927	0.2308

91.2923	0.2308	87.4243	0.3298	79.4550	0.2355	70.7093	0.0521	95.0783	0.5553	96.2798	0.6154
93.5330	0.2308	87.4239	0.3329	86.1593	0.2395	76.0048	0.0648	103.9951	0.5553	96.2794	0.6154
94.8290	0.2308	82.9469	0.3416	86.1589	0.2435	84.9217	0.0694	109.2907	0.5553	107.3874	0.6154
94.8291	0.2308	80.3442	0.3533	79.4547	0.2545	84.9213	0.0741	109.2909	0.5553	114.0927	0.6154
93.5333	0.2308	80.3443	0.3651	75.5226	0.2694	76.0045	0.0868	103.9954	0.5553	114.0928	0.6154
91.2927	0.2308	82.9472	0.3737	75.5227	0.2844	70.7091	0.1041	95.0787	0.5553	107.3877	0.6154
91.2923	0.2308	87.4243	0.3769	79.4550	0.2954	70.7092	0.1215	95.0783	0.5553	96.2798	0.6154
93.5330	0.2308	92.5757	0.3769	86.1593	0.2994	76.0048	0.1342	103.9951	0.5553	96.2794	0.6154
94.8290	0.2308	97.0527	0.3769	86.1589	0.3034	84.9217	0.1388	109.2907	0.5553	107.3874	0.6154
94.8291	0.2308	99.6557	0.3769	79.4547	0.3143	84.9213	0.1435	109.2909	0.5553	114.0927	0.6154
93.5333	0.2308	99.6558	0.3769	75.5226	0.3293	76.0045	0.1562	103.9954	0.5553	114.0928	0.6154
91.2927	0.2308	97.0530	0.3769	75.5227	0.3443	70.7091	0.1735	95.0787	0.5553	107.3877	0.6154
91.2923	0.2308	92.5761	0.3769	79.4550	0.3552	70.7092	0.1909	20.0000	0.7035	96.2798	0.6154
93.5330	0.2308	92.5757	0.3769	86.1593	0.3592	76.0048	0.2036	20.0000	0.7777	96.2794	0.6154
94.8290	0.2308	97.0527	0.3769	86.1589	0.3633	84.9217	0.2082	20.0000	0.9259	107.3874	0.6154
94.8291	0.2308	99.6557	0.3769	79.4547	0.3742	84.9213	0.2129	20.0000	1.0000	114.0927	0.6154
93.5333	0.2308	99.6558	0.3769	75.5226	0.3892	76.0045	0.2256	83.7201	0.0052	114.0928	0.6154
91.2927	0.2308	97.0530	0.3769	75.5227	0.4041	70.7091	0.2429	72.6122	0.0192	107.3877	0.6154
91.2923	0.2308	92.5761	0.3769	79.4550	0.4151	70.7092	0.2603	65.9071	0.0385	96.2798	0.6154
93.5330	0.2308	92.5757	0.3769	86.1593	0.4191	76.0048	0.2730	65.9073	0.0577	96.2794	0.6154
94.8290	0.2308	97.0527	0.3769	86.1589	0.4231	84.9217	0.2777	72.6125	0.0718	107.3874	0.6154
94.8291	0.2308	99.6557	0.3769	79.4547	0.4341	84.9213	0.2823	83.7205	0.0769	114.0927	0.6154
93.5333	0.2308	99.6558	0.3769	75.5226	0.4490	76.0045	0.2950	83.7201	0.0821	114.0928	0.6154
91.2927	0.2308	97.0530	0.3769	75.5227	0.4640	70.7091	0.3124	72.6122	0.0962	107.3877	0.6154
91.2923	0.2308	92.5761	0.3769	79.4550	0.4750	70.7092	0.3297	65.9071	0.1154	96.2798	0.6154
93.5330	0.2308	92.5757	0.3769	86.1593	0.4790	76.0048	0.3424	65.9072	0.1346	96.2794	0.6154
94.8290	0.2308	97.0527	0.3769	93.8407	0.4790	84.9217	0.3471	72.6125	0.1487	107.3874	0.6154
94.8291	0.2308	99.6557	0.3769	100.5450	0.4790	84.9213	0.3517	83.7205	0.1538	114.0927	0.6154
93.5333	0.2308	99.6558	0.3769	104.4772	0.4790	76.0045	0.3644	83.7201	0.1590	114.0928	0.6154
91.2927	0.2308	97.0530	0.3769	104.4774	0.4790	70.7091	0.3818	72.6122	0.1731	107.3877	0.6154
91.2923	0.2308	92.5761	0.3769	100.5453	0.4790	70.7092	0.3991	65.9071	0.1923	96.2798	0.6154
93.5330	0.2308	92.5757	0.3769	93.8411	0.4790	76.0048	0.4118	65.9072	0.2115	25.0000	0.7436
94.8290	0.2308	97.0527	0.3769	93.8407	0.4790	84.9217	0.4165	72.6125	0.2256	25.0000	0.8077
94.8291	0.2308	99.6557	0.3769	100.5450	0.4790	84.9213	0.4211	83.7205	0.2308	25.0000	0.9359
93.5333	0.2308	99.6558	0.3769	104.4772	0.4790	76.0045	0.4338	83.7201	0.2359	25.0000	1.0000
91.2927	0.2308	97.0530	0.3769	104.4774	0.4790	70.7091	0.4512	72.6122	0.2500	82.5643	0.0056
4.9999	0.4872	92.5761	0.3769	100.5453	0.4790	70.7092	0.4685	65.9071	0.2692	69.2951	0.0208
4.9999	0.6153	92.5757	0.3769	93.8411	0.4790	76.0048	0.4812	65.9072	0.2885	61.1210	0.0415
4.9999	0.8717	97.0527	0.3769	93.8407	0.4790	84.9217	0.4859	72.6125	0.3025	61.1212	0.0623
4.9999	0.9999	99.6557	0.3769	100.5450	0.4790	84.9213	0.4905	83.7205	0.3077	69.2954	0.0775
87.4239	0.0032	99.6558	0.3769	104.4772	0.4790	76.0045	0.5032	83.7201	0.3128	82.5647	0.0831
82.9469	0.0118	97.0530	0.3769	104.4774	0.4790	70.7091	0.5206	72.6122	0.3269	82.5643	0.0886
80.3442	0.0236	92.5761	0.3769	100.5453	0.4790	70.7092	0.5380	65.9071	0.3461	69.2951	0.1038
80.3443	0.0353	92.5757	0.3769	93.8411	0.4790	76.0048	0.5507	65.9072	0.3654	61.1210	0.1246
82.9472	0.0440	97.0527	0.3769	93.8407	0.4790	84.9217	0.5553	72.6125	0.3795	61.1211	0.1454
87.4243	0.0471	99.6557	0.3769	100.5450	0.4790	95.0783	0.5553	83.7205	0.3846	69.2954	0.1606
87.4239	0.0503	99.6558	0.3769	104.4772	0.4790	103.9951	0.5553	83.7201	0.3898	82.5647	0.1661
82.9469	0.0589	97.0530	0.3769	104.4774	0.4790	109.2907	0.5553	72.6122	0.4038	82.5643	0.1717
80.3442	0.0707	92.5761	0.3769	100.5453	0.4790	109.2909	0.5553	65.9071	0.4231	69.2951	0.1869
80.3443	0.0824	92.5757	0.3769	93.8411	0.4790	103.9954	0.5553	65.9072	0.4423	61.1210	0.2077
82.9472	0.0911	97.0527	0.3769	93.8407	0.4790	95.0787	0.5553	72.6125	0.4564	61.1211	0.2284
87.4243	0.0942	99.6557	0.3769	100.5450	0.4790	95.0783	0.5553	83.7205	0.4615	69.2954	0.2436
87.4239	0.0974	99.6558	0.3769	104.4772	0.4790	103.9951	0.5553	83.7201	0.4667	82.5647	0.2492
82.9469	0.1060	97.0530	0.3769	104.4774	0.4790	109.2907	0.5553	72.6122	0.4808	82.5643	0.2548
80.3442	0.1178	92.5761	0.3769	100.5453	0.4790	109.2909	0.5553	65.9071	0.5000	69.2951	0.2700
80.3443	0.1296	10.0000	0.5846	93.8411	0.4790	103.9954	0.5553	65.9072	0.5192	61.1210	0.2907
82.9472	0.1382	10.0000	0.6884	93.8407	0.4790	95.0787	0.5553	72.6125	0.5333	61.1211	0.3115
87.4243	0.1413	10.0000	0.8961	100.5450	0.4790	95.0783	0.5553	83.7205	0.5384	69.2954	0.3267
87.4239	0.1445	10.0000	1.0000	104.4772	0.4790	103.9951	0.5553	83.7201	0.5436	82.5647	0.3323
82.9469	0.1531	86.1589	0.0040	104.4774	0.4790	109.2907	0.5553	72.6122	0.5577	82.5643	0.3378
80.3442	0.1649	79.4547	0.0150	100.5453	0.4790	109.2909	0.5553	65.9071	0.5769	69.2951	0.3530
80.3443	0.1767	75.5226	0.0299	93.8411	0.4790	103.9954	0.5553	65.9072	0.5961	61.1210	0.3738
82.9472	0.1853	75.5227	0.0449	93.8407	0.4790	95.0787	0.5553	72.6125	0.6102	61.1211	0.3946
87.4243	0.1884	79.4550	0.0559	100.5450	0.4790	95.0783	0.5553	83.7205	0.6154	69.2954	0.4098
87.4239	0.1916	86.1593	0.0599	104.4772	0.4790	103.9951	0.5553	96.2794	0.6154	82.5647	0.4153
82.9469	0.2002	86.1589	0.0639	104.4774	0.4790	109.2907	0.5553	107.3874	0.6154	82.5643	0.4209
80.3442	0.2120	79.4547	0.0748	100.5453	0.4790	109.2909	0.5553	114.0927	0.6154	69.2951	0.4361
80.3443	0.2238	75.5226	0.0898	93.8411	0.4790	103.9954	0.5553	114.0928	0.6154	61.1210	0.4569
82.9472	0.2324	75.5227	0.1048	93.8407	0.4790	95.0787	0.5553	107.3877	0.6154	61.1211	0.4776
87.4243	0.2356	79.4550	0.1157	100.5450	0.4790	95.0783	0.5553	96.2798	0.6154	69.2954	0.4928
87.4239	0.2387	86.1593	0.1197	104.4772	0.4790	103.9951	0.5553	96.2794	0.6154	82.5647	0.4984
82.9469	0.2473	86.1589	0.1238	104.4774	0.4790	109.2907	0.5553	107.3874	0.6154	82.5643	0.5040
80.3442	0.2591	79.4547	0.1347	100.5453	0.4790	109.2909	0.5553	114.0927	0.6154	69.2951	0.5192
80.3443	0.2709	75.5226	0.1497	93.8411	0.4790	103.9954	0.5553	114.0928	0.6154	61.1210	0.5399
82.9472	0.2795	75.5227	0.1647	15.0000	0.6527	95.0787	0.5553	107.3877	0.6154	61.1211	0.5607
87.4243	0.2827	79.4550	0.1756	15.0000	0.7395	95.0783	0.5553	96.2798	0.6154	69.2954	0.5759
87.4239	0.2858	86.1593	0.1796	15.0000	0.9132	103.9951	0.5553	96.2794	0.6154	82.5647	0.5815
82.9469	0.2945	86.1589	0.1836	15.0000	1.0000	109.2907	0.5553	107.3874	0.6154	82.5643	0.5870
80.3442	0.3062	79.4547	0.1946	84.9213	0.0047	109.2909	0.5553	114.0927	0.6154	69.2951	0.6022
80.3443	0.3180	75.5226	0.2096	76.0045	0.0174	103.9954	0.5553	114.0928	0.6154	61.1210	0.6230
82.9472	0.3266	75.5227	0.2245	70.7091	0.0347	95.0787	0.5553	107.3877	0.6154	61.1211	0.6438

69.2954	0.6590	56.3561	0.4193	51.6192	0.1392	99.5767	0.7422	120.0000	0.7743	137.7264	0.8035
82.5647	0.6645	66.0728	0.4354	51.6193	0.1624	99.5763	0.7422	100.5454	0.7743	122.7978	0.8035
97.4352	0.6645	81.4629	0.4413	62.9662	0.1793	117.0337	0.7422	100.5450	0.7743	101.4357	0.8035
110.7045	0.6645	81.4625	0.4472	80.4236	0.1856	128.3806	0.7422	119.9997	0.7743	101.4353	0.8035
118.8789	0.6645	66.0724	0.4634	80.4232	0.1918	128.3807	0.7422	133.0793	0.7743	122.7974	0.8035
118.8790	0.6645	56.3559	0.4854	62.9659	0.2087	117.0340	0.7422	133.0794	0.7743	137.7263	0.8035
110.7048	0.6645	56.3561	0.5075	51.6192	0.2319	99.5767	0.7422	120.0000	0.7743	137.7264	0.8035
97.4356	0.6645	66.0728	0.5237	51.6193	0.2551	40.0001	0.8281	100.5454	0.7743	122.7978	0.8035
97.4352	0.6645	81.4629	0.5296	62.9662	0.2721	40.0001	0.8711	100.5450	0.7743	101.4357	0.8035
110.7045	0.6645	81.4625	0.5355	80.4236	0.2783	40.0001	0.9571	119.9997	0.7743	101.4353	0.8035
118.8789	0.6645	66.0724	0.5516	80.4232	0.2845	40.0001	1.0000	133.0793	0.7743	122.7974	0.8035
118.8790	0.6645	56.3559	0.5737	62.9659	0.3015	79.4545	0.0065	133.0794	0.7743	137.7263	0.8035
110.7048	0.6645	56.3561	0.5958	51.6192	0.3247	59.9999	0.0242	120.0000	0.7743	137.7264	0.8035
97.4356	0.6645	66.0728	0.6119	51.6193	0.3479	46.9205	0.0484	100.5454	0.7743	122.7978	0.8035
97.4352	0.6645	81.4629	0.6178	62.9662	0.3649	46.9207	0.0726	100.5450	0.7743	101.4357	0.8035
110.7045	0.6645	81.4625	0.6238	80.4236	0.3711	60.0002	0.0903	119.9997	0.7743	101.4353	0.8035
118.8789	0.6645	66.0724	0.6399	80.4232	0.3773	79.4549	0.0968	133.0793	0.7743	122.7974	0.8035
118.8790	0.6645	56.3559	0.6620	62.9659	0.3943	79.4545	0.1033	133.0794	0.7743	137.7263	0.8035
110.7048	0.6645	56.3561	0.6840	51.6192	0.4175	59.9999	0.1210	120.0000	0.7743	137.7264	0.8035
97.4356	0.6645	66.0728	0.7002	51.6193	0.4407	46.9205	0.1452	100.5454	0.7743	122.7978	0.8035
97.4352	0.6645	81.4629	0.7061	62.9662	0.4577	46.9206	0.1694	100.5450	0.7743	101.4357	0.8035
110.7045	0.6645	98.5370	0.7061	80.4236	0.4639	60.0002	0.1871	119.9997	0.7743	101.4353	0.8035
118.8789	0.6645	113.9271	0.7061	80.4232	0.4701	79.4549	0.1936	133.0793	0.7743	122.7974	0.8035
118.8790	0.6645	123.6439	0.7061	62.9659	0.4871	79.4545	0.2001	133.0794	0.7743	137.7263	0.8035
110.7048	0.6645	123.6440	0.7061	51.6192	0.5103	59.9999	0.2178	120.0000	0.7743	137.7264	0.8035
97.4356	0.6645	113.9275	0.7061	51.6193	0.5335	46.9205	0.2420	100.5454	0.7743	122.7978	0.8035
97.4352	0.6645	98.5374	0.7061	62.9662	0.5504	46.9206	0.2662	45.0001	0.8495	101.4357	0.8035
110.7045	0.6645	98.5370	0.7061	80.4236	0.5567	60.0002	0.2839	45.0001	0.8871	101.4353	0.8035
118.8789	0.6645	113.9271	0.7061	80.4232	0.5629	79.4549	0.2904	45.0001	0.9624	122.7974	0.8035
118.8790	0.6645	123.6439	0.7061	62.9659	0.5798	79.4545	0.2968	45.0001	1.0000	137.7263	0.8035
110.7048	0.6645	123.6440	0.7061	51.6192	0.6030	59.9999	0.3146	78.5641	0.0067	137.7264	0.8035
97.4356	0.6645	113.9275	0.7061	51.6193	0.6262	46.9205	0.3388	57.2021	0.0251	122.7978	0.8035
97.4352	0.6645	98.5374	0.7061	62.9662	0.6432	46.9206	0.3630	42.2735	0.0502	101.4357	0.8035
110.7045	0.6645	98.5370	0.7061	80.4236	0.6494	60.0002	0.3807	42.2738	0.0753	101.4353	0.8035
118.8789	0.6645	113.9271	0.7061	80.4232	0.6556	79.4549	0.3871	57.2024	0.0937	122.7974	0.8035
118.8790	0.6645	123.6439	0.7061	62.9659	0.6726	79.4545	0.3936	78.5646	0.1004	137.7263	0.8035
110.7048	0.6645	123.6440	0.7061	51.6192	0.6958	59.9999	0.4113	78.5641	0.1072	137.7264	0.8035
97.4356	0.6645	113.9275	0.7061	51.6193	0.7190	46.9205	0.4355	57.2021	0.1255	122.7978	0.8035
97.4352	0.6645	98.5374	0.7061	62.9662	0.7360	46.9206	0.4597	42.2735	0.1506	101.4357	0.8035
110.7045	0.6645	98.5370	0.7061	80.4236	0.7422	60.0002	0.4775	42.2736	0.1758	101.4353	0.8035
118.8789	0.6645	113.9271	0.7061	99.5763	0.7422	79.4549	0.4839	57.2024	0.1941	122.7974	0.8035
118.8790	0.6645	123.6439	0.7061	117.0337	0.7422	79.4545	0.4904	78.5646	0.2009	137.7263	0.8035
110.7048	0.6645	123.6440	0.7061	128.3806	0.7422	59.9999	0.5081	78.5641	0.2076	137.7264	0.8035
97.4356	0.6645	113.9275	0.7061	128.3807	0.7422	46.9205	0.5323	57.2021	0.2260	122.7978	0.8035
97.4352	0.6645	98.5374	0.7061	117.0340	0.7422	46.9206	0.5565	42.2735	0.2511	101.4357	0.8035
110.7045	0.6645	98.5370	0.7061	99.5767	0.7422	60.0002	0.5742	42.2736	0.2762	50.0001	0.8690
118.8789	0.6645	113.9271	0.7061	99.5763	0.7422	79.4549	0.5807	57.2024	0.2946	50.0001	0.9017
118.8790	0.6645	123.6439	0.7061	117.0337	0.7422	79.4545	0.5872	78.5646	0.3013	50.0001	0.9672
110.7048	0.6645	123.6440	0.7061	128.3806	0.7422	59.9999	0.6049	78.5641	0.3080	50.0001	1.0000
97.4356	0.6645	113.9275	0.7061	128.3807	0.7422	46.9205	0.6291	57.2021	0.3264	77.7595	0.0070
30.0000	0.7763	98.5374	0.7061	117.0340	0.7422	46.9206	0.6533	42.2735	0.3515	54.6036	0.0260
30.0000	0.8323	98.5370	0.7061	99.5767	0.7422	60.0002	0.6710	42.2736	0.3766	37.6984	0.0519
30.0000	0.9441	113.9271	0.7061	99.5763	0.7422	79.4549	0.6775	57.2024	0.3950	37.6987	0.0779
30.0000	1.0000	123.6439	0.7061	117.0337	0.7422	79.4545	0.6840	78.5646	0.4017	54.6039	0.0969
81.4625	0.0059	123.6440	0.7061	128.3806	0.7422	59.9999	0.7017	78.5641	0.4085	77.7599	0.1038
66.0724	0.0221	113.9275	0.7061	128.3807	0.7422	46.9205	0.7259	57.2021	0.4268	77.7595	0.1108
56.3559	0.0441	98.5374	0.7061	117.0340	0.7422	46.9206	0.7501	42.2735	0.4519	54.6036	0.1298
56.3562	0.0662	98.5370	0.7061	99.5767	0.7422	60.0002	0.7678	42.2736	0.4771	37.6984	0.1557
66.0728	0.0824	113.9271	0.7061	99.5763	0.7422	79.4549	0.7743	57.2024	0.4954	37.6986	0.1817
81.4629	0.0883	123.6439	0.7061	117.0337	0.7422	100.5450	0.7743	78.5646	0.5022	54.6039	0.2007
81.4625	0.0942	123.6440	0.7061	128.3806	0.7422	119.9997	0.7743	78.5641	0.5089	77.7599	0.2076
66.0724	0.1103	113.9275	0.7061	128.3807	0.7422	133.0793	0.7743	57.2021	0.5273	77.7595	0.2146
56.3559	0.1324	98.5374	0.7061	117.0340	0.7422	133.0794	0.7743	42.2735	0.5524	54.6036	0.2336
56.3561	0.1545	98.5370	0.7061	99.5767	0.7422	120.0000	0.7743	42.2736	0.5775	37.6984	0.2595
66.0728	0.1706	113.9271	0.7061	99.5763	0.7422	100.5454	0.7743	57.2024	0.5959	37.6986	0.2855
81.4629	0.1765	123.6439	0.7061	117.0337	0.7422	100.5450	0.7743	78.5646	0.6026	54.6039	0.3045
81.4625	0.1824	123.6440	0.7061	128.3806	0.7422	119.9997	0.7743	78.5641	0.6093	77.7599	0.3114
66.0724	0.1986	113.9275	0.7061	128.3807	0.7422	133.0793	0.7743	57.2021	0.6277	77.7595	0.3184
56.3559	0.2207	98.5374	0.7061	117.0340	0.7422	133.0794	0.7743	42.2735	0.6528	54.6036	0.3374
56.3561	0.2427	35.0000	0.8041	99.5767	0.7422	120.0000	0.7743	42.2736	0.6779	37.6984	0.3633
66.0728	0.2589	35.0000	0.8531	99.5763	0.7422	100.5454	0.7743	57.2024	0.6963	37.6986	0.3893
81.4629	0.2648	35.0000	0.9510	117.0337	0.7422	100.5450	0.7743	78.5646	0.7030	54.6039	0.4083
81.4625	0.2707	35.0000	1.0000	128.3806	0.7422	119.9997	0.7743	78.5641	0.7098	77.7599	0.4153
66.0724	0.2869	80.4232	0.0062	128.3807	0.7422	133.0793	0.7743	57.2021	0.7281	77.7595	0.4222
56.3559	0.3089	62.9659	0.0232	117.0340	0.7422	133.0794	0.7743	42.2735	0.7532	54.6036	0.4412
56.3561	0.3310	51.6192	0.0464	99.5767	0.7422	120.0000	0.7743	42.2736	0.7784	37.6984	0.4672
66.0728	0.3471	51.6195	0.0696	99.5763	0.7422	100.5454	0.7743	57.2024	0.7967	37.6986	0.4931
81.4629	0.3531	62.9662	0.0866	117.0337	0.7422	100.5450	0.7743	78.5646	0.8035	54.6039	0.5121
81.4625	0.3590	80.4236	0.0928	128.3806	0.7422	119.9997	0.7743	101.4353	0.8035	77.7599	0.5191
66.0724	0.3751	80.4232	0.0990	128.3807	0.7422	133.0793	0.7743	122.7974	0.8035	77.7595	0.5260
56.3559	0.3972	62.9659	0.1160	117.0340	0.7422	133.0794	0.7743	137.7263	0.8035	54.6036	0.5450

37.6984	0.5710	52.2386	0.2407	127.7613	0.8559	151.0955	0.8803	155.1856	0.9041	46.9203	0.7246
37.6986	0.5969	33.2259	0.2675	102.9527	0.8559	129.8558	0.8803	155.1858	0.9041	21.0904	0.7536
54.6039	0.6159	33.2261	0.2942	60.0001	0.9040	103.5664	0.8803	131.6413	0.9041	21.0907	0.7826
77.7599	0.6229	52.2389	0.3138	60.0001	0.9280	103.5660	0.8803	104.0762	0.9041	46.9207	0.8038
77.7595	0.6298	77.0476	0.3210	60.0001	0.9760	129.8554	0.8803	104.0758	0.9041	75.5227	0.8116
54.6036	0.6488	77.0472	0.3281	60.0001	1.0000	151.0952	0.8803	131.6409	0.9041	75.5223	0.8194
37.6984	0.6748	52.2386	0.3477	76.4335	0.0074	151.0955	0.8803	155.1856	0.9041	46.9203	0.8406
37.6986	0.7007	33.2259	0.3745	50.1441	0.0275	129.8558	0.8803	155.1858	0.9041	21.0904	0.8696
54.6039	0.7197	33.2261	0.4012	28.9044	0.0550	103.5664	0.8803	131.6413	0.9041	21.0907	0.8986
77.7599	0.7267	52.2389	0.4208	28.9048	0.0825	103.5660	0.8803	104.0762	0.9041	46.9207	0.9198
77.7595	0.7336	77.0476	0.4280	50.1445	0.1027	129.8554	0.8803	104.0758	0.9041	75.5227	0.9276
54.6036	0.7526	77.0472	0.4351	76.4339	0.1100	151.0952	0.8803	131.6409	0.9041	104.4772	0.9276
37.6984	0.7786	52.2386	0.4547	76.4335	0.1174	151.0955	0.8803	155.1856	0.9041	133.0792	0.9276
37.6986	0.8046	33.2259	0.4815	50.1441	0.1376	129.8558	0.8803	155.1858	0.9041	158.9092	0.9276
54.6039	0.8236	33.2261	0.5082	28.9044	0.1651	103.5664	0.8803	131.6413	0.9041	158.9095	0.9276
77.7599	0.8305	52.2389	0.5278	28.9047	0.1926	103.5660	0.8803	104.0762	0.9041	133.0796	0.9276
102.2400	0.8305	77.0476	0.5350	50.1445	0.2127	129.8554	0.8803	104.0758	0.9041	104.4777	0.9276
125.3960	0.8305	77.0472	0.5421	76.4339	0.2201	151.0952	0.8803	131.6409	0.9041	104.4772	0.9276
142.3013	0.8305	52.2386	0.5617	76.4335	0.2275	151.0955	0.8803	155.1856	0.9041	133.0792	0.9276
142.3015	0.8305	33.2259	0.5885	50.1441	0.2476	129.8558	0.8803	155.1858	0.9041	158.9092	0.9276
125.3963	0.8305	33.2261	0.6152	28.9044	0.2751	103.5664	0.8803	131.6413	0.9041	158.9095	0.9276
102.2404	0.8305	52.2389	0.6348	28.9047	0.3026	65.0001	0.9202	104.0762	0.9041	133.0796	0.9276
102.2400	0.8305	77.0476	0.6420	50.1445	0.3228	65.0001	0.9402	104.0758	0.9041	104.4777	0.9276
125.3960	0.8305	77.0472	0.6491	76.4339	0.3301	65.0001	0.9800	131.6409	0.9041	104.4772	0.9276
142.3013	0.8305	52.2386	0.6687	76.4335	0.3375	65.0001	1.0000	155.1856	0.9041	133.0792	0.9276
142.3015	0.8305	33.2259	0.6955	50.1441	0.3576	75.9237	0.0076	155.1858	0.9041	158.9092	0.9276
125.3963	0.8305	33.2261	0.7222	28.9044	0.3851	48.3586	0.0283	131.6413	0.9041	158.9095	0.9276
102.2404	0.8305	52.2389	0.7418	28.9047	0.4127	24.8141	0.0565	104.0762	0.9041	133.0796	0.9276
102.2400	0.8305	77.0476	0.7490	50.1445	0.4328	24.8145	0.0848	104.0758	0.9041	104.4777	0.9276
125.3960	0.8305	77.0472	0.7561	76.4339	0.4402	48.3590	0.1054	131.6409	0.9041	104.4772	0.9276
142.3013	0.8305	52.2386	0.7757	76.4335	0.4475	75.9241	0.1130	155.1856	0.9041	133.0792	0.9276
142.3015	0.8305	33.2259	0.8025	50.1441	0.4677	75.9237	0.1206	155.1858	0.9041	158.9092	0.9276
125.3963	0.8305	33.2261	0.8292	28.9044	0.4952	48.3586	0.1413	131.6413	0.9041	158.9095	0.9276
102.2404	0.8305	52.2389	0.8488	28.9047	0.5227	24.8141	0.1695	104.0762	0.9041	133.0796	0.9276
102.2400	0.8305	77.0476	0.8559	50.1445	0.5428	24.8143	0.1978	104.0758	0.9041	104.4777	0.9276
125.3960	0.8305	102.9522	0.8559	76.4339	0.5502	48.3590	0.2184	131.6409	0.9041	104.4772	0.9276
142.3013	0.8305	127.7609	0.8559	76.4335	0.5576	75.9241	0.2260	155.1856	0.9041	133.0792	0.9276
142.3015	0.8305	146.7738	0.8559	50.1441	0.5777	75.9237	0.2336	155.1858	0.9041	158.9092	0.9276
125.3963	0.8305	146.7740	0.8559	28.9044	0.6052	48.3586	0.2543	131.6413	0.9041	158.9095	0.9276
102.2404	0.8305	127.7613	0.8559	28.9047	0.6327	24.8141	0.2825	104.0762	0.9041	133.0796	0.9276
102.2400	0.8305	102.9527	0.8559	50.1445	0.6529	24.8143	0.3108	70.0001	0.9360	104.4777	0.9276
125.3960	0.8305	102.9522	0.8559	76.4339	0.6602	48.3590	0.3315	70.0001	0.9520	104.4772	0.9276
142.3013	0.8305	127.7609	0.8559	76.4335	0.6676	75.9241	0.3390	70.0001	0.9840	133.0792	0.9276
142.3015	0.8305	146.7738	0.8559	50.1441	0.6878	75.9237	0.3466	70.0001	1.0000	158.9092	0.9276
125.3963	0.8305	146.7740	0.8559	28.9044	0.7153	48.3586	0.3673	75.5223	0.0078	158.9095	0.9276
102.2404	0.8305	127.7613	0.8559	28.9047	0.7428	24.8141	0.3955	46.9203	0.0290	133.0796	0.9276
102.2400	0.8305	102.9527	0.8559	50.1445	0.7629	24.8143	0.4238	21.0904	0.0580	104.4777	0.9276
125.3960	0.8305	102.9522	0.8559	76.4339	0.7703	48.3590	0.4445	21.0908	0.0870	104.4772	0.9276
142.3013	0.8305	127.7609	0.8559	76.4335	0.7777	75.9241	0.4520	46.9207	0.1082	133.0792	0.9276
142.3015	0.8305	146.7738	0.8559	50.1441	0.7978	75.9237	0.4596	75.5227	0.1159	158.9092	0.9276
125.3963	0.8305	146.7740	0.8559	28.9044	0.8253	48.3586	0.4803	75.5223	0.1237	158.9095	0.9276
102.2404	0.8305	127.7613	0.8559	28.9047	0.8528	24.8141	0.5085	46.9203	0.1449	133.0796	0.9276
102.2400	0.8305	102.9527	0.8559	50.1445	0.8730	24.8143	0.5368	21.0904	0.1739	104.4777	0.9276
125.3960	0.8305	102.9522	0.8559	76.4339	0.8803	48.3590	0.5575	21.0907	0.2029	104.4772	0.9276
142.3013	0.8305	127.7609	0.8559	103.5660	0.8803	75.9241	0.5650	46.9207	0.2241	133.0792	0.9276
142.3015	0.8305	146.7738	0.8559	129.8554	0.8803	75.9237	0.5726	75.5227	0.2319	158.9092	0.9276
125.3963	0.8305	146.7740	0.8559	151.0952	0.8803	48.3586	0.5933	75.5223	0.2397	158.9095	0.9276
102.2404	0.8305	127.7613	0.8559	151.0955	0.8803	24.8141	0.6216	46.9203	0.2609	133.0796	0.9276
102.2400	0.8305	102.9527	0.8559	129.8558	0.8803	24.8143	0.6498	21.0904	0.2899	104.4777	0.9276
125.3960	0.8305	102.9522	0.8559	103.5664	0.8803	48.3590	0.6705	21.0907	0.3188	75.0002	0.9517
142.3013	0.8305	127.7609	0.8559	103.5660	0.8803	75.9241	0.6781	46.9207	0.3401	75.0002	0.9638
142.3015	0.8305	146.7738	0.8559	129.8554	0.8803	75.9237	0.6856	75.5227	0.3478	75.0002	0.9879
125.3963	0.8305	146.7740	0.8559	151.0952	0.8803	48.3586	0.7063	75.5223	0.3556	75.0002	1.0000
102.2404	0.8305	127.7613	0.8559	151.0955	0.8803	24.8141	0.7346	46.9203	0.3768	75.2329	0.0080
55.0001	0.8870	102.9527	0.8559	129.8558	0.8803	24.8143	0.7628	21.0904	0.4058	45.8638	0.0297
55.0001	0.9153	102.9522	0.8559	103.5664	0.8803	48.3590	0.7835	21.0907	0.4348	17.9637	0.0594
55.0001	0.9718	127.7609	0.8559	103.5660	0.8803	75.9241	0.7911	46.9207	0.4560	17.9641	0.0892
55.0001	1.0000	146.7738	0.8559	129.8554	0.8803	75.9237	0.7986	75.5227	0.4638	45.8642	0.1109
77.0472	0.0072	146.7740	0.8559	151.0952	0.8803	48.3586	0.8193	75.5223	0.4715	75.2333	0.1189
52.2386	0.0267	127.7613	0.8559	151.0955	0.8803	24.8141	0.8476	46.9203	0.4928	75.2329	0.1269
33.2259	0.0535	102.9527	0.8559	129.8558	0.8803	24.8143	0.8758	21.0904	0.5217	45.8638	0.1486
33.2262	0.0802	102.9522	0.8559	103.5664	0.8803	48.3590	0.8965	21.0907	0.5507	17.9637	0.1783
52.2389	0.0998	127.7609	0.8559	103.5660	0.8803	75.9241	0.9041	46.9207	0.5720	17.9640	0.2081
77.0476	0.1070	146.7738	0.8559	129.8554	0.8803	104.0758	0.9041	75.5227	0.5797	45.8642	0.2298
77.0472	0.1142	146.7740	0.8559	151.0952	0.8803	131.6409	0.9041	75.5223	0.5875	75.2333	0.2378
52.2386	0.1337	127.7613	0.8559	151.0955	0.8803	155.1856	0.9041	46.9203	0.6087	75.2329	0.2458
33.2259	0.1605	102.9527	0.8559	129.8558	0.8803	155.1858	0.9041	21.0904	0.6377	45.8638	0.2675
33.2261	0.1872	102.9522	0.8559	103.5664	0.8803	131.6413	0.9041	21.0907	0.6667	17.9637	0.2972
52.2389	0.2068	127.7609	0.8559	103.5660	0.8803	104.0762	0.9041	46.9207	0.6879	17.9640	0.3270
77.0476	0.2140	146.7738	0.8559	129.8554	0.8803	104.0758	0.9041	75.5227	0.6957	45.8642	0.3487
77.0472	0.2212	146.7740	0.8559	151.0952	0.8803	131.6409	0.9041	75.5223	0.7034	75.2333	0.3567

75.2329	0.3646
45.8638	0.3864
17.9637	0.4161
17.9640	0.4459
45.8642	0.4676
75.2333	0.4756
75.2329	0.4835
45.8638	0.5053
17.9637	0.5350
17.9640	0.5647
45.8642	0.5865
75.2333	0.5945
75.2329	0.6024
45.8638	0.6242
17.9637	0.6539
17.9640	0.6836
45.8642	0.7054
75.2333	0.7134
75.2329	0.7213
45.8638	0.7431
17.9637	0.7728
17.9640	0.8025
45.8642	0.8243
75.2333	0.8323
75.2329	0.8402
45.8638	0.8620
17.9637	0.8917
17.9640	0.9214
45.8642	0.9432
75.2333	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
104.7666	0.9512
134.1358	0.9512
162.0359	0.9512
162.0362	0.9512
134.1362	0.9512
104.7670	0.9512
80.0002	0.9674
80.0002	0.9756
80.0002	0.9919
80.0002	1.0000
75.0582	0.0082
45.2174	0.0305
15.7930	0.0609
15.7934	0.0914
45.2178	0.1137
75.0586	0.1219
75.0582	0.1301
45.2174	0.1524
15.7930	0.1828
15.7934	0.2133
45.2178	0.2356
75.0586	0.2438
75.0582	0.2519
45.2174	0.2742
15.7930	0.3047
15.7934	0.3352
45.2178	0.3575
75.0586	0.3657
75.0582	0.3738
45.2174	0.3961
15.7930	0.4266
15.7934	0.4571
45.2178	0.4794
75.0586	0.4876
75.0582	0.4957
45.2174	0.5180
15.7930	0.5485
15.7934	0.5790
45.2178	0.6013
75.0586	0.6094
75.0582	0.6176
45.2174	0.6399
15.7930	0.6704
15.7934	0.7009
45.2178	0.7232
75.0586	0.7313
75.0582	0.7395
45.2174	0.7618
15.7930	0.7923
15.7934	0.8228
45.2178	0.8451
75.0586	0.8532
75.0582	0.8614
45.2174	0.8837
15.7930	0.9142
15.7934	0.9446
45.2178	0.9669
75.0586	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
104.9413	0.9751
134.7821	0.9751
164.2065	0.9751
164.2069	0.9751
134.7825	0.9751
104.9417	0.9751
85.0002	0.9834
85.0002	0.9875
85.0002	0.9958
85.0002	1.0000
74.9998	0.0084
44.9998	0.0312
14.9998	0.0625
15.0001	0.0937
45.0002	0.1166
75.0002	0.1250
74.9998	0.1334
44.9998	0.1562
14.9998	0.1875
15.0002	0.2187
45.0002	0.2416
75.0002	0.2500
74.9998	0.2584
44.9998	0.2812
14.9998	0.3125
15.0002	0.3437
45.0002	0.3666
75.0002	0.3750
74.9998	0.3834
44.9998	0.4062
14.9998	0.4375
15.0002	0.4687
45.0002	0.4916
75.0002	0.5000
74.9998	0.5084
44.9998	0.5312
14.9998	0.5625
15.0002	0.5937
45.0002	0.6166
75.0002	0.6250
74.9998	0.6334
44.9998	0.6562
14.9998	0.6875
15.0002	0.7187
45.0002	0.7416
75.0002	0.7500
74.9998	0.7584
44.9998	0.7812
14.9998	0.8125
15.0002	0.8437
45.0002	0.8666
75.0002	0.8750
74.9998	0.8834
44.9998	0.9062
14.9998	0.9375
15.0002	0.9687
45.0002	0.9916
75.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
165.0002	1.0000
135.0002	1.0000
105.0002	1.0000
90.0002	1.0000
90.0002	1.0000
90.0002	1.0000
90.0002	1.0000

APPENDIX G

JLAB.DAT Data File

Obliquity (degrees)	Cum. Prob.
74.9998	0.0084
44.9998	0.0312
14.9998	0.0625
15.0001	0.0937
45.0002	0.1166
75.0002	0.1250
74.9998	0.1334
44.9998	0.1562
14.9998	0.1875
15.0002	0.2187
45.0002	0.2416
75.0002	0.2500
74.9998	0.2584
44.9998	0.2812
14.9998	0.3125
15.0002	0.3437
45.0002	0.3666
75.0002	0.3750
74.9998	0.3834
44.9998	0.4062
14.9998	0.4375
15.0002	0.4687
45.0002	0.4916
75.0002	0.5000
74.9998	0.5084
44.9998	0.5312
14.9998	0.5625
15.0002	0.5937
45.0002	0.6166
75.0002	0.6250
74.9998	0.6334
44.9998	0.6562
14.9998	0.6875
15.0002	0.7187
45.0002	0.7416
75.0002	0.7500
74.9998	0.7584
44.9998	0.7812
14.9998	0.8125
15.0002	0.8437
45.0002	0.8666
75.0002	0.8750
74.9998	0.8834
44.9998	0.9062
14.9998	0.9375
15.0002	0.9687
45.0002	0.9916
75.0002	1.0000
75.0582	0.0084
45.2174	0.0313
15.7930	0.0625
15.7934	0.0937
45.2178	0.1166
75.0586	0.1250
75.0582	0.1334
45.2174	0.1563
15.7930	0.1875
15.7934	0.2187
45.2178	0.2416
75.0586	0.2500
75.0582	0.2583
45.2174	0.2812
15.7930	0.3125
15.7934	0.3438
45.2178	0.3666
75.0586	0.3750
75.0582	0.3833
45.2174	0.4062
15.7930	0.4375
15.7934	0.4688
45.2178	0.4916
75.0586	0.5001
75.0582	0.5084
45.2174	0.5312
15.7930	0.5625
15.7934	0.5938
45.2178	0.6167
75.0586	0.6250
75.0582	0.6334
45.2174	0.6562
15.7930	0.6875
15.7934	0.7188
45.2178	0.7417
75.0586	0.7500
75.0582	0.7584
45.2174	0.7813
15.7930	0.8125
15.7934	0.8438
45.2178	0.8667
75.0586	0.8750
75.0582	0.8834
45.2174	0.9063
15.7930	0.9375
15.7934	0.9687
45.2178	0.9916
75.0586	1.0000
75.2329	0.0084
45.8638	0.0312
17.9637	0.0624
17.9641	0.0938
45.8642	0.1166
75.2333	0.1250
75.2329	0.1334
45.8638	0.1562
17.9637	0.1874
17.9640	0.2188
45.8642	0.2416
75.2333	0.2500
75.2329	0.2584
45.8638	0.2812
17.9637	0.3124
17.9640	0.3438
45.8642	0.3666
75.2333	0.3750
75.2329	0.3833
45.8638	0.4062
17.9637	0.4374
17.9640	0.4688
45.8642	0.4916
75.2333	0.5000
75.2329	0.5083
45.8638	0.5312
17.9637	0.5624
17.9640	0.5937
45.8642	0.6166
75.2333	0.6250
75.2329	0.6333
45.8638	0.6562
17.9637	0.6874
17.9640	0.7187
45.8642	0.7416
75.2333	0.7500
75.2329	0.7583
45.8638	0.7812
17.9637	0.8124
17.9640	0.8437
45.8642	0.8666
75.2333	0.8750
75.2329	0.8833
45.8638	0.9062
17.9637	0.9374
17.9640	0.9687
45.8642	0.9916
75.2333	1.0000
75.5223	0.0084
46.9203	0.0313
21.0904	0.0625
21.0908	0.0938
46.9207	0.1166
75.5227	0.1249
75.5223	0.1334
46.9203	0.1562
21.0904	0.1875
21.0907	0.2187
46.9207	0.2416
75.5227	0.2500
75.5223	0.2584
46.9203	0.2813
21.0904	0.3125
21.0907	0.3437
46.9207	0.3666
75.5227	0.3749
75.5223	0.3834
46.9203	0.4062
21.0904	0.4375
21.0907	0.4687
46.9207	0.4916
75.5227	0.5000
75.5223	0.5083
46.9203	0.5313
21.0904	0.5624
21.0907	0.5937
46.9207	0.6166
75.5227	0.6249
75.5223	0.6334
46.9203	0.6562
21.0904	0.6875
21.0907	0.7187
46.9207	0.7416
75.5227	0.7500
75.5223	0.7583
46.9203	0.7812
21.0904	0.8124
21.0907	0.8437
46.9207	0.8665
75.5227	0.8749
75.5223	0.8834
46.9203	0.9062
21.0904	0.9375
21.0907	0.9687
46.9207	0.9916
75.5227	1.0000
75.9237	0.0084
48.3586	0.0313
24.8141	0.0625
24.8145	0.0938
48.3590	0.1166
75.9241	0.1250
75.9237	0.1334
48.3586	0.1563
24.8141	0.1875
24.8143	0.2188
48.3590	0.2416
75.9241	0.2500
75.9237	0.2584
48.3586	0.2813
24.8141	0.3125
24.8143	0.3438
48.3590	0.3667
75.9241	0.3750
75.9237	0.3834
48.3586	0.4063
24.8141	0.4375
24.8143	0.4688
48.3590	0.4916
75.9241	0.4999
75.9237	0.5084
48.3586	0.5312
24.8141	0.5624
24.8143	0.5937
48.3590	0.6166
75.9241	0.6249
75.9237	0.6333
48.3586	0.6562
24.8141	0.6875
24.8143	0.7187
48.3590	0.7416
75.9241	0.7500
75.9237	0.7583
48.3586	0.7812
24.8141	0.8125
24.8143	0.8437
48.3590	0.8666
75.9241	0.8750
75.9237	0.8833
48.3586	0.9062
24.8141	0.9375
24.8143	0.9687
48.3590	0.9916
75.9241	1.0000
76.4335	0.0084
50.1441	0.0312
28.9044	0.0625
28.9048	0.0937
50.1445	0.1167
76.4339	0.1250
76.4335	0.1334
50.1441	0.1563
28.9044	0.1875
28.9047	0.2188
50.1445	0.2416
76.4339	0.2500
76.4335	0.2584
50.1441	0.2813
28.9044	0.3125
28.9047	0.3437
50.1445	0.3667
76.4339	0.3750
76.4335	0.3834
50.1441	0.4062
28.9044	0.4375
28.9047	0.4688
50.1445	0.4917
76.4339	0.5001
76.4335	0.5083
50.1441	0.5313
28.9044	0.5625
28.9047	0.5938
50.1445	0.6166
76.4339	0.6250
76.4335	0.6334
50.1441	0.6563
28.9044	0.6875
28.9047	0.7187
50.1445	0.7417
76.4339	0.7500
76.4335	0.7584
50.1441	0.7813
28.9044	0.8126
28.9047	0.8438
50.1445	0.8666
76.4339	0.8750
76.4335	0.8834
50.1441	0.9063
28.9044	0.9375
28.9047	0.9688
50.1445	0.9917
76.4339	1.0000
77.0472	0.0084
52.2386	0.0312
33.2259	0.0625
33.2262	0.0937
52.2389	0.1166
77.0476	0.1250
77.0472	0.1334
52.2386	0.1562
33.2259	0.1875
33.2261	0.2187
52.2389	0.2416
77.0476	0.2500
77.0472	0.2584
52.2386	0.2812
33.2259	0.3125
33.2261	0.3437
52.2389	0.3666
77.0476	0.3750
77.0472	0.3833
52.2386	0.4062
33.2259	0.4376
33.2261	0.4687
52.2389	0.4916
77.0476	0.5001
77.0472	0.5084
52.2386	0.5313
33.2259	0.5626
33.2261	0.5938
52.2389	0.6167
77.0476	0.6251
77.0472	0.6334
52.2386	0.6563
33.2259	0.6876
33.2261	0.7188
52.2389	0.7417
77.0476	0.7501
77.0472	0.7584
52.2386	0.7813
33.2259	0.8126
33.2261	0.8438
52.2389	0.8667
77.0476	0.8751
77.0472	0.8834
52.2386	0.9063
33.2259	0.9376
33.2261	0.9688
52.2389	0.9917
77.0476	1.0000
77.7595	0.0084
54.6036	0.0313
37.6984	0.0625
37.6987	0.0938
54.6039	0.1167
77.7599	0.1250
77.7595	0.1334
54.6036	0.1563
37.6984	0.1875
37.6986	0.2188
54.6039	0.2417
77.7599	0.2500
77.7595	0.2584
54.6036	0.2813
37.6984	0.3125
37.6986	0.3438
54.6039	0.3666
77.7599	0.3750
77.7595	0.3834
54.6036	0.4063
37.6984	0.4374
37.6986	0.4688
54.6039	0.4916
77.7599	0.5001
77.7595	0.5084
54.6036	0.5312
37.6984	0.5626
37.6986	0.5937
54.6039	0.6166
77.7599	0.6250
77.7595	0.6334
54.6036	0.6562
37.6984	0.6875
37.6986	0.7187
54.6039	0.7416
77.7599	0.7500
77.7595	0.7583
54.6036	0.7812
37.6984	0.8125
37.6986	0.8437
54.6039	0.8666
77.7599	0.8750
77.7595	0.8833
54.6036	0.9062
37.6984	0.9375
37.6986	0.9688
54.6039	0.9917
77.7599	1.0000
78.5641	0.0083
57.2021	0.0312
42.2735	0.0625
42.2738	0.0937
57.2024	0.1166
78.5646	0.1250
78.5641	0.1334
57.2021	0.1562
42.2735	0.1874
42.2736	0.2188
57.2024	0.2416
78.5646	0.2500
78.5641	0.2584
57.2021	0.2813
42.2735	0.3125
42.2736	0.3437
57.2024	0.3666
78.5646	0.3750
78.5641	0.3833
57.2021	0.4062
42.2735	0.4375
42.2736	0.4687
57.2024	0.4916
78.5646	0.4999
78.5641	0.5084
57.2021	0.5312
42.2735	0.5624
42.2736	0.5938
57.2024	0.6166
78.5646	0.6250
78.5641	0.6334
57.2021	0.6563
42.2735	0.6875
42.2736	0.7187
57.2024	0.7416
78.5646	0.7500
78.5641	0.7583
57.2021	0.7812
42.2735	0.8124
42.2736	0.8437
57.2024	0.8666
78.5646	0.8749
78.5641	0.8834
57.2021	0.9062
42.2735	0.9374
42.2736	0.9688
57.2024	0.9915
78.5646	1.0000
79.4545	0.0084
59.9999	0.0313
46.9205	0.0625
46.9207	0.0938
60.0002	0.1166
79.4549	0.1250
79.4545	0.1334
59.9999	0.1563
46.9205	0.1875
46.9206	0.2188
60.0002	0.2416
79.4549	0.2500
79.4545	0.2584
59.9999	0.2813
46.9205	0.3125
46.9206	0.3438
60.0002	0.3667
79.4549	0.3750
79.4545	0.3833
59.9999	0.4063
46.9205	0.4376
46.9206	0.4688
60.0002	0.4917
79.4549	0.4999
79.4545	0.5083
59.9999	0.5312
46.9205	0.5624
46.9206	0.5937
60.0002	0.6167
79.4549	0.6250
79.4545	0.6333
59.9999	0.6562
46.9205	0.6875
46.9206	0.7187
60.0002	0.7416
79.4549	0.7500
79.4545	0.7584
59.9999	0.7812
46.9205	0.8125
46.9206	0.8437
60.0002	0.8666
79.4549	0.8750
79.4545	0.8834
59.9999	0.9062
46.9205	0.9375
46.9206	0.9687
60.0002	0.9916
79.4549	1.0000
80.4232	0.0084
62.9659	0.0313
51.6192	0.0625

51.6195	0.0938
62.9662	0.1167
80.4236	0.1250
80.4232	0.1334
62.9659	0.1563
51.6192	0.1876
51.6193	0.2188
62.9662	0.2416
80.4236	0.2501
80.4232	0.2584
62.9659	0.2812
51.6192	0.3124
51.6193	0.3437
62.9662	0.3666
80.4236	0.3750
80.4232	0.3833
62.9659	0.4062
51.6192	0.4375
51.6193	0.4687
62.9662	0.4916
80.4236	0.5000
80.4232	0.5084
62.9659	0.5313
51.6192	0.5625
51.6193	0.5938
62.9662	0.6167
80.4236	0.6250
80.4232	0.6334
62.9659	0.6563
51.6192	0.6876
51.6193	0.7188
62.9662	0.7416
80.4236	0.7501
80.4232	0.7584
62.9659	0.7812
51.6192	0.8124
51.6193	0.8437
62.9662	0.8666
80.4236	0.8750
80.4232	0.8833
62.9659	0.9062
51.6192	0.9375
51.6193	0.9687
62.9662	0.9916
80.4236	1.0000
81.4625	0.0084
66.0724	0.0313
56.3559	0.0625
56.3562	0.0938
66.0728	0.1167
81.4629	0.1251
81.4625	0.1334
66.0724	0.1562
56.3559	0.1875
56.3561	0.2188
66.0728	0.2416
81.4629	0.2500
81.4625	0.2583
66.0724	0.2813
56.3559	0.3126
56.3561	0.3437
66.0728	0.3667
81.4629	0.3750
81.4625	0.3834
66.0724	0.4063
56.3559	0.4375
56.3561	0.4688
66.0728	0.4916
81.4629	0.5001
81.4625	0.5084
66.0724	0.5312
56.3559	0.5625
56.3561	0.5938
66.0728	0.6166
81.4629	0.6250
81.4625	0.6333
66.0724	0.6563
56.3559	0.6874
56.3561	0.7187
66.0728	0.7417
81.4629	0.7500
81.4625	0.7584
66.0724	0.7812
56.3559	0.8125
56.3561	0.8438
66.0728	0.8666
81.4629	0.8749
81.4625	0.8834
66.0724	0.9062
56.3559	0.9375
56.3561	0.9687
66.0728	0.9916
81.4625	1.0000
82.5643	0.0084
69.2951	0.0313
61.1210	0.0625
61.1212	0.0938
69.2954	0.1166
82.5647	0.1251
82.5643	0.1333
69.2951	0.1562
61.1210	0.1875
61.1211	0.2188
69.2954	0.2417
82.5647	0.2500
82.5643	0.2584
69.2951	0.2813
61.1210	0.3126
61.1211	0.3437
69.2954	0.3666
82.5647	0.3750
82.5643	0.3834
69.2951	0.4063
61.1210	0.4375
61.1211	0.4688
69.2954	0.4916
82.5647	0.5001
82.5643	0.5084
69.2951	0.5312
61.1210	0.5625
61.1211	0.5938
69.2954	0.6167
82.5647	0.6250
82.5643	0.6334
69.2951	0.6563
61.1210	0.6876
61.1211	0.7187
69.2954	0.7416
82.5647	0.7500
82.5643	0.7585
69.2951	0.7813
61.1210	0.8125
61.1211	0.8438
69.2954	0.8667
82.5647	0.8751
82.5643	0.8834
69.2951	0.9062
61.1210	0.9375
61.1211	0.9688
69.2954	0.9917
82.5647	1.0000
83.7201	0.0084
72.6122	0.0312
65.9071	0.0626
65.9073	0.0938
72.6125	0.1167
83.7205	0.1250
83.7201	0.1334
72.6122	0.1563
65.9071	0.1875
65.9072	0.2187
72.6125	0.2416
83.7205	0.2499
83.7201	0.2584
72.6122	0.2813
65.9071	0.3125
65.9072	0.3437
72.6125	0.3666
83.7205	0.3750
83.7201	0.3833
72.6122	0.4062
65.9071	0.4374
65.9072	0.4688
72.6125	0.4916
83.7205	0.5000
83.7201	0.5083
72.6122	0.5312
65.9071	0.5624
65.9072	0.5938
72.6125	0.6167
83.7205	0.6250
83.7201	0.6334
72.6122	0.6562
65.9071	0.6875
65.9072	0.7187
72.6125	0.7416
83.7205	0.7499
83.7201	0.7584
72.6122	0.7813
65.9071	0.8125
65.9072	0.8437
72.6125	0.8666
83.7205	0.8749
83.7201	0.8833
72.6122	0.9062
65.9071	0.9374
65.9072	0.9686
72.6125	0.9916
83.7205	1.0000
84.9213	0.0085
76.0045	0.0313
70.7091	0.0625
70.7093	0.0938
76.0048	0.1167
84.9217	0.1250
84.9213	0.1334
76.0045	0.1563
70.7091	0.1875
70.7092	0.2188
76.0048	0.2417
84.9217	0.2500
84.9213	0.2584
76.0045	0.2813
70.7091	0.3124
70.7092	0.3438
76.0048	0.3666
84.9217	0.3749
84.9213	0.3834
76.0045	0.4063
70.7091	0.4374
70.7092	0.4688
76.0048	0.4916
84.9217	0.5001
84.9213	0.5084
76.0045	0.5312
70.7091	0.5626
70.7092	0.5937
76.0048	0.6166
84.9217	0.6251
84.9213	0.6334
76.0045	0.6562
70.7091	0.6876
70.7092	0.7187
76.0048	0.7416
84.9217	0.7500
84.9213	0.7583
76.0045	0.7812
70.7091	0.8125
70.7092	0.8437
76.0048	0.8666
84.9217	0.8750
84.9213	0.8833
76.0045	0.9062
70.7091	0.9375
70.7092	0.9688
76.0048	0.9917
84.9217	1.0000
86.1589	0.0084
79.4547	0.0313
75.5226	0.0624
75.5227	0.0937
79.4550	0.1167
86.1593	0.1251
86.1589	0.1334
79.4547	0.1562
75.5226	0.1875
75.5227	0.2188
79.4550	0.2415
86.1593	0.2499
86.1589	0.2585
79.4547	0.2812
75.5226	0.3125
75.5227	0.3438
79.4550	0.3666
86.1593	0.3749
86.1589	0.3833
79.4547	0.4063
75.5226	0.4376
75.5227	0.4687
79.4550	0.4916
86.1593	0.5000
86.1589	0.5084
79.4547	0.5313
75.5226	0.5624
75.5227	0.5937
79.4550	0.6167
86.1593	0.6251
86.1589	0.6334
79.4547	0.6562
75.5226	0.6875
75.5227	0.7188
79.4550	0.7415
86.1593	0.7499
86.1589	0.7585
79.4547	0.7812
75.5226	0.8125
75.5227	0.8436
79.4550	0.8666
86.1593	0.8749
86.1589	0.8833
79.4547	0.9063
75.5226	0.9374
75.5227	0.9687
79.4550	0.9916
86.1593	1.0000
87.4239	0.0085
82.9469	0.0313
80.3442	0.0626
80.3443	0.0937
82.9472	0.1167
87.4243	0.1250
87.4239	0.1335
82.9469	0.1563
80.3442	0.1876
80.3443	0.2186
82.9472	0.2417
87.4243	0.2499
87.4239	0.2584
82.9469	0.2812
80.3442	0.3125
80.3443	0.3439
82.9472	0.3667
87.4243	0.3749
87.4239	0.3834
82.9469	0.4062
80.3442	0.4375
80.3443	0.4688
82.9472	0.4916
87.4243	0.4999
87.4239	0.5084
82.9469	0.5312
80.3442	0.5625
80.3443	0.5938
82.9472	0.6166
87.4243	0.6251
87.4239	0.6333
82.9469	0.6561
80.3442	0.6875
80.3443	0.7188
82.9472	0.7416
87.4243	0.7501
87.4239	0.7583
82.9469	0.7814
80.3442	0.8124
80.3443	0.8437
82.9472	0.8665
87.4243	0.8750
87.4239	0.8833
82.9469	0.9063
80.3442	0.9374
80.3443	0.9687
82.9472	0.9915
87.4243	1.0000
88.7073	0.0082
86.4667	0.0312
85.1709	0.0624
85.1710	0.0936
86.4670	0.1166
88.7077	0.1248
88.7073	0.1334
86.4667	0.1564
85.1709	0.1876
85.1710	0.2188
86.4670	0.2418
88.7077	0.2500
88.7073	0.2582
86.4667	0.2812
85.1709	0.3124
85.1710	0.3436
86.4670	0.3666
88.7077	0.3748
88.7073	0.3834
86.4667	0.4064
85.1709	0.4376
85.1710	0.4688
86.4670	0.4918
88.7077	0.5000
88.7073	0.5082
86.4667	0.5312
85.1709	0.5624
85.1710	0.5936
86.4670	0.6166
88.7077	0.6248
88.7073	0.6334
86.4667	0.6560
85.1709	0.6876
85.1710	0.7188
86.4670	0.7418
88.7077	0.7500
88.7073	0.7582
86.4667	0.7812
85.1709	0.8124
85.1710	0.8436
86.4670	0.8666
88.7077	0.8748
88.7073	0.8834
86.4667	0.9060
85.1709	0.9376
85.1710	0.9688
86.4670	0.9913
88.7077	1.0000

APPENDIX H

ESA.DAT Data File

Obliquity (degrees)	Cum. Prob.
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
74.9998	0.0167
44.9998	0.0625
14.9998	0.1250
15.0001	0.1875
45.0002	0.2333
75.0002	0.2500

74.9998	0.2667
44.9998	0.3125
14.9998	0.3750
15.0002	0.4375
45.0002	0.4833
75.0002	0.5000
74.9998	0.5167
44.9998	0.5625
14.9998	0.6250
15.0002	0.6875
5.0002	0.7333
75.0002	0.7500
74.9998	0.7667
44.9998	0.8125
14.9998	0.8750
15.0002	0.9375
45.0002	0.9833
75.0002	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000

0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
75.0582	0.0079
45.2174	0.0294
15.7930	0.0588
15.7934	0.0882
45.2178	0.1098
75.0586	0.1176
75.0582	0.1373
45.2174	0.1912
15.7930	0.2647
15.7934	0.3382
45.2178	0.3921
75.0586	0.4118
75.0582	0.4315
45.2174	0.4853
15.7930	0.5588
15.7934	0.6324
45.2178	0.6862
75.0586	0.7059
75.0582	0.7256
45.2174	0.7794
15.7930	0.8529
15.7934	0.9265
45.2178	0.9803
75.0586	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000

0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
75.2329	0.0000
45.8638	0.0000
17.9637	0.0000
17.9641	0.0000
45.8642	0.0000
75.2333	0.0000
75.2329	0.0223
45.8638	0.0833
17.9637	0.1667
17.9640	0.2500
45.8642	0.3110
75.2333	0.3333
75.2329	0.3557
45.8638	0.4167
17.9637	0.5000
17.9640	0.5833
45.8642	0.6443
75.2333	0.6667
75.2329	0.6890
45.8638	0.7500
17.9637	0.8333
17.9640	0.9167
45.8642	0.9777
75.2333	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000

0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
75.5223	0.0000
46.9203	0.0000
21.0904	0.0000
21.0908	0.0000
46.9207	0.0000
75.5227	0.0000
75.5223	0.0087
46.9203	0.0326
21.0904	0.0652
21.0907	0.0978
46.9207	0.1217
75.5227	0.1304
75.5223	0.1595
46.9203	0.2391
21.0904	0.3478
21.0907	0.4565
46.9207	0.5361
75.5227	0.5652
75.5223	0.5943
46.9203	0.6739
21.0904	0.7826
21.0907	0.8913
46.9207	0.9709
75.5227	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	1.0000
0.0000	0.0000
0.0000	0.0000

0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
75.9237	0.0000
48.3586	0.0000
24.8141	0.0000
24.8145	0.0000
48.3590	0.0000
75.9241	0.0000
75.9237	0.0000
48.3586	0.0000
24.8141	0.0000
24.8143	0.0000
48.3590	0.0000

75.9241	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.9237	0.0298	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48.3586	0.1111	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24.8141	0.2222	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24.8143	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48.3590	0.4147	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.9241	0.4444	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.9237	0.4817	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48.3586	0.5833	76.4335	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24.8141	0.7222	50.1441	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24.8143	0.8611	28.9044	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48.3590	0.9628	28.9048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.9241	1.0000	50.1445	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	1.0000	76.4339	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	1.0000	76.4335	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	1.0000	50.1441	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	1.0000	28.9044	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	28.9047	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	50.1445	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	76.4339	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	76.4335	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	50.1441	0.0227	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	28.9044	0.0455	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	28.9047	0.0682	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	50.1445	0.0848	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	76.4339	0.0909	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	76.4335	0.1518	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	50.1441	0.3182	77.0472	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	28.9044	0.5454	52.2386	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	28.9047	0.7727	33.2259	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	50.1445	0.9391	33.2262	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	76.4339	1.0000	52.2389	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	1.0000	77.0476	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	1.0000	77.0472	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	1.0000	52.2386	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	1.0000	33.2259	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	33.2261	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	52.2389	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	77.0476	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	77.0472	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	52.2386	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	33.2259	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	33.2261	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	52.2389	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	77.0476	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	77.0472	0.0670	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	52.2386	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	33.2259	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	33.2261	0.7500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	52.2389	0.9330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	77.0476	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.0056
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.0208
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.0417
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.0625
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.0777
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7077	0.0833
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.0889
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.1041
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.1250
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.1458
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.1610
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7077	0.1666
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.1722
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.1874
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.2083
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.2291
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.2443
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7077	0.2499
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.2555
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.2708
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.2916
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.3124
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.3277
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7077	0.3332
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.3388
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.3541
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.3749
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.3957
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.4110
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7077	0.4165
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.4221
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.4374
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.4582
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.4790
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.4943
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7077	0.4999
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	88.7073	0.5054
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4667	0.5207
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1709	0.5415
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85.1710	0.5623
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	86.4670	0.5776

88.7077	0.5832	82.9472	0.3277	75.5227	0.0625	0.0000	1.0000	0.0000	0.9167	72.6125	0.6611
88.7073	0.5887	87.4243	0.3333	79.4550	0.0778	0.0000	1.0000	0.0000	0.9223	83.7205	0.6667
86.4667	0.6040	87.4239	0.3389	86.1593	0.0833	0.0000	1.0000	0.0000	0.9375	83.7201	0.6723
85.1709	0.6248	82.9469	0.3542	86.1589	0.0889	0.0000	1.0000	0.0000	0.9584	72.6122	0.6875
85.1710	0.6456	80.3442	0.3750	79.4547	0.1042	0.0000	1.0000	0.0000	0.9792	65.9071	0.7084
86.4670	0.6609	80.3443	0.3958	75.5226	0.1250	0.0000	1.0000	0.0000	0.9944	65.9072	0.7292
88.7077	0.6665	82.9472	0.4111	75.5227	0.1458	0.0000	1.0000	0.0000	1.0000	72.6125	0.7444
88.7073	0.6721	87.4243	0.4166	79.4550	0.1611	0.0000	1.0000	0.0000	1.0000	83.7205	0.7500
86.4667	0.6873	87.4239	0.4222	86.1593	0.1667	0.0000	1.0000	0.0000	1.0000	83.7201	0.7556
85.1709	0.7081	82.9469	0.4375	86.1589	0.1723	0.0000	1.0000	0.0000	1.0000	72.6122	0.7709
85.1710	0.7290	80.3442	0.4583	79.4547	0.1875	0.0000	1.0000	0.0000	1.0000	65.9071	0.7917
86.4670	0.7442	80.3443	0.4791	75.5226	0.2083	0.0000	1.0000	0.0000	1.0000	65.9072	0.8125
88.7077	0.7498	82.9472	0.4944	75.5227	0.2292	0.0000	1.0000	0.0000	1.0000	72.6125	0.8278
88.7073	0.7554	87.4243	0.5000	79.4550	0.2444	0.0000	1.0000	0.0000	1.0000	83.7205	0.8334
86.4667	0.7706	87.4239	0.5056	86.1593	0.2500	0.0000	1.0000	0.0000	1.0000	83.7201	0.8389
85.1709	0.7914	82.9469	0.5208	86.1589	0.2556	0.0000	1.0000	0.0000	1.0000	72.6122	0.8542
85.1710	0.8123	80.3442	0.5416	79.4547	0.2708	84.9213	0.0056	0.0000	1.0000	65.9071	0.8750
86.4670	0.8275	80.3443	0.5625	75.5226	0.2917	76.0045	0.0208	0.0000	1.0000	65.9072	0.8959
88.7077	0.8331	82.9472	0.5777	75.5227	0.3125	70.7091	0.0417	0.0000	1.0000	72.6125	0.9111
88.7073	0.8387	87.4243	0.5833	79.4550	0.3278	70.7093	0.0625	0.0000	1.0000	83.7205	0.9167
86.4667	0.8539	87.4239	0.5889	86.1593	0.3333	76.0048	0.0778	0.0000	1.0000	83.7201	0.9223
85.1709	0.8747	82.9469	0.6041	86.1589	0.3389	84.9217	0.0833	0.0000	1.0000	72.6122	0.9375
85.1710	0.8956	80.3442	0.6250	79.4547	0.3542	84.9213	0.0889	0.0000	1.0000	65.9071	0.9584
86.4670	0.9108	80.3443	0.6458	75.5226	0.3750	76.0045	0.1042	0.0000	1.0000	65.9072	0.9792
88.7077	0.9164	82.9472	0.6611	75.5227	0.3959	70.7091	0.1250	0.0000	1.0000	72.6125	0.9944
88.7073	0.9220	87.4243	0.6666	79.4550	0.4111	70.7092	0.1458	0.0000	1.0000	83.7205	1.0000
86.4667	0.9372	87.4239	0.6722	86.1593	0.4167	76.0048	0.1611	0.0000	1.0000	0.0000	1.0000
85.1709	0.9581	82.9469	0.6875	86.1589	0.4223	84.9217	0.1667	0.0000	1.0000	0.0000	1.0000
85.1710	0.9789	80.3442	0.7083	79.4547	0.4375	84.9213	0.1723	0.0000	1.0000	0.0000	1.0000
86.4670	0.9941	80.3443	0.7291	75.5226	0.4584	76.0045	0.1875	0.0000	1.0000	0.0000	1.0000
88.7077	0.9997	82.9472	0.7444	75.5227	0.4792	70.7091	0.2083	0.0000	1.0000	0.0000	1.0000
0.0000	0.9997	87.4243	0.7500	79.4550	0.4944	70.7092	0.2292	0.0000	1.0000	0.0000	1.0000
0.0000	0.9997	87.4239	0.7556	86.1593	0.5000	76.0048	0.2444	0.0000	1.0000	0.0000	1.0000
0.0000	0.9997	82.9469	0.7708	86.1589	0.5056	84.9217	0.2500	0.0000	1.0000	0.0000	1.0000
0.0000	0.9997	80.3442	0.7916	79.4547	0.5209	84.9213	0.2556	0.0000	1.0000	0.0000	1.0000
0.0000	0.9997	80.3443	0.8125	75.5226	0.5417	76.0045	0.2708	83.7201	0.0056	0.0000	1.0000
0.0000	0.9997	82.9472	0.8277	75.5227	0.5625	70.7091	0.2917	72.6122	0.0208	0.0000	1.0000
0.0000	0.9997	87.4243	0.8333	79.4550	0.5778	70.7092	0.3125	65.9071	0.0417	0.0000	1.0000
0.0000	0.9997	87.4239	0.8389	86.1593	0.5834	76.0048	0.3278	65.9073	0.0625	0.0000	1.0000
0.0000	0.9997	82.9469	0.8541	86.1589	0.5889	84.9217	0.3333	72.6125	0.0778	0.0000	1.0000
0.0000	0.9997	80.3442	0.8750	79.4547	0.6042	84.9213	0.3389	83.7205	0.0833	0.0000	1.0000
0.0000	0.9997	80.3443	0.8958	75.5226	0.6250	76.0045	0.3542	83.7201	0.0889	0.0000	1.0000
0.0000	0.9997	82.9472	0.9110	75.5227	0.6459	70.7091	0.3750	72.6122	0.1042	0.0000	1.0000
0.0000	0.9997	87.4243	0.9166	79.4550	0.6611	70.7092	0.3958	65.9071	0.1250	0.0000	1.0000
0.0000	0.9997	87.4239	0.9222	86.1593	0.6667	76.0048	0.4111	65.9072	0.1458	0.0000	1.0000
0.0000	0.9997	82.9469	0.9375	86.1589	0.6723	84.9217	0.4167	72.6125	0.1611	0.0000	1.0000
0.0000	0.9997	80.3442	0.9583	79.4547	0.6875	84.9213	0.4223	83.7205	0.1667	0.0000	1.0000
0.0000	0.9997	80.3443	0.9791	75.5226	0.7084	76.0045	0.4375	83.7201	0.1723	0.0000	1.0000
0.0000	0.9997	82.9472	0.9944	75.5227	0.7292	70.7091	0.4583	72.6122	0.1875	0.0000	1.0000
0.0000	0.9997	87.4243	1.0000	79.4550	0.7444	70.7092	0.4792	65.9071	0.2083	0.0000	1.0000
0.0000	0.9997	0.0000	1.0000	86.1593	0.7500	76.0048	0.4944	65.9072	0.2292	0.0000	1.0000
0.0000	0.9997	0.0000	1.0000	86.1589	0.7556	84.9217	0.5000	72.6125	0.2444	0.0000	1.0000
0.0000	0.9997	0.0000	1.0000	79.4547	0.7709	84.9213	0.5056	83.7205	0.2500	0.0000	1.0000
0.0000	0.9997	0.0000	1.0000	75.5226	0.7917	76.0045	0.5208	83.7201	0.2556	0.0000	1.0000
0.0000	0.9997	0.0000	1.0000	75.5227	0.8125	70.7091	0.5417	72.6122	0.2708	82.5643	0.0056
0.0000	0.9997	0.0000	1.0000	79.4550	0.8278	70.7092	0.5625	65.9071	0.2917	69.2951	0.0208
0.0000	0.9997	0.0000	1.0000	86.1593	0.8334	76.0048	0.5778	65.9072	0.3125	61.1210	0.0417
0.0000	0.9997	0.0000	1.0000	86.1589	0.8390	84.9217	0.5833	72.6125	0.3278	61.1212	0.0625
0.0000	0.9997	0.0000	1.0000	79.4547	0.8542	84.9213	0.5889	83.7205	0.3333	69.2954	0.0778
87.4239	0.0056	0.0000	1.0000	75.5226	0.8750	76.0045	0.6042	83.7201	0.3389	82.5647	0.0833
82.9469	0.0208	0.0000	1.0000	75.5227	0.8959	70.7091	0.6250	72.6122	0.3542	82.5643	0.0889
80.3442	0.0417	0.0000	1.0000	79.4550	0.9111	70.7092	0.6458	65.9071	0.3750	69.2951	0.1042
80.3443	0.0625	0.0000	1.0000	86.1593	0.9167	76.0048	0.6611	65.9072	0.3958	61.1210	0.1250
82.9472	0.0777	0.0000	1.0000	86.1589	0.9223	84.9217	0.6667	72.6125	0.4111	61.1211	0.1458
87.4243	0.0833	0.0000	1.0000	79.4547	0.9375	0.0000	0.6723	83.7205	0.4167	69.2954	0.1611
87.4239	0.0889	0.0000	1.0000	75.5226	0.9584	0.0000	0.6875	83.7201	0.4223	82.5647	0.1667
82.9469	0.1042	0.0000	1.0000	75.5227	0.9792	0.0000	0.7084	72.6122	0.4375	82.5643	0.1722
80.3442	0.1250	0.0000	1.0000	79.4550	0.9945	0.0000	0.7292	65.9071	0.4583	69.2951	0.1875
80.3443	0.1458	0.0000	1.0000	86.1593	1.0000	0.0000	0.7444	65.9072	0.4792	61.1210	0.2083
82.9472	0.1611	0.0000	1.0000	0.0000	1.0000	0.0000	0.7500	72.6125	0.4944	61.1211	0.2292
87.4243	0.1667	0.0000	1.0000	0.0000	1.0000	0.0000	0.7556	83.7205	0.5000	69.2954	0.2444
87.4239	0.1722	0.0000	1.0000	0.0000	1.0000	0.0000	0.7709	83.7201	0.5056	82.5647	0.2500
82.9469	0.1875	0.0000	1.0000	0.0000	1.0000	0.0000	0.7917	72.6122	0.5208	82.5643	0.2556
80.3442	0.2083	0.0000	1.0000	0.0000	1.0000	0.0000	0.8125	65.9071	0.5417	69.2951	0.2708
80.3443	0.2292	0.0000	1.0000	0.0000	1.0000	0.0000	0.8278	65.9072	0.5625	61.1210	0.2917
82.9472	0.2444	0.0000	1.0000	0.0000	1.0000	0.0000	0.8334	72.6125	0.5778	61.1211	0.3125
87.4243	0.2500	0.0000	1.0000	0.0000	1.0000	0.0000	0.8389	83.7205	0.5833	69.2954	0.3278
87.4239	0.2556	0.0000	1.0000	0.0000	1.0000	0.0000	0.8542	83.7201	0.5889	82.5647	0.3333
82.9469	0.2708	86.1589	0.0056	0.0000	1.0000	0.0000	0.8750	72.6122	0.6042	82.5643	0.3389
80.3442	0.2917	79.4547	0.0208	0.0000	1.0000	0.0000	0.8959	65.9071	0.6250	69.2951	0.3542
80.3443	0.3125	75.5226	0.0417	0.0000	1.0000	0.0000	0.9111	65.9072	0.6459	61.1210	0.3750

61.1211	0.3958	56.3559	0.1250	0.0000	1.0001	62.9662	0.9944	46.9206	0.7292	42.2735	0.4583
69.2954	0.4111	56.3561	0.1458	0.0000	1.0001	80.4236	1.0000	60.0002	0.7444	42.2736	0.4792
82.5647	0.4167	66.0728	0.1611	0.0000	1.0001	0.0000	1.0000	79.4549	0.7500	57.2024	0.4944
82.5643	0.4223	81.4629	0.1667	0.0000	1.0001	0.0000	1.0000	79.4545	0.7556	78.5646	0.5000
69.2951	0.4375	81.4625	0.1723	0.0000	1.0001	0.0000	1.0000	59.9999	0.7708	78.5641	0.5056
61.1210	0.4583	66.0724	0.1875	0.0000	1.0001	0.0000	1.0000	46.9205	0.7917	57.2021	0.5208
61.1211	0.4792	56.3559	0.2083	0.0000	1.0001	0.0000	1.0000	46.9206	0.8125	42.2735	0.5417
69.2954	0.4944	56.3561	0.2292	0.0000	1.0001	0.0000	1.0000	60.0002	0.8277	42.2736	0.5625
82.5647	0.5000	66.0728	0.2444	0.0000	1.0001	0.0000	1.0000	79.4549	0.8333	57.2024	0.5777
82.5643	0.5056	81.4629	0.2500	0.0000	1.0001	0.0000	1.0000	79.4545	0.8389	78.5646	0.5833
69.2951	0.5208	81.4625	0.2556	0.0000	1.0001	0.0000	1.0000	59.9999	0.8542	78.5641	0.5889
61.1210	0.5417	66.0724	0.2708	80.4232	0.0056	0.0000	1.0000	46.9205	0.8750	57.2021	0.6042
61.1211	0.5625	56.3559	0.2917	62.9659	0.0208	0.0000	1.0000	46.9206	0.8958	42.2735	0.6250
69.2954	0.5778	56.3561	0.3125	51.6192	0.0417	0.0000	1.0000	60.0002	0.9111	42.2736	0.6458
82.5647	0.5833	66.0728	0.3278	51.6195	0.0625	0.0000	1.0000	79.4549	0.9167	57.2024	0.6611
82.5643	0.5889	81.4629	0.3334	62.9662	0.0778	0.0000	1.0000	79.4545	0.9222	78.5646	0.6667
69.2951	0.6042	81.4625	0.3389	80.4236	0.0833	0.0000	1.0000	59.9999	0.9375	78.5641	0.6722
61.1210	0.6250	66.0724	0.3542	80.4232	0.0889	0.0000	1.0000	46.9205	0.9583	57.2021	0.6875
61.1211	0.6458	56.3559	0.3750	62.9659	0.1042	0.0000	1.0000	46.9206	0.9792	42.2735	0.7083
69.2954	0.6611	56.3561	0.3959	51.6192	0.1250	0.0000	1.0000	60.0002	0.9944	42.2736	0.7292
82.5647	0.6667	66.0728	0.4111	51.6193	0.1458	0.0000	1.0000	79.4549	1.0000	57.2024	0.7444
82.5643	0.6723	81.4629	0.4167	62.9662	0.1611	0.0000	1.0000	0.0000	1.0000	78.5646	0.7500
69.2951	0.6875	81.4625	0.4223	80.4236	0.1667	0.0000	1.0000	0.0000	1.0000	78.5641	0.7556
61.1210	0.7083	66.0724	0.4375	80.4232	0.1722	0.0000	1.0000	0.0000	1.0000	57.2021	0.7708
61.1212	0.7292	56.3559	0.4584	62.9659	0.1875	0.0000	1.0000	0.0000	1.0000	42.2735	0.7917
69.2954	0.7444	56.3561	0.4792	51.6192	0.2083	0.0000	1.0000	0.0000	1.0000	42.2736	0.8125
82.5647	0.7500	66.0728	0.4944	51.6193	0.2292	0.0000	1.0000	0.0000	1.0000	57.2024	0.8277
82.5643	0.7556	81.4629	0.5000	62.9662	0.2444	0.0000	1.0000	0.0000	1.0000	78.5646	0.8333
69.2951	0.7708	81.4625	0.5056	80.4236	0.2500	0.0000	1.0000	0.0000	1.0000	78.5641	0.8389
61.1210	0.7917	66.0724	0.5209	80.4232	0.2556	0.0000	1.0000	0.0000	1.0000	57.2021	0.8542
61.1211	0.8125	56.3559	0.5417	62.9659	0.2708	79.4545	0.0056	0.0000	1.0000	42.2735	0.8750
69.2954	0.8278	56.3561	0.5625	51.6192	0.2917	59.9999	0.0208	0.0000	1.0000	42.2736	0.8958
82.5647	0.8333	66.0728	0.5778	51.6193	0.3125	46.9205	0.0417	0.0000	1.0000	57.2024	0.9111
82.5643	0.8389	81.4629	0.5834	62.9662	0.3278	46.9207	0.0625	0.0000	1.0000	78.5646	0.9167
69.2951	0.8542	81.4625	0.5889	80.4236	0.3333	60.0002	0.0778	0.0000	1.0000	78.5641	0.9222
61.1210	0.8750	66.0724	0.6042	80.4232	0.3389	79.4549	0.0833	0.0000	1.0000	57.2021	0.9375
61.1211	0.8958	56.3559	0.6250	62.9659	0.3542	79.4545	0.0889	0.0000	1.0000	42.2735	0.9583
69.2954	0.9111	56.3561	0.6459	51.6192	0.3750	59.9999	0.1042	0.0000	1.0000	42.2736	0.9792
82.5647	0.9167	66.0728	0.6611	51.6193	0.3958	46.9205	0.1250	0.0000	1.0000	57.2024	0.9944
82.5643	0.9223	81.4629	0.6667	62.9662	0.4111	46.9206	0.1458	0.0000	1.0000	78.5646	1.0000
69.2951	0.9375	81.4625	0.6723	80.4236	0.4167	60.0002	0.1611	0.0000	1.0000	0.0000	1.0000
61.1210	0.9583	66.0724	0.6875	80.4232	0.4222	79.4549	0.1667	0.0000	1.0000	0.0000	1.0000
61.1211	0.9792	56.3559	0.7084	62.9659	0.4375	79.4545	0.1722	0.0000	1.0000	0.0000	1.0000
69.2954	0.9944	56.3561	0.7292	51.6192	0.4583	59.9999	0.1875	0.0000	1.0000	0.0000	1.0000
82.5647	1.0000	66.0728	0.7445	51.6193	0.4792	46.9205	0.2083	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	81.4629	0.7500	62.9662	0.4944	46.9206	0.2292	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	81.4625	0.7556	80.4236	0.5000	60.0002	0.2444	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	66.0724	0.7709	80.4232	0.5056	79.4549	0.2500	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	56.3559	0.7917	62.9659	0.5208	79.4545	0.2556	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	56.3561	0.8125	51.6192	0.5417	59.9999	0.2708	78.5641	0.0056	0.0000	1.0000
0.0000	1.0000	66.0728	0.8278	51.6193	0.5625	46.9205	0.2917	57.2021	0.0208	0.0000	1.0000
0.0000	1.0000	81.4629	0.8334	62.9662	0.5778	46.9206	0.3125	42.2735	0.0417	0.0000	1.0000
0.0000	1.0000	81.4625	0.8390	80.4236	0.5833	60.0002	0.3278	42.2738	0.0625	0.0000	1.0000
0.0000	1.0000	66.0724	0.8542	80.4232	0.5889	79.4549	0.3333	57.2024	0.0778	0.0000	1.0000
0.0000	1.0000	56.3559	0.8751	62.9659	0.6042	79.4545	0.3389	78.5646	0.0833	0.0000	1.0000
0.0000	1.0000	56.3561	0.8959	51.6192	0.6250	59.9999	0.3542	78.5641	0.0889	0.0000	1.0000
0.0000	1.0000	66.0728	0.9111	51.6193	0.6458	46.9205	0.3750	57.2021	0.1042	0.0000	1.0000
0.0000	1.0000	81.4629	0.9167	62.9662	0.6611	46.9206	0.3958	42.2735	0.1250	0.0000	1.0000
0.0000	1.0000	81.4625	0.9223	80.4236	0.6667	60.0002	0.4111	42.2736	0.1458	0.0000	1.0000
0.0000	1.0000	66.0724	0.9376	80.4232	0.6722	79.4549	0.4167	57.2024	0.1611	0.0000	1.0000
0.0000	1.0000	56.3559	0.9584	62.9659	0.6875	79.4545	0.4222	78.5646	0.1667	0.0000	1.0000
0.0000	1.0000	56.3561	0.9792	51.6192	0.7083	59.9999	0.4375	78.5641	0.1722	0.0000	1.0000
0.0000	1.0000	66.0728	0.9945	51.6193	0.7292	46.9205	0.4583	57.2021	0.1875	0.0000	1.0000
0.0000	1.0000	81.4629	1.0001	62.9662	0.7444	46.9206	0.4792	42.2735	0.2083	0.0000	1.0000
0.0000	1.0000	0.0000	1.0001	80.4236	0.7500	60.0002	0.4944	42.2736	0.2292	0.0000	1.0000
0.0000	1.0000	0.0000	1.0001	80.4232	0.7556	79.4549	0.5000	57.2024	0.2444	0.0000	1.0000
0.0000	1.0000	0.0000	1.0001	62.9659	0.7708	79.4545	0.5056	78.5646	0.2500	0.0000	1.0000
0.0000	1.0000	0.0000	1.0001	51.6192	0.7917	59.9999	0.5208	78.5641	0.2556	0.0000	1.0000
0.0000	1.0000	0.0000	1.0001	51.6193	0.8125	46.9205	0.5417	57.2021	0.2708	77.7595	0.0056
0.0000	1.0000	0.0000	1.0001	62.9662	0.8278	46.9206	0.5625	42.2735	0.2917	54.6036	0.0208
0.0000	1.0000	0.0000	1.0001	80.4236	0.8333	60.0002	0.5777	42.2736	0.3125	37.6984	0.0417
0.0000	1.0000	0.0000	1.0001	80.4232	0.8389	79.4549	0.5833	57.2024	0.3277	37.6987	0.0625
0.0000	1.0000	0.0000	1.0001	62.9659	0.8542	79.4545	0.5889	78.5646	0.3333	54.6039	0.0778
81.4625	0.0056	0.0000	1.0001	51.6192	0.8750	59.9999	0.6042	78.5641	0.3389	77.7599	0.0833
66.0724	0.0208	0.0000	1.0001	51.6193	0.8958	46.9205	0.6250	57.2021	0.3542	77.7595	0.0889
56.3559	0.0417	0.0000	1.0001	62.9662	0.9111	46.9206	0.6458	42.2735	0.3750	54.6036	0.1042
56.3562	0.0625	0.0000	1.0001	80.4236	0.9167	60.0002	0.6611	42.2736	0.3958	37.6984	0.1250
66.0728	0.0778	0.0000	1.0001	80.4232	0.9222	79.4549	0.6667	57.2024	0.4111	37.6986	0.1458
81.4629	0.0833	0.0000	1.0001	62.9659	0.9375	79.4545	0.6722	78.5646	0.4167	54.6039	0.1611
81.4625	0.0889	0.0000	1.0001	51.6192	0.9583	59.9999	0.6875	78.5641	0.4222	77.7599	0.1667
66.0724	0.1042	0.0000	1.0001	51.6193	0.9792	46.9205	0.7083	57.2021	0.4375	77.7595	0.1723

54.6036	0.1875	0.0000	1.0000	0.0000	1.0000	28.9044	0.7917	48.3586	0.5208	75.5223	0.2556
37.6984	0.2083	0.0000	1.0000	0.0000	1.0000	28.9047	0.8125	24.8141	0.5417	46.9203	0.2708
37.6986	0.2292	0.0000	1.0000	0.0000	1.0000	50.1445	0.8277	24.8143	0.5625	21.0904	0.2917
54.6039	0.2444	0.0000	1.0000	0.0000	1.0000	76.4339	0.8333	48.3590	0.5777	21.0907	0.3125
77.7599	0.2500	0.0000	1.0000	0.0000	1.0000	76.4335	0.8389	75.9241	0.5833	46.9207	0.3278
77.7595	0.2556	0.0000	1.0000	0.0000	1.0000	50.1441	0.8542	75.9237	0.5889	75.5227	0.3333
54.6036	0.2708	77.0472	0.0056	0.0000	1.0000	28.9044	0.8750	48.3586	0.6042	75.5223	0.3389
37.6984	0.2917	52.2386	0.0208	0.0000	1.0000	28.9047	0.8958	24.8141	0.6250	46.9203	0.3542
37.6986	0.3125	33.2259	0.0417	0.0000	1.0000	50.1445	0.9111	24.8143	0.6458	21.0904	0.3750
54.6039	0.3278	33.2262	0.0625	0.0000	1.0000	76.4339	0.9167	48.3590	0.6611	21.0908	0.3958
77.7599	0.3333	52.2389	0.0778	0.0000	1.0000	76.4335	0.9222	75.9241	0.6667	46.9207	0.4111
77.7595	0.3389	77.0476	0.0833	0.0000	1.0000	50.1441	0.9375	75.9237	0.6722	75.5227	0.4167
54.6036	0.3542	77.0472	0.0889	0.0000	1.0000	28.9044	0.9583	48.3586	0.6875	75.5223	0.4223
37.6984	0.3750	52.2386	0.1042	0.0000	1.0000	28.9047	0.9792	24.8141	0.7083	46.9203	0.4375
37.6986	0.3958	33.2259	0.1250	0.0000	1.0000	50.1445	0.9944	24.8145	0.7292	21.0904	0.4583
54.6039	0.4111	33.2261	0.1458	0.0000	1.0000	76.4339	1.0000	48.3590	0.7444	21.0907	0.4792
77.7599	0.4167	52.2389	0.1611	0.0000	1.0000	0.0000	1.0000	75.9241	0.7500	46.9207	0.4944
77.7595	0.4223	77.0476	0.1667	0.0000	1.0000	0.0000	1.0000	75.9237	0.7556	75.5227	0.5000
54.6036	0.4375	77.0472	0.1723	0.0000	1.0000	0.0000	1.0000	48.3586	0.7708	75.5223	0.5056
37.6984	0.4583	52.2386	0.1875	0.0000	1.0000	0.0000	1.0000	24.8141	0.7917	46.9203	0.5208
37.6986	0.4792	33.2259	0.2083	0.0000	1.0000	0.0000	1.0000	24.8143	0.8125	21.0904	0.5417
54.6039	0.4944	33.2261	0.2292	0.0000	1.0000	0.0000	1.0000	48.3590	0.8277	21.0907	0.5625
77.7599	0.5000	52.2389	0.2444	0.0000	1.0000	0.0000	1.0000	75.9241	0.8333	46.9207	0.5778
77.7595	0.5056	77.0476	0.2500	0.0000	1.0000	0.0000	1.0000	75.9237	0.8389	75.5227	0.5833
54.6036	0.5208	77.0472	0.2556	0.0000	1.0000	0.0000	1.0000	48.3586	0.8542	75.5223	0.5889
37.6984	0.5417	52.2386	0.2708	76.4335	0.0056	0.0000	1.0000	24.8141	0.8750	46.9203	0.6042
37.6986	0.5625	33.2259	0.2917	50.1441	0.0208	0.0000	1.0000	24.8143	0.8958	21.0904	0.6250
54.6039	0.5778	33.2261	0.3125	28.9044	0.0417	0.0000	1.0000	48.3590	0.9111	21.0907	0.6458
77.7599	0.5833	52.2389	0.3278	28.9048	0.0625	0.0000	1.0000	75.9241	0.9167	46.9207	0.6611
77.7595	0.5889	77.0476	0.3333	50.1445	0.0777	0.0000	1.0000	75.9237	0.9222	75.5227	0.6667
54.6036	0.6042	77.0472	0.3389	76.4339	0.0833	0.0000	1.0000	48.3586	0.9375	75.5223	0.6723
37.6984	0.6250	52.2386	0.3542	76.4335	0.0889	0.0000	1.0000	24.8141	0.9583	46.9203	0.6875
37.6986	0.6458	33.2259	0.3750	50.1441	0.1042	0.0000	1.0000	24.8143	0.9792	21.0904	0.7083
54.6039	0.6611	33.2261	0.3958	28.9044	0.1250	0.0000	1.0000	48.3590	0.9944	21.0907	0.7292
77.7599	0.6667	52.2389	0.4111	28.9047	0.1458	0.0000	1.0000	75.9241	1.0000	46.9207	0.7444
77.7595	0.6723	77.0476	0.4167	50.1445	0.1611	0.0000	1.0000	0.0000	1.0000	75.5227	0.7500
54.6036	0.6875	77.0472	0.4223	76.4339	0.1667	0.0000	1.0000	0.0000	1.0000	75.5223	0.7556
37.6984	0.7083	52.2386	0.4375	76.4335	0.1722	0.0000	1.0000	0.0000	1.0000	46.9203	0.7708
37.6986	0.7292	33.2259	0.4583	50.1441	0.1875	0.0000	1.0000	0.0000	1.0000	21.0904	0.7917
54.6039	0.7444	33.2261	0.4792	28.9044	0.2083	0.0000	1.0000	0.0000	1.0000	21.0907	0.8125
77.7599	0.7500	52.2389	0.4944	28.9047	0.2292	0.0000	1.0000	0.0000	1.0000	46.9207	0.8278
77.7595	0.7556	77.0476	0.5000	50.1445	0.2444	0.0000	1.0000	0.0000	1.0000	75.5227	0.8333
54.6036	0.7708	77.0472	0.5056	76.4339	0.2500	0.0000	1.0000	0.0000	1.0000	75.5223	0.8389
37.6984	0.7917	52.2386	0.5208	76.4335	0.2556	0.0000	1.0000	0.0000	1.0000	46.9203	0.8542
37.6986	0.8125	33.2259	0.5417	50.1441	0.2708	75.9237	0.0056	0.0000	1.0000	21.0904	0.8750
54.6039	0.8278	33.2261	0.5625	28.9044	0.2917	48.3586	0.0208	0.0000	1.0000	21.0907	0.8958
77.7599	0.8333	52.2389	0.5778	28.9047	0.3125	24.8141	0.0417	0.0000	1.0000	46.9207	0.9111
77.7595	0.8389	77.0476	0.5833	50.1445	0.3277	24.8145	0.0625	0.0000	1.0000	75.5227	0.9167
54.6036	0.8542	77.0472	0.5889	76.4339	0.3333	48.3590	0.0777	0.0000	1.0000	75.5223	0.9223
37.6984	0.8750	52.2386	0.6042	76.4335	0.3389	75.9241	0.0833	0.0000	1.0000	46.9203	0.9375
37.6986	0.8958	33.2259	0.6250	50.1441	0.3542	75.9237	0.0889	0.0000	1.0000	21.0904	0.9583
54.6039	0.9111	33.2261	0.6458	28.9044	0.3750	48.3586	0.1042	0.0000	1.0000	21.0907	0.9792
77.7599	0.9167	52.2389	0.6611	28.9047	0.3958	24.8141	0.1250	0.0000	1.0000	46.9207	0.9944
77.7595	0.9223	77.0476	0.6667	50.1445	0.4111	24.8143	0.1458	0.0000	1.0000	75.5227	1.0000
54.6036	0.9375	77.0472	0.6723	76.4339	0.4167	48.3590	0.1611	0.0000	1.0000	0.0000	1.0000
37.6984	0.9583	52.2386	0.6875	76.4335	0.4222	75.9241	0.1667	0.0000	1.0000	0.0000	1.0000
37.6986	0.9792	33.2259	0.7083	50.1441	0.4375	75.9237	0.1722	0.0000	1.0000	0.0000	1.0000
54.6039	0.9944	33.2261	0.7292	28.9044	0.4583	48.3586	0.1875	0.0000	1.0000	0.0000	1.0000
77.7599	1.0000	52.2389	0.7444	28.9047	0.4792	24.8141	0.2083	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	77.0476	0.7500	50.1445	0.4944	24.8143	0.2292	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	77.0472	0.7556	76.4339	0.5000	48.3590	0.2444	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	52.2386	0.7708	76.4335	0.5056	75.9241	0.2500	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	33.2259	0.7917	50.1441	0.5208	75.9237	0.2556	0.0000	1.0000	0.0000	1.0000
0.0000	1.0000	33.2261	0.8125	28.9044	0.5417	48.3586	0.2708	75.5223	0.0056	0.0000	1.0000
0.0000	1.0000	52.2389	0.8278	28.9047	0.5625	24.8141	0.2917	46.9203	0.0208	0.0000	1.0000
0.0000	1.0000	77.0476	0.8333	50.1445	0.5777	24.8143	0.3125	21.0904	0.0417	0.0000	1.0000
0.0000	1.0000	77.0472	0.8389	76.4339	0.5833	48.3590	0.3277	21.0908	0.0625	0.0000	1.0000
0.0000	1.0000	52.2386	0.8542	76.4335	0.5889	75.9241	0.3333	46.9207	0.0778	0.0000	1.0000
0.0000	1.0000	33.2259	0.8750	50.1441	0.6042	75.9237	0.3389	75.5227	0.0833	0.0000	1.0000
0.0000	1.0000	33.2261	0.8958	28.9044	0.6250	48.3586	0.3542	75.5223	0.0889	0.0000	1.0000
0.0000	1.0000	52.2389	0.9111	28.9047	0.6458	24.8141	0.3750	46.9203	0.1042	0.0000	1.0000
0.0000	1.0000	77.0476	0.9167	50.1445	0.6611	24.8143	0.3958	21.0904	0.1250	0.0000	1.0000
0.0000	1.0000	77.0472	0.9223	76.4339	0.6667	48.3590	0.4111	21.0907	0.1458	0.0000	1.0000
0.0000	1.0000	52.2386	0.9375	76.4335	0.6722	75.9241	0.4167	46.9207	0.1611	0.0000	1.0000
0.0000	1.0000	33.2259	0.9583	50.1441	0.6875	75.9237	0.4222	75.5227	0.1667	0.0000	1.0000
0.0000	1.0000	33.2261	0.9792	28.9044	0.7083	48.3586	0.4375	75.5223	0.1723	0.0000	1.0000
0.0000	1.0000	52.2389	0.9944	28.9047	0.7292	24.8141	0.4583	46.9203	0.1875	0.0000	1.0000
0.0000	1.0000	77.0476	1.0000	50.1445	0.7444	24.8143	0.4792	21.0904	0.2083	0.0000	1.0000
0.0000	1.0000	0.0000	1.0000	76.4339	0.7500	48.3590	0.4944	21.0907	0.2292	0.0000	1.0000
0.0000	1.0000	0.0000	1.0000	76.4335	0.7556	75.9241	0.5000	46.9207	0.2444	0.0000	1.0000
0.0000	1.0000	0.0000	1.0000	50.1441	0.7708	75.9237	0.5056	75.5227	0.2500	0.0000	1.0000

0.0000	1.0000	0.0000	1.0001	45.2174	0.8542	74.9998	0.5889
75.2329	0.0056	0.0000	1.0001	15.7930	0.8750	44.9998	0.6042
45.8638	0.0208	0.0000	1.0001	15.7934	0.8958	14.9998	0.6250
17.9637	0.0417	0.0000	1.0001	45.2178	0.9111	15.0002	0.6458
17.9641	0.0625	0.0000	1.0001	75.0586	0.9166	45.0002	0.6611
45.8642	0.0778	0.0000	1.0001	75.0582	0.9222	75.0002	0.6667
75.2333	0.0833	0.0000	1.0001	45.2174	0.9375	74.9998	0.6723
75.2329	0.0889	0.0000	1.0001	15.7930	0.9583	44.9998	0.6875
45.8638	0.1042	0.0000	1.0001	15.7934	0.9791	14.9998	0.7083
17.9637	0.1250	0.0000	1.0001	45.2178	0.9944	15.0001	0.7292
17.9640	0.1458	0.0000	1.0001	75.0586	1.0000	45.0002	0.7444
45.8642	0.1611	0.0000	1.0001	0.0000	1.0000	75.0002	0.7500
75.2333	0.1667	0.0000	1.0001	0.0000	1.0000	74.9998	0.7556
75.2329	0.1723	0.0000	1.0001	0.0000	1.0000	44.9998	0.7708
45.8638	0.1875	0.0000	1.0001	0.0000	1.0000	14.9998	0.7917
17.9637	0.2083	0.0000	1.0001	0.0000	1.0000	15.0002	0.8125
17.9640	0.2292	0.0000	1.0001	0.0000	1.0000	45.0002	0.8278
45.8642	0.2444	0.0000	1.0001	0.0000	1.0000	75.0002	0.8333
75.2333	0.2500	0.0000	1.0001	0.0000	1.0000	74.9998	0.8389
75.2329	0.2556	0.0000	1.0001	0.0000	1.0000	44.9998	0.8542
45.8638	0.2708	75.0582	0.0056	0.0000	1.0000	14.9998	0.8750
17.9637	0.2917	45.2174	0.0208	0.0000	1.0000	15.0002	0.8958
17.9640	0.3125	15.7930	0.0417	0.0000	1.0000	45.0002	0.9111
45.8642	0.3278	15.7934	0.0625	0.0000	1.0000	75.0002	0.9167
75.2333	0.3334	45.2178	0.0778	0.0000	1.0000	74.9998	0.9223
75.2329	0.3389	75.0586	0.0833	0.0000	1.0000	44.9998	0.9375
45.8638	0.3542	75.0582	0.0889	0.0000	1.0000	14.9998	0.9583
17.9637	0.3750	45.2174	0.1042	0.0000	1.0000	15.0002	0.9792
17.9640	0.3959	15.7930	0.1250	0.0000	1.0000	45.0002	0.9944
45.8642	0.4111	15.7934	0.1458	0.0000	1.0000	75.0002	1.0000
75.2333	0.4167	45.2178	0.1611	0.0000	1.0000	0.0000	1.0000
75.2329	0.4223	75.0586	0.1667	0.0000	1.0000	0.0000	1.0000
45.8638	0.4375	75.0582	0.1722	0.0000	1.0000	0.0000	1.0000
17.9637	0.4584	45.2174	0.1875	0.0000	1.0000	0.0000	1.0000
17.9640	0.4792	15.7930	0.2083	0.0000	1.0000	0.0000	1.0000
45.8642	0.4944	15.7934	0.2292	0.0000	1.0000	0.0000	1.0000
75.2333	0.5000	45.2178	0.2444	0.0000	1.0000	0.0000	1.0000
75.2329	0.5056	75.0586	0.2500	0.0000	1.0000	0.0000	1.0000
45.8638	0.5209	75.0582	0.2556	0.0000	1.0000	0.0000	1.0000
17.9637	0.5417	45.2174	0.2708	74.9998	0.0056	0.0000	1.0000
17.9640	0.5625	15.7930	0.2917	44.9998	0.0208	0.0000	1.0000
45.8642	0.5778	15.7934	0.3125	14.9998	0.0417	0.0000	1.0000
75.2333	0.5834	45.2178	0.3277	15.0001	0.0625	0.0000	1.0000
75.2329	0.5889	75.0586	0.3333	45.0002	0.0778	0.0000	1.0000
45.8638	0.6042	75.0582	0.3389	75.0002	0.0833	0.0000	1.0000
17.9637	0.6250	45.2174	0.3542	74.9998	0.0889	0.0000	1.0000
17.9640	0.6459	15.7930	0.3750	44.9998	0.1042	0.0000	1.0000
45.8642	0.6611	15.7934	0.3958	14.9998	0.1250	0.0000	1.0000
75.2333	0.6667	45.2178	0.4111	15.0002	0.1458	0.0000	1.0000
75.2329	0.6723	75.0586	0.4167	45.0002	0.1611	0.0000	1.0000
45.8638	0.6875	75.0582	0.4222	75.0002	0.1667	0.0000	1.0000
17.9637	0.7084	45.2174	0.4375	74.9998	0.1723	0.0000	1.0000
17.9641	0.7292	15.7930	0.4583	44.9998	0.1875	0.0000	1.0000
45.8642	0.7445	15.7934	0.4792	14.9998	0.2083	0.0000	1.0000
75.2333	0.7500	45.2178	0.4944	15.0002	0.2292	0.0000	1.0000
75.2329	0.7556	75.0586	0.5000	45.0002	0.2444	0.0000	1.0000
45.8638	0.7709	75.0582	0.5056	75.0002	0.2500	0.0000	1.0000
17.9637	0.7917	45.2174	0.5208	74.9998	0.2556	0.0000	1.0000
17.9640	0.8125	15.7930	0.5417	44.9998	0.2708		
45.8642	0.8278	15.7934	0.5625	14.9998	0.2917		
75.2333	0.8334	45.2178	0.5777	15.0002	0.3125		
75.2329	0.8390	75.0586	0.5833	45.0002	0.3278		
45.8638	0.8542	75.0582	0.5889	75.0002	0.3333		
17.9637	0.8750	45.2174	0.6042	74.9998	0.3389		
17.9640	0.8959	15.7930	0.6250	44.9998	0.3542		
45.8642	0.9111	15.7934	0.6458	14.9998	0.3750		
75.2333	0.9167	45.2178	0.6611	15.0002	0.3958		
75.2329	0.9223	75.0586	0.6667	45.0002	0.4111		
45.8638	0.9375	75.0582	0.6722	75.0002	0.4167		
17.9637	0.9584	45.2174	0.6875	74.9998	0.4223		
17.9640	0.9792	15.7930	0.7083	44.9998	0.4375		
45.8642	0.9945	15.7934	0.7292	14.9998	0.4583		
75.2333	1.0001	45.2178	0.7444	15.0002	0.4792		
0.0000	1.0001	75.0586	0.7500	45.0002	0.4944		
0.0000	1.0001	75.0582	0.7556	75.0002	0.5000		
0.0000	1.0001	45.2174	0.7708	74.9998	0.5056		
0.0000	1.0001	15.7930	0.7917	44.9998	0.5208		
0.0000	1.0001	15.7934	0.8125	14.9998	0.5417		
0.0000	1.0001	45.2178	0.8277	15.0002	0.5625		
0.0000	1.0001	75.0586	0.8333	45.0002	0.5778		
0.0000	1.0001	75.0582	0.8389	75.0002	0.5833		

APPENDIX I

NODE2.DAT Data File

Obliquity (degrees)	Cum. Prob.
89.9999	0.0000
89.9999	0.0000
89.9999	0.0000
89.9999	0.0000
89.9999	0.0000
90.0000	0.0000
90.0000	0.0000
90.0000	0.0000
90.0000	0.0000
90.0000	0.0000
90.0001	0.0000
90.0001	0.0000
90.0001	0.0000
90.0001	0.0000
90.0001	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
0.0003	0.0937
0.0003	0.1875
0.0003	0.2812
0.0003	0.3749
0.0003	0.4686
0.0003	0.5623
0.0003	0.6561
0.0003	0.7498
0.0003	1.0000
88.7073	0.0025
88.7073	0.0050
88.7073	0.0074
88.7073	0.0099
88.7073	0.0124
86.4667	0.0185
86.4667	0.0249
86.4667	0.0317
86.4667	0.0385
86.4667	0.0453
85.1709	0.0453
85.1709	0.0453
85.1709	0.0480
85.1709	0.0536
85.1709	0.0619
85.1710	0.0619
85.1710	0.0619
85.1710	0.0647
85.1710	0.0702
85.1710	0.0786
86.4670	0.0847
86.4670	0.0911
86.4670	0.0979
86.4670	0.1046
86.4670	0.1114
88.7077	0.1139
88.7077	0.1164
88.7077	0.1189
88.7077	0.1213
88.7077	0.1238
4.9999	0.2059
4.9999	0.2881
4.9999	0.3702
4.9999	0.4523
4.9999	0.5344
4.9999	0.6165
4.9999	0.6986
4.9999	0.7808
4.9999	1.0000
87.4239	0.0046
87.4239	0.0093
87.4239	0.0139
87.4239	0.0186
87.4239	0.0232
82.9469	0.0296
82.9469	0.0385
82.9469	0.0499
82.9469	0.0626
82.9469	0.0753
80.3442	0.0753
80.3442	0.0753
80.3442	0.0753
80.3442	0.0788
80.3442	0.0926
80.3443	0.0926
80.3443	0.0926
80.3443	0.0926
80.3443	0.0961
80.3443	0.1100
82.9472	0.1163
82.9472	0.1252
82.9472	0.1366
82.9472	0.1493
82.9472	0.1620
87.4243	0.1667
87.4243	0.1713
87.4243	0.1760
87.4243	0.1806
87.4243	0.1853
10.0000	0.2616
10.0000	0.3380
10.0000	0.4143
10.0000	0.4907
10.0000	0.5671
10.0000	0.6434
10.0000	0.7198
10.0000	0.7961
10.0000	1.0000
86.1589	0.0068
86.1589	0.0137
86.1589	0.0205
86.1589	0.0274
86.1589	0.0342
79.4547	0.0361
79.4547	0.0435
79.4547	0.0547
79.4547	0.0716
79.4547	0.0902
75.5226	0.0902
75.5226	0.0902
75.5226	0.0902
75.5226	0.0902
75.5226	0.1055
75.5227	0.1055
75.5227	0.1055
75.5227	0.1055
75.5227	0.1055
75.5227	0.1209
79.4550	0.1227
79.4550	0.1302
79.4550	0.1414
79.4550	0.1582
79.4550	0.1769
86.1593	0.1837
86.1593	0.1906
86.1593	0.1974
86.1593	0.2042
86.1593	0.2111
15.0000	0.2850
15.0000	0.3590
15.0000	0.4329
15.0000	0.5068
15.0000	0.5808
15.0000	0.6547
15.0000	0.7287
15.0000	0.8026
15.0000	1.0000
84.9213	0.0080
84.9213	0.0169
84.9213	0.0259
84.9213	0.0348
84.9213	0.0437
76.0045	0.0437
76.0045	0.0486
76.0045	0.0608
76.0045	0.0802
76.0045	0.1046
70.7091	0.1046
70.7091	0.1046
70.7091	0.1046
70.7091	0.1046
70.7091	0.1213
70.7092	0.1213
70.7092	0.1213
70.7092	0.1213
70.7092	0.1213
70.7092	0.1379
76.0048	0.1379
76.0048	0.1428
76.0048	0.1549
76.0048	0.1744
76.0048	0.1988
84.9217	0.2068
84.9217	0.2157
84.9217	0.2247
84.9217	0.2336
84.9217	0.2425
20.0000	0.3135
20.0000	0.3845
20.0000	0.4555
20.0000	0.5265
20.0000	0.5975
20.0000	0.6685
20.0000	0.7395
20.0000	0.8105
20.0000	1.0000
83.7201	0.0078
83.7201	0.0190
83.7201	0.0301
83.7201	0.0413
83.7201	0.0524
72.6122	0.0524
72.6122	0.0524
72.6122	0.0616
72.6122	0.0829
72.6122	0.1134
65.9071	0.1134
65.9071	0.1134
65.9071	0.1134
65.9071	0.1134
65.9071	0.1301
65.9072	0.1301
65.9072	0.1301
65.9072	0.1301
65.9072	0.1301
65.9072	0.1467
72.6125	0.1467
72.6125	0.1467
72.6125	0.1559
72.6125	0.1772
72.6125	0.2077
83.7205	0.2155
83.7205	0.2267
83.7205	0.2378
83.7205	0.2490
83.7205	0.2602
25.0000	0.3295
25.0000	0.3988
25.0000	0.4682
25.0000	0.5375
25.0000	0.6069
25.0000	0.6762
25.0000	0.7455
25.0000	0.8149
25.0000	1.0000
82.5643	0.0054
82.5643	0.0134
82.5643	0.0269
82.5643	0.0403
82.5643	0.0538
69.2951	0.0538
69.2951	0.0538
69.2951	0.0611
69.2951	0.0832
69.2951	0.1199
61.1210	0.1199
61.1210	0.1199
61.1210	0.1199
61.1210	0.1199
61.1210	0.1400
61.1211	0.1400
61.1211	0.1400
61.1211	0.1400
61.1211	0.1400
61.1211	0.1601
69.2954	0.1601
69.2954	0.1601
69.2954	0.1674
69.2954	0.1894
69.2954	0.2262
82.5647	0.2316
82.5647	0.2396
82.5647	0.2531
82.5647	0.2665
82.5647	0.2800
30.0000	0.3475
30.0000	0.4149
30.0000	0.4824
30.0000	0.5499
30.0000	0.6174
30.0000	0.6849
30.0000	0.7524
30.0000	0.8198
30.0000	1.0000
81.4625	0.0016
81.4625	0.0096
81.4625	0.0255
81.4625	0.0415
81.4625	0.0574
66.0724	0.0574
66.0724	0.0574
66.0724	0.0618
66.0724	0.0836
66.0724	0.1271
56.3559	0.1271
56.3559	0.1271
56.3559	0.1271
56.3559	0.1271
56.3559	0.1480
56.3561	0.1480
56.3561	0.1480
56.3561	0.1480
56.3561	0.1480
56.3561	0.1688
66.0728	0.1688
66.0728	0.1688
66.0728	0.1731
66.0728	0.1949
66.0728	0.2385
81.4629	0.2401
81.4629	0.2481
81.4629	0.2640
81.4629	0.2800
81.4629	0.2959
35.0000	0.3619
35.0000	0.4279
35.0000	0.4939
35.0000	0.5599
35.0000	0.6259
35.0000	0.6918
35.0000	0.7578
35.0000	0.8238
35.0000	1.0000
80.4232	0.0000
80.4232	0.0075
80.4232	0.0245
80.4232	0.0433
80.4232	0.0621
62.9659	0.0621
62.9659	0.0621
62.9659	0.0621
62.9659	0.0826
62.9659	0.1289
51.6192	0.1289
51.6192	0.1289
51.6192	0.1289
51.6192	0.1289
51.6192	0.1535
51.6193	0.1535
51.6193	0.1535
51.6193	0.1535
51.6193	0.1535
51.6193	0.1780
62.9662	0.1780
62.9662	0.1780
62.9662	0.1780
62.9662	0.1986
62.9662	0.2448
80.4236	0.2448
80.4236	0.2524
80.4236	0.2693
80.4236	0.2881
80.4236	0.3069
40.0001	0.3719
40.0001	0.4368
40.0001	0.5018
40.0001	0.5668
40.0001	0.6317
40.0001	0.6967
40.0001	0.7616
40.0001	0.8266
40.0001	1.0000
79.4545	0.0000
79.4545	0.0065
79.4545	0.0237
79.4545	0.0452
79.4545	0.0667
59.9999	0.0667
59.9999	0.0667
59.9999	0.0667
59.9999	0.0903
59.9999	0.1432
46.9205	0.1432
46.9205	0.1432
46.9205	0.1432
46.9205	0.1432
46.9205	0.1673
46.9206	0.1673
46.9206	0.1673
46.9206	0.1673
46.9206	0.1673
46.9206	0.1914
60.0002	0.1914
60.0002	0.1914
60.0002	0.1914
60.0002	0.2149
60.0002	0.2678
79.4549	0.2678
79.4549	0.2743
79.4549	0.2915
79.4549	0.3130
79.4549	0.3345
45.0001	0.3969
45.0001	0.4593
45.0001	0.5217
45.0001	0.5840
45.0001	0.6464
45.0001	0.7088
45.0001	0.7711
45.0001	0.8335
45.0001	1.0000
78.5641	0.0000
78.5641	0.0050
78.5641	0.0224
78.5641	0.0472
78.5641	0.0720
57.2021	0.0720
57.2021	0.0720
57.2021	0.0720
57.2021	0.0924
57.2021	0.1501
42.2735	0.1501
42.2735	0.1501
42.2735	0.1501
42.2735	0.1501
42.2735	0.1779
42.2736	0.1779
42.2736	0.1779
42.2736	0.1779
42.2736	0.1779
42.2736	0.2057
57.2024	0.2057
57.2024	0.2057
57.2024	0.2057
57.2024	0.2260
57.2024	0.2837
78.5646	0.2837
78.5646	0.2887
78.5646	0.3061
78.5646	0.3309
78.5646	0.3557
50.0001	0.4161
50.0001	0.4765
50.0001	0.5369
50.0001	0.5973
50.0001	0.6576
50.0001	0.7180
50.0001	0.7784
50.0001	0.8388
50.0001	1.0000
77.7595	0.0000
77.7595	0.0029
77.7595	0.0200
77.7595	0.0487
77.7595	0.0773
54.6036	0.0773
54.6036	0.0773
54.6036	0.0773
54.6036	0.1008
54.6036	0.1634
37.6984	0.1634
37.6984	0.1634
37.6984	0.1634
37.6984	0.1634
37.6984	0.1901
37.6986	0.1901
37.6986	0.1901
37.6986	0.1901
37.6986	0.1901
37.6986	0.2168
54.6039	0.2168
54.6039	0.2168
54.6039	0.2168
54.6039	0.2403
54.6039	0.3028
77.7599	0.3028
77.7599	0.3057
77.7599	0.3229
77.7599	0.3515
77.7599	0.3802
55.0001	0.4382
55.0001	0.4963
55.0001	0.5544
55.0001	0.6125
55.0001	0.6706
55.0001	0.7287
55.0001	0.7868
55.0001	0.8449
55.0001	1.0000
77.0472	0.0000
77.0472	0.0000
77.0472	0.0168
77.0472	0.0471
77.0472	0.0808
52.2386	0.0808
52.2386	0.0808
52.2386	0.0808
52.2386	0.0992
52.2386	0.1682
33.2259	0.1682
33.2259	0.1682
33.2259	0.1682
33.2259	0.1682
33.2259	0.1996

33.2261	0.1996	24.8143	0.2301	45.8642	0.3945	45.0002	0.8141	75.2333	1.0000	110.0002	1.0000
33.2261	0.1996	24.8143	0.2659	45.8642	0.3945	75.0002	0.8606	75.2333	1.0000	110.0002	1.0000
33.2261	0.1996	48.3590	0.2659	45.8642	0.3945	75.0002	0.9070	75.2333	1.0000	110.0002	1.0000
33.2261	0.1996	48.3590	0.2659	45.8642	0.5013	75.0002	0.9303	100.0002	1.0000	110.0002	1.0000
33.2261	0.2310	48.3590	0.2659	75.2333	0.5469	75.0002	0.9535	100.0002	1.0000	110.0002	1.0000
52.2389	0.2310	48.3590	0.2790	75.2333	0.5469	75.0002	1.0000	100.0002	1.0000	110.0002	1.0000
52.2389	0.2310	48.3590	0.3642	75.2333	0.5469	90.0002	1.0000	100.0002	1.0000	110.0002	1.0000
52.2389	0.2310	75.9241	0.3642	75.2333	0.5795	90.0002	1.0000	100.0002	1.0000	110.0002	1.0000
52.2389	0.2494	75.9241	0.3642	75.2333	0.6447	90.0002	1.0000	100.0002	1.0000	110.0002	1.0000
52.2389	0.3184	75.9241	0.3786	80.0002	0.6780	90.0002	1.0000	100.0002	1.0000	76.4336	0.0000
77.0476	0.3184	75.9241	0.4122	80.0002	0.7113	90.0002	1.0000	100.0002	1.0000	76.4336	0.0000
77.0476	0.3184	75.9241	0.4601	80.0002	0.7446	90.0002	1.0000	100.0002	1.0000	76.4336	0.2813
77.0476	0.3352	70.0001	0.5107	80.0002	0.7779	90.0002	1.0000	75.5223	0.0380	76.4336	0.3438
77.0476	0.3655	70.0001	0.5613	80.0002	0.8112	90.0002	1.0000	75.5223	0.0855	76.4336	0.3438
77.0476	0.3991	70.0001	0.6119	80.0002	0.8445	90.0002	1.0000	75.5223	0.1187	50.1442	0.3438
60.0001	0.4555	70.0001	0.6625	80.0002	0.8778	75.0582	0.0416	75.5223	0.1187	50.1442	0.3438
60.0001	0.5118	70.0001	0.7131	80.0002	0.9111	75.0582	0.0832	75.5223	0.1187	50.1442	0.3438
60.0001	0.5681	70.0001	0.7637	80.0002	1.0000	75.0582	0.1040	46.9203	0.1836	50.1442	0.3438
60.0001	0.6244	70.0001	0.8143	75.0582	0.0480	75.0582	0.1040	46.9203	0.2744	50.1442	0.3438
60.0001	0.6807	70.0001	0.8649	75.0582	0.0720	75.0582	0.1206	46.9203	0.2874	28.9046	0.3438
60.0001	0.7370	70.0001	1.0000	75.0582	0.0720	45.2174	0.2342	46.9203	0.2874	28.9046	0.3438
60.0001	0.7933	75.5223	0.0000	75.0582	0.0960	45.2174	0.3138	46.9203	0.2874	28.9046	0.3438
60.0001	0.8497	75.5223	0.0000	75.0582	0.1440	45.2174	0.3138	21.0905	0.4646	28.9046	0.3438
60.0001	1.0000	75.5223	0.0060	45.2174	0.2489	45.2174	0.3138	21.0905	0.5000	28.9046	0.3438
76.4335	0.0000	75.5223	0.0421	45.2174	0.2489	45.2174	0.3138	21.0905	0.5000	28.9048	0.3438
76.4335	0.0000	75.5223	0.1022	45.2174	0.2489	15.7931	0.4690	21.0905	0.5000	28.9048	0.3438
76.4335	0.0159	46.9203	0.1022	45.2174	0.2489	15.7931	0.5000	21.0905	0.5000	28.9048	0.3438
76.4335	0.0476	46.9203	0.1022	45.2174	0.3276	15.7931	0.5000	21.0908	0.6772	28.9048	0.3438
76.4335	0.0872	46.9203	0.1022	15.7930	0.4172	15.7931	0.5000	21.0908	0.7127	28.9048	0.3438
50.1441	0.0872	46.9203	0.1187	15.7930	0.4172	15.7931	0.5000	21.0908	0.7127	50.1446	0.3438
50.1441	0.0872	46.9203	0.2172	15.7930	0.4172	15.7935	0.6552	21.0908	0.7127	50.1446	0.3438
50.1441	0.0872	21.0904	0.2172	15.7930	0.4172	15.7935	0.6862	21.0908	0.7127	50.1446	0.3438
50.1441	0.1089	21.0904	0.2172	15.7930	0.4351	15.7935	0.6862	46.9207	0.7775	50.1446	0.3438
50.1441	0.1847	21.0904	0.2172	15.7934	0.5247	15.7935	0.6862	46.9207	0.8683	50.1446	0.3438
28.9044	0.1847	21.0904	0.2172	15.7934	0.5247	15.7935	0.6862	46.9207	0.8813	76.4340	0.3438
28.9044	0.1847	21.0904	0.2509	15.7934	0.5247	45.2178	0.7999	46.9207	0.8813	76.4340	0.6563
28.9044	0.1847	21.0907	0.2509	15.7934	0.5247	45.2178	0.8794	46.9207	0.8813	76.4340	0.9375
28.9044	0.1847	21.0907	0.2509	15.7934	0.5426	45.2178	0.8794	75.5227	0.9193	76.4340	1.0000
28.9044	0.2143	21.0907	0.2509	45.2178	0.6475	45.2178	0.8794	75.5227	0.9668	76.4340	1.0000
28.9047	0.2143	21.0907	0.2509	45.2178	0.6475	45.2178	0.8794	75.5227	1.0000	115.0002	1.0000
28.9047	0.2143	21.0907	0.2846	45.2178	0.6475	75.0586	0.9210	75.5227	1.0000	115.0002	1.0000
28.9047	0.2143	46.9207	0.2846	45.2178	0.6475	75.0586	0.9626	75.5227	1.0000	115.0002	1.0000
28.9047	0.2143	46.9207	0.2846	45.2178	0.7262	75.0586	0.9834	105.0002	1.0000	115.0002	1.0000
28.9047	0.2439	46.9207	0.2846	75.0586	0.7742	75.0586	0.9834	105.0002	1.0000	115.0002	1.0000
50.1445	0.2439	46.9207	0.3010	75.0586	0.7982	75.0586	1.0000	105.0002	1.0000	115.0002	1.0000
50.1445	0.2439	46.9207	0.3996	75.0586	0.7982	95.0002	1.0000	105.0002	1.0000	115.0002	1.0000
50.1445	0.2439	75.5227	0.3996	75.0586	0.8222	95.0002	1.0000	105.0002	1.0000	115.0002	1.0000
50.1445	0.2655	75.5227	0.3996	75.0586	0.8702	95.0002	1.0000	105.0002	1.0000	115.0002	1.0000
50.1445	0.3413	75.5227	0.4056	85.0002	0.8823	95.0002	1.0000	105.0002	1.0000	77.0473	0.0000
76.4339	0.3413	75.5227	0.4417	85.0002	0.8945	95.0002	1.0000	105.0002	1.0000	77.0473	0.0000
76.4339	0.3413	75.5227	0.5018	85.0002	0.9067	95.0002	1.0000	105.0002	1.0000	77.0473	0.0000
76.4339	0.3572	75.0002	0.5485	85.0002	0.9188	95.0002	1.0000	75.9237	0.0000	77.0473	0.5000
76.4339	0.3889	75.0002	0.5952	85.0002	0.9310	95.0002	1.0000	75.9237	0.1278	77.0473	0.5000
76.4339	0.4285	75.0002	0.6419	85.0002	0.9432	95.0002	1.0000	75.9237	0.2300	52.2387	0.5000
65.0001	0.4821	75.0002	0.6886	85.0002	0.9553	75.2329	0.0472	75.9237	0.2556	52.2387	0.5000
65.0001	0.5357	75.0002	0.7353	85.0002	0.9675	75.2329	0.0943	75.9237	0.2556	52.2387	0.5000
65.0001	0.5892	75.0002	0.7820	85.0002	1.0000	75.2329	0.1226	48.3587	0.2556	52.2387	0.5000
65.0001	0.6428	75.0002	0.8287	74.9998	0.0465	75.2329	0.1226	48.3587	0.4302	52.2387	0.5000
65.0001	0.6963	75.0002	0.8753	74.9998	0.0930	75.2329	0.1226	48.3587	0.5000	33.2260	0.5000
65.0001	0.7499	75.0002	1.0000	74.9998	0.1162	45.8638	0.2514	48.3587	0.5000	33.2260	0.5000
65.0001	0.8035	75.2329	0.0456	74.9998	0.1394	45.8638	0.3416	48.3587	0.5000	33.2260	0.5000
65.0001	0.8570	75.2329	0.0456	74.9998	0.1859	45.8638	0.3416	24.8142	0.5000	33.2260	0.5000
65.0001	1.0000	75.2329	0.0456	44.9998	0.3129	45.8638	0.3416	24.8142	0.5000	33.2260	0.5000
75.9237	0.0000	75.2329	0.0782	44.9998	0.3891	45.8638	0.3416	24.8142	0.5000	33.2262	0.5000
75.9237	0.0000	75.2329	0.1434	44.9998	0.3891	17.9637	0.4648	24.8142	0.5000	33.2262	0.5000
75.9237	0.0144	45.8638	0.1790	44.9998	0.3891	17.9637	0.5000	24.8142	0.5000	33.2262	0.5000
75.9237	0.0480	45.8638	0.1790	44.9998	0.4653	17.9637	0.5000	24.8145	0.5000	33.2262	0.5000
75.9237	0.0960	45.8638	0.1790	14.9998	0.4827	17.9637	0.5000	24.8145	0.5000	33.2262	0.5000
48.3586	0.0960	45.8638	0.1790	14.9998	0.4827	17.9637	0.5000	24.8145	0.5000	52.2390	0.5000
48.3586	0.0960	45.8638	0.2859	14.9998	0.4827	17.9641	0.6232	24.8145	0.5000	52.2390	0.5000
48.3586	0.0960	17.9637	0.2859	14.9998	0.4827	17.9641	0.6584	24.8145	0.5000	52.2390	0.5000
48.3586	0.1091	17.9637	0.2859	14.9998	0.5000	17.9641	0.6584	48.3591	0.5000	52.2390	0.5000
48.3586	0.1943	17.9637	0.2859	15.0002	0.5174	17.9641	0.6584	48.3591	0.6746	52.2390	0.5000
24.8141	0.1943	17.9637	0.2859	15.0002	0.5174	17.9641	0.6584	48.3591	0.7444	77.0477	0.5000
24.8141	0.1943	17.9637	0.3223	15.0002	0.5174	45.8642	0.7872	48.3591	0.7444	77.0477	0.5000
24.8141	0.1943	17.9640	0.3223	15.0002	0.5174	45.8642	0.8774	48.3591	0.7444	77.0477	0.5000
24.8141	0.1943	17.9640	0.3223	15.0002	0.5347	45.8642	0.8774	75.9242	0.7444	77.0477	1.0000
24.8141	0.2301	17.9640	0.3223	45.0002	0.6617	45.8642	0.8774	75.9242	0.8722	77.0477	1.0000
24.8143	0.2301	17.9640	0.3223	45.0002	0.7379	45.8642	0.8774	75.9242	0.9744	120.0003	1.0000
24.8143	0.2301	17.9640	0.3588	45.0002	0.7379	75.2333	0.9246	75.9242	1.0000	120.0003	1.0000
24.8143	0.2301	45.8642	0.3945	45.0002	0.7379	75.2333	0.9717	75.9242	1.0000	120.0003	1.0000

120.0003	1.0000	125.0003	0.0000	77.7596	0.0000	77.7596	0.0000	79.4548	0.5000	86.4669	0.5001
120.0003	1.0000	125.0003	0.0000	77.7596	0.0000	77.7596	0.0000	79.4548	0.5000	85.1711	0.5001
120.0003	1.0000	130.0003	0.0000	77.7596	0.0000	54.6037	0.0000	79.4548	0.5000	85.1711	0.5001
120.0003	1.0000	77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	79.4548	0.5000	85.1711	0.5001
120.0003	1.0000	77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	75.5227	0.5000	85.1711	0.5001
120.0003	1.0000	77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	75.5227	0.5000	85.1711	0.5001
77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	75.5227	0.5000	85.1712	0.5001
77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	37.6985	0.0000	75.5227	0.5000	85.1712	0.5001
77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	75.5227	0.5000	85.1712	0.5001
77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	75.5229	0.5000	85.1712	0.5001
77.7596	0.0000	54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	75.5229	0.5000	85.1712	0.5001
54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	75.5229	0.5000	86.4671	0.5001
54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	37.6987	0.0000	75.5229	0.5000	86.4671	0.5001
54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	75.5229	0.5000	86.4671	0.5001
54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	79.4551	0.5000	86.4671	0.5001
54.6037	0.0000	37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	79.4551	0.5000	86.4671	0.5001
37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	79.4551	0.5000	88.7078	0.6000
37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	54.6040	0.0000	79.4551	0.5000	88.7078	0.7000
37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	79.4551	0.5000	88.7078	0.8000
37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	86.1594	0.7500	88.7078	0.9000
37.6985	0.0000	37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	86.1594	0.9167	88.7078	1.0000
37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	86.1594	1.0000	175.0004	1.0000
37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	77.7600	0.0000	86.1594	1.0000	175.0004	1.0000
37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	86.1594	1.0000	175.0004	1.0000
37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	165.0004	1.0000	175.0004	1.0000
37.6987	0.0000	54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	165.0004	1.0000	175.0004	1.0000
54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	165.0004	1.0000	175.0004	1.0000
54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	125.0003	0.0000	165.0004	1.0000	175.0004	1.0000
54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	165.0004	1.0000	175.0004	1.0000
54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	165.0004	1.0000	175.0004	1.0000
54.6040	0.0000	77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	165.0004	1.0000	89.9999	0.0000
77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	165.0004	1.0000	89.9999	0.0000
77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	165.0004	1.0000	89.9999	0.0000
77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	87.4240	0.1000	89.9999	0.0000
77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	87.4240	0.2000	89.9999	0.0000
77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	155.0003	0.0000	87.4240	0.3000	90.0000	0.0000
125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	77.7596	0.0000	87.4240	0.4000	90.0000	0.0000
125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	77.7596	0.0000	87.4240	0.5000	90.0000	0.0000
125.0003	0.0000	125.0003	0.0000	145.0003	0.0000	77.7596	0.0000	82.9471	0.5000	90.0000	0.0000
125.0003	0.0000	125.0003	0.0000	77.7596	0.0000	77.7596	0.0000	82.9471	0.5000	90.0000	0.0000
125.0003	0.0000	125.0003	0.0000	77.7596	0.0000	77.7596	0.0000	82.9471	0.5000	90.0001	0.0000
125.0003	0.0000	135.0003	0.0000	77.7596	0.0000	54.6037	0.0000	82.9471	0.5000	90.0001	0.0000
125.0003	0.0000	77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	82.9471	0.5000	90.0001	0.0000
125.0003	0.0000	77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	80.3443	0.5000	90.0001	0.0000
125.0003	0.0000	77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	80.3443	0.5000	90.0001	0.0000
77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	80.3443	0.5000	90.0003	0.0000
77.7596	0.0000	77.7596	0.0000	54.6037	0.0000	37.6985	0.0000	80.3443	0.5000	90.0003	0.0000
77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	80.3443	0.5000	90.0003	0.0000
77.7596	0.0000	54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	80.3444	0.5000	90.0003	0.0000
77.7596	0.0000	54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	80.3444	0.5000	90.0003	0.0000
54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	80.3444	0.5000	90.0003	0.0000
54.6037	0.0000	54.6037	0.0000	37.6985	0.0000	37.6987	0.0000	80.3444	0.5000	90.0003	0.0000
54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	80.3444	0.5000	90.0003	0.0000
54.6037	0.0000	37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	82.9474	0.5000	90.0003	0.0000
54.6037	0.0000	37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	82.9474	0.5000	90.0003	0.0000
37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	82.9474	0.5000	90.0003	0.0000
37.6985	0.0000	37.6985	0.0000	37.6987	0.0000	54.6040	0.0000	82.9474	0.5000	90.0003	0.0000
37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	82.9474	0.5000	90.0003	0.0000
37.6985	0.0000	37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	87.4245	0.6000	90.0003	0.0000
37.6985	0.0000	37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	87.4245	0.7000	90.0003	0.0000
37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	87.4245	0.8000	0.0003	0.0000
37.6987	0.0000	37.6987	0.0000	54.6040	0.0000	77.7600	0.0000	87.4245	0.9000	0.0003	0.0000
37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	87.4245	1.0000	0.0003	0.0000
37.6987	0.0000	54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	170.0004	1.0000	0.0003	0.0000
37.6987	0.0000	54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	170.0004	1.0000	0.0003	0.0000
54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	170.0004	1.0000	0.0003	0.0000
54.6040	0.0000	54.6040	0.0000	77.7600	0.0000	125.0003	0.0000	170.0004	1.0000	0.0003	0.0000
54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	170.0004	1.0000	0.0003	0.0000
54.6040	0.0000	77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	170.0004	1.0000	180.0252	0.0000
54.6040	0.0000	77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	170.0004	1.0000		
77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	170.0004	1.0000		
77.7600	0.0000	77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	170.0004	1.0000		
77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	88.7074	0.1000		
77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	88.7074	0.2000		
77.7600	0.0000	125.0003	0.0000	125.0003	0.0000	160.0003	0.0000	88.7074	0.3000		
125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	86.1590	0.2500	88.7074	0.4001		
125.0003	0.0000	125.0003	0.0000	125.0003	0.0000	86.1590	0.4167	88.7074	0.5001		
125.0003	0.0000	125.0003	0.0000	150.0003	0.0000	86.1590	0.5000	86.4669	0.5001		
125.0003	0.0000	125.0003	0.0000	77.7596	0.0000	86.1590	0.5000	86.4669	0.5001		
125.0003	0.0000	125.0003	0.0000	77.7596	0.0000	86.1590	0.5000	86.4669	0.5001		
125.0003	0.0000	140.0003	0.0000	77.7596	0.0000	79.4548	0.5000	86.4669	0.5001		

APPENDIX J

NODE1.DAT Data File

Obliquity (degrees)	Cum. Prob.
89.9999	0.0000
89.9999	0.0000
89.9999	0.0000
89.9999	0.0000
89.9999	0.0000
90.0000	0.0000
90.0000	0.0000
90.0000	0.0000
90.0000	0.0000
90.0000	0.0000
90.0001	0.0000
90.0001	0.0000
90.0001	0.0000
90.0001	0.0000
90.0001	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
90.0003	0.0000
0.0003	0.0000
0.0003	0.0000
0.0003	0.0000
0.0003	0.0000
0.0003	0.0000
0.0003	0.0000
0.0003	0.0000
0.0003	0.0000
180.0252	0.0000
88.7074	0.1000
88.7074	0.2000
88.7074	0.3000
88.7074	0.4001
88.7074	0.5001
86.4669	0.5001
86.4669	0.5001
86.4669	0.5001
86.4669	0.5001
86.4669	0.5001
85.1711	0.5001
85.1711	0.5001
85.1711	0.5001
85.1711	0.5001
85.1711	0.5001
85.1712	0.5001
85.1712	0.5001
85.1712	0.5001
85.1712	0.5001
85.1712	0.5001
86.4671	0.5001
86.4671	0.5001
86.4671	0.5001
86.4671	0.5001
86.4671	0.5001
88.7078	0.6000
88.7078	0.7000
88.7078	0.8000
88.7078	0.9000
88.7078	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
175.0004	1.0000
87.4240	0.1000
87.4240	0.2000
87.4240	0.3000
87.4240	0.4000
87.4240	0.5000
82.9471	0.5000
82.9471	0.5000
82.9471	0.5000
82.9471	0.5000
82.9471	0.5000
80.3443	0.5000
80.3443	0.5000
80.3443	0.5000
80.3443	0.5000
80.3443	0.5000
80.3444	0.5000
80.3444	0.5000
80.3444	0.5000
80.3444	0.5000
80.3444	0.5000
82.9474	0.5000
82.9474	0.5000
82.9474	0.5000
82.9474	0.5000
82.9474	0.5000
87.4245	0.6000
87.4245	0.7000
87.4245	0.8000
87.4245	0.9000
87.4245	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
170.0004	1.0000
86.1590	0.2500
86.1590	0.4167
86.1590	0.5000
86.1590	0.5000
86.1590	0.5000
79.4548	0.5000
79.4548	0.5000
79.4548	0.5000
79.4548	0.5000
79.4548	0.5000
75.5227	0.5000
75.5227	0.5000
75.5227	0.5000
75.5227	0.5000
75.5227	0.5000
75.5229	0.5000
75.5229	0.5000
75.5229	0.5000
75.5229	0.5000
75.5229	0.5000
79.4551	0.5000
79.4551	0.5000
79.4551	0.5000
79.4551	0.5000
79.4551	0.5000
86.1594	0.7500
86.1594	0.9167
86.1594	1.0000
86.1594	1.0000
86.1594	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
165.0004	1.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
160.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
155.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
150.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
145.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
140.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
135.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
130.0003	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
77.7596	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
54.6037	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6985	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
37.6987	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
54.6040	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
77.7600	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
125.0003	0.0000
77.0473	0.0000
77.0473	0.0000
77.0473	0.0000
77.0473	0.5000
77.0473	0.5000
52.2387	0.5000
52.2387	0.5000
52.2387	0.5000
52.2387	0.5000
52.2387	0.5000
33.2260	0.5000
33.2260	0.5000
33.2260	0.5000
33.2260	0.5000
33.2260	0.5000

33.2262	0.5000	24.8145	0.5000	45.8642	0.8774	45.0002	0.8141	75.2333	0.5469	70.0001	0.5107
33.2262	0.5000	24.8145	0.5000	45.8642	0.8774	75.0002	0.8606	75.2333	0.5795	70.0001	0.5613
33.2262	0.5000	48.3591	0.5000	45.8642	0.8774	75.0002	0.9070	75.2333	0.6447	70.0001	0.6119
33.2262	0.5000	48.3591	0.6746	45.8642	0.8774	75.0002	0.9303	80.0002	0.6780	70.0001	0.6625
33.2262	0.5000	48.3591	0.7444	75.2333	0.9246	75.0002	0.9535	80.0002	0.7113	70.0001	0.7131
52.2390	0.5000	48.3591	0.7444	75.2333	0.9717	75.0002	1.0000	80.0002	0.7446	70.0001	0.7637
52.2390	0.5000	48.3591	0.7444	75.2333	1.0000	90.0002	1.0000	80.0002	0.7779	70.0001	0.8143
52.2390	0.5000	75.9242	0.7444	75.2333	1.0000	90.0002	1.0000	80.0002	0.8112	70.0001	0.8649
52.2390	0.5000	75.9242	0.8722	75.2333	1.0000	90.0002	1.0000	80.0002	0.8445	70.0001	1.0000
52.2390	0.5000	75.9242	0.9744	100.0002	1.0000	90.0002	1.0000	80.0002	0.8778	76.4335	0.0000
77.0477	0.5000	75.9242	1.0000	100.0002	1.0000	90.0002	1.0000	80.0002	0.9111	76.4335	0.0000
77.0477	0.5000	75.9242	1.0000	100.0002	1.0000	90.0002	1.0000	80.0002	1.0000	76.4335	0.0159
77.0477	0.5000	110.0002	1.0000	100.0002	1.0000	90.0002	1.0000	75.5223	0.0000	76.4335	0.0476
77.0477	1.0000	110.0002	1.0000	100.0002	1.0000	90.0002	1.0000	75.5223	0.0000	76.4335	0.0872
77.0477	1.0000	110.0002	1.0000	100.0002	1.0000	90.0002	1.0000	75.5223	0.0060	50.1441	0.0872
120.0003	1.0000	110.0002	1.0000	100.0002	1.0000	75.0582	0.0480	75.5223	0.0421	50.1441	0.0872
120.0003	1.0000	110.0002	1.0000	100.0002	1.0000	75.0582	0.0720	75.5223	0.1022	50.1441	0.0872
120.0003	1.0000	110.0002	1.0000	100.0002	1.0000	75.0582	0.0720	46.9203	0.1022	50.1441	0.1089
120.0003	1.0000	110.0002	1.0000	75.0582	0.0416	75.0582	0.0960	46.9203	0.1022	50.1441	0.1847
120.0003	1.0000	110.0002	1.0000	75.0582	0.0832	75.0582	0.1440	46.9203	0.1022	28.9044	0.1847
120.0003	1.0000	110.0002	1.0000	75.0582	0.1040	45.2174	0.2489	46.9203	0.1187	28.9044	0.1847
120.0003	1.0000	75.5223	0.0380	75.0582	0.1040	45.2174	0.2489	46.9203	0.2172	28.9044	0.1847
120.0003	1.0000	75.5223	0.0855	75.0582	0.1206	45.2174	0.2489	21.0904	0.2172	28.9044	0.1847
120.0003	1.0000	75.5223	0.1187	45.2174	0.2342	45.2174	0.2489	21.0904	0.2172	28.9044	0.2143
76.4336	0.0000	75.5223	0.1187	45.2174	0.3138	45.2174	0.3276	21.0904	0.2172	28.9047	0.2143
76.4336	0.0000	75.5223	0.1187	45.2174	0.3138	15.7930	0.4172	21.0904	0.2172	28.9047	0.2143
76.4336	0.2813	46.9203	0.1836	45.2174	0.3138	15.7930	0.4172	21.0904	0.2509	28.9047	0.2143
76.4336	0.3438	46.9203	0.2744	45.2174	0.3138	15.7930	0.4172	21.0907	0.2509	28.9047	0.2143
76.4336	0.3438	46.9203	0.2874	15.7931	0.4690	15.7930	0.4172	21.0907	0.2509	28.9047	0.2439
50.1442	0.3438	46.9203	0.2874	15.7931	0.5000	15.7930	0.4351	21.0907	0.2509	50.1445	0.2439
50.1442	0.3438	46.9203	0.2874	15.7931	0.5000	15.7934	0.5247	21.0907	0.2509	50.1445	0.2439
50.1442	0.3438	21.0905	0.4646	15.7931	0.5000	15.7934	0.5247	21.0907	0.2846	50.1445	0.2439
50.1442	0.3438	21.0905	0.5000	15.7931	0.5000	15.7934	0.5247	46.9207	0.2846	50.1445	0.2655
50.1442	0.3438	21.0905	0.5000	15.7935	0.6552	15.7934	0.5247	46.9207	0.2846	50.1445	0.3413
28.9046	0.3438	21.0905	0.5000	15.7935	0.6862	15.7934	0.5426	46.9207	0.2846	76.4339	0.3413
28.9046	0.3438	21.0905	0.5000	15.7935	0.6862	45.2178	0.6475	46.9207	0.3010	76.4339	0.3413
28.9046	0.3438	21.0905	0.6772	15.7935	0.6862	45.2178	0.6475	46.9207	0.3996	76.4339	0.3572
28.9046	0.3438	21.0908	0.7127	15.7935	0.6862	45.2178	0.6475	75.5227	0.3996	76.4339	0.3889
28.9046	0.3438	21.0908	0.7127	45.2178	0.7999	45.2178	0.6475	75.5227	0.3996	76.4339	0.4285
28.9048	0.3438	21.0908	0.7127	45.2178	0.8794	45.2178	0.7262	75.5227	0.4056	65.0001	0.4821
28.9048	0.3438	21.0908	0.7127	45.2178	0.8794	75.0586	0.7742	75.5227	0.4417	65.0001	0.5357
28.9048	0.3438	46.9207	0.7775	45.2178	0.8794	75.0586	0.7982	75.5227	0.5018	65.0001	0.5892
28.9048	0.3438	46.9207	0.8683	45.2178	0.8794	75.0586	0.7982	75.0002	0.5485	65.0001	0.6428
28.9048	0.3438	46.9207	0.8813	75.0586	0.9210	75.0586	0.8222	75.0002	0.5952	65.0001	0.6963
50.1446	0.3438	46.9207	0.8813	75.0586	0.9626	75.0586	0.8702	75.0002	0.6419	65.0001	0.7499
50.1446	0.3438	46.9207	0.8813	75.0586	0.9834	85.0002	0.8823	75.0002	0.6886	65.0001	0.8035
50.1446	0.3438	75.5227	0.9193	75.0586	0.9834	85.0002	0.8945	75.0002	0.7353	65.0001	0.8570
50.1446	0.3438	75.5227	0.9668	75.0586	1.0000	85.0002	0.9067	75.0002	0.7820	65.0001	1.0000
50.1446	0.3438	75.5227	1.0000	95.0002	1.0000	85.0002	0.9188	75.0002	0.8287	77.0472	0.0000
76.4340	0.3438	75.5227	1.0000	95.0002	1.0000	85.0002	0.9310	75.0002	0.8753	77.0472	0.0000
76.4340	0.6563	75.5227	1.0000	95.0002	1.0000	85.0002	0.9432	75.0002	1.0000	77.0472	0.0168
76.4340	0.9375	105.0002	1.0000	95.0002	1.0000	85.0002	0.9553	75.9237	0.0000	77.0472	0.0471
76.4340	1.0000	105.0002	1.0000	95.0002	1.0000	85.0002	0.9675	75.9237	0.0000	77.0472	0.0808
76.4340	1.0000	105.0002	1.0000	95.0002	1.0000	85.0002	1.0000	75.9237	0.0144	52.2386	0.0808
115.0002	1.0000	105.0002	1.0000	95.0002	1.0000	75.2329	0.0456	75.9237	0.0480	52.2386	0.0808
115.0002	1.0000	105.0002	1.0000	95.0002	1.0000	75.2329	0.0456	75.9237	0.0960	52.2386	0.0808
115.0002	1.0000	105.0002	1.0000	95.0002	1.0000	75.2329	0.0456	48.3586	0.0960	52.2386	0.0992
115.0002	1.0000	105.0002	1.0000	74.9998	0.0465	75.2329	0.0782	48.3586	0.0960	52.2386	0.1682
115.0002	1.0000	105.0002	1.0000	74.9998	0.0930	75.2329	0.1434	48.3586	0.0960	33.2259	0.1682
115.0002	1.0000	105.0002	1.0000	74.9998	0.1162	45.8638	0.1790	48.3586	0.1091	33.2259	0.1682
115.0002	1.0000	75.2329	0.0472	74.9998	0.1394	45.8638	0.1790	48.3586	0.1943	33.2259	0.1682
115.0002	1.0000	75.2329	0.0943	74.9998	0.1859	45.8638	0.1790	24.8141	0.1943	33.2259	0.1682
115.0002	1.0000	75.2329	0.1226	44.9998	0.3129	45.8638	0.1790	24.8141	0.1943	33.2259	0.1996
75.9237	0.0000	75.2329	0.1226	44.9998	0.3891	45.8638	0.2859	24.8141	0.1943	33.2261	0.1996
75.9237	0.1278	75.2329	0.1226	44.9998	0.3891	17.9637	0.2859	24.8141	0.1943	33.2261	0.1996
75.9237	0.2300	45.8638	0.2514	44.9998	0.3891	17.9637	0.2859	24.8141	0.2301	33.2261	0.1996
75.9237	0.2556	45.8638	0.3416	44.9998	0.4653	17.9637	0.2859	24.8143	0.2301	33.2261	0.1996
75.9237	0.2556	45.8638	0.3416	14.9998	0.4827	17.9637	0.2859	24.8143	0.2301	33.2261	0.2310
48.3587	0.2556	45.8638	0.3416	14.9998	0.4827	17.9637	0.3223	24.8143	0.2301	52.2389	0.2310
48.3587	0.4302	45.8638	0.3416	14.9998	0.4827	17.9640	0.3223	24.8143	0.2301	52.2389	0.2310
48.3587	0.5000	17.9637	0.4648	14.9998	0.4827	17.9640	0.3223	24.8143	0.2659	52.2389	0.2310
48.3587	0.5000	17.9637	0.5000	14.9998	0.5000	17.9640	0.3223	48.3590	0.2659	52.2389	0.2494
48.3587	0.5000	17.9637	0.5000	15.0002	0.5174	17.9640	0.3223	48.3590	0.2659	52.2389	0.3184
24.8142	0.5000	17.9637	0.5000	15.0002	0.5174	17.9640	0.3588	48.3590	0.2659	77.0476	0.3184
24.8142	0.5000	17.9637	0.5000	15.0002	0.5174	45.8642	0.3945	48.3590	0.2790	77.0476	0.3184
24.8142	0.5000	17.9641	0.6232	15.0002	0.5174	45.8642	0.3945	48.3590	0.3642	77.0476	0.3352
24.8142	0.5000	17.9641	0.6584	15.0002	0.5347	45.8642	0.3945	75.9241	0.3642	77.0476	0.3655
24.8142	0.5000	17.9641	0.6584	45.0002	0.6617	45.8642	0.3945	75.9241	0.3642	77.0476	0.3991
24.8145	0.5000	17.9641	0.6584	45.0002	0.7379	45.8642	0.5013	75.9241	0.3786	60.0001	0.4555
24.8145	0.5000	17.9641	0.6584	45.0002	0.7379	75.2333	0.5469	75.9241	0.4122	60.0001	0.5118
24.8145	0.5000	45.8642	0.7872	45.0002	0.7379	75.2333	0.5469	75.9241	0.4601	60.0001	0.5681

60.0001	0.6244	50.0001	0.7784	81.4625	0.0016	83.7201	0.0413	79.4547	0.0435	86.4667	0.0453
60.0001	0.6807	50.0001	0.8388	81.4625	0.0096	83.7201	0.0524	79.4547	0.0547	85.1709	0.0453
60.0001	0.7370	50.0001	1.0000	81.4625	0.0255	72.6122	0.0524	79.4547	0.0716	85.1709	0.0453
60.0001	0.7933	79.4545	0.0000	81.4625	0.0415	72.6122	0.0524	79.4547	0.0902	85.1709	0.0480
60.0001	0.8497	79.4545	0.0065	81.4625	0.0574	72.6122	0.0616	75.5226	0.0902	85.1709	0.0536
60.0001	1.0000	79.4545	0.0237	66.0724	0.0574	72.6122	0.0829	75.5226	0.0902	85.1709	0.0619
77.7595	0.0000	79.4545	0.0452	66.0724	0.0574	72.6122	0.1134	75.5226	0.0902	85.1710	0.0619
77.7595	0.0029	79.4545	0.0667	66.0724	0.0618	65.9071	0.1134	75.5226	0.0902	85.1710	0.0619
77.7595	0.0200	59.9999	0.0667	66.0724	0.0836	65.9071	0.1134	75.5226	0.1055	85.1710	0.0647
77.7595	0.0487	59.9999	0.0667	66.0724	0.1271	65.9071	0.1134	75.5227	0.1055	85.1710	0.0702
77.7595	0.0773	59.9999	0.0667	56.3559	0.1271	65.9071	0.1134	75.5227	0.1055	85.1710	0.0786
54.6036	0.0773	59.9999	0.0903	56.3559	0.1271	65.9071	0.1301	75.5227	0.1055	86.4670	0.0847
54.6036	0.0773	59.9999	0.1432	56.3559	0.1271	65.9072	0.1301	75.5227	0.1055	86.4670	0.0911
54.6036	0.0773	46.9205	0.1432	56.3559	0.1271	65.9072	0.1301	75.5227	0.1209	86.4670	0.0979
54.6036	0.1008	46.9205	0.1432	56.3559	0.1480	65.9072	0.1301	79.4550	0.1227	86.4670	0.1046
54.6036	0.1634	46.9205	0.1432	56.3561	0.1480	65.9072	0.1301	79.4550	0.1302	86.4670	0.1114
37.6984	0.1634	46.9205	0.1432	56.3561	0.1480	65.9072	0.1467	79.4550	0.1414	88.7077	0.1139
37.6984	0.1634	46.9205	0.1673	56.3561	0.1480	72.6125	0.1467	79.4550	0.1582	88.7077	0.1164
37.6984	0.1634	46.9206	0.1673	56.3561	0.1480	72.6125	0.1467	79.4550	0.1769	88.7077	0.1189
37.6984	0.1634	46.9206	0.1673	56.3561	0.1688	72.6125	0.1559	86.1593	0.1837	88.7077	0.1213
37.6984	0.1901	46.9206	0.1673	66.0728	0.1688	72.6125	0.1772	86.1593	0.1906	88.7077	0.1238
37.6986	0.1901	46.9206	0.1673	66.0728	0.1688	72.6125	0.2077	86.1593	0.1974	4.9999	0.2059
37.6986	0.1901	46.9206	0.1914	66.0728	0.1731	83.7205	0.2155	86.1593	0.2042	4.9999	0.2881
37.6986	0.1901	60.0002	0.1914	66.0728	0.1949	83.7205	0.2267	86.1593	0.2111	4.9999	0.3702
37.6986	0.1901	60.0002	0.1914	66.0728	0.2385	83.7205	0.2378	15.0000	0.2850	4.9999	0.4523
37.6986	0.2168	60.0002	0.1914	81.4629	0.2401	83.7205	0.2490	15.0000	0.3590	4.9999	0.5344
54.6039	0.2168	60.0002	0.2149	81.4629	0.2481	83.7205	0.2602	15.0000	0.4329	4.9999	0.6165
54.6039	0.2168	60.0002	0.2678	81.4629	0.2640	25.0000	0.3295	15.0000	0.5068	4.9999	0.6986
54.6039	0.2168	79.4549	0.2678	81.4629	0.2800	25.0000	0.3988	15.0000	0.5808	4.9999	0.7808
54.6039	0.2403	79.4549	0.2743	81.4629	0.2959	25.0000	0.4682	15.0000	0.6547	4.9999	1.0000
54.6039	0.3028	79.4549	0.2915	35.0000	0.3619	25.0000	0.5375	15.0000	0.7287	89.9999	0.0000
77.7599	0.3028	79.4549	0.3130	35.0000	0.4279	25.0000	0.6069	15.0000	0.8026	89.9999	0.0000
77.7599	0.3057	79.4549	0.3345	35.0000	0.4939	25.0000	0.6762	15.0000	1.0000	89.9999	0.0000
77.7599	0.3229	45.0001	0.3969	35.0000	0.5599	25.0000	0.7455	87.4239	0.0046	89.9999	0.0000
77.7599	0.3515	45.0001	0.4593	35.0000	0.6259	25.0000	0.8149	87.4239	0.0093	89.9999	0.0000
77.7599	0.3802	45.0001	0.5217	35.0000	0.6918	25.0000	1.0000	87.4239	0.0139	90.0000	0.0000
55.0001	0.4382	45.0001	0.5840	35.0000	0.7578	84.9213	0.0080	87.4239	0.0186	90.0000	0.0000
55.0001	0.4963	45.0001	0.6464	35.0000	0.8238	84.9213	0.0169	87.4239	0.0232	90.0000	0.0000
55.0001	0.5544	45.0001	0.7088	35.0000	1.0000	84.9213	0.0259	82.9469	0.0296	90.0000	0.0000
55.0001	0.6125	45.0001	0.7711	82.5643	0.0054	84.9213	0.0348	82.9469	0.0385	90.0000	0.0000
55.0001	0.6706	45.0001	0.8335	82.5643	0.0134	84.9213	0.0437	82.9469	0.0499	90.0001	0.0000
55.0001	0.7287	45.0001	1.0000	82.5643	0.0269	76.0045	0.0437	82.9469	0.0626	90.0001	0.0000
55.0001	0.7868	80.4232	0.0000	82.5643	0.0403	76.0045	0.0486	82.9469	0.0753	90.0001	0.0000
55.0001	0.8449	80.4232	0.0075	82.5643	0.0538	76.0045	0.0608	80.3442	0.0753	90.0001	0.0000
55.0001	1.0000	80.4232	0.0245	69.2951	0.0538	76.0045	0.0802	80.3442	0.0753	90.0001	0.0000
78.5641	0.0000	80.4232	0.0433	69.2951	0.0538	76.0045	0.1046	80.3442	0.0753	90.0003	0.0000
78.5641	0.0050	80.4232	0.0621	69.2951	0.0611	70.7091	0.1046	80.3442	0.0788	90.0003	0.0000
78.5641	0.0224	62.9659	0.0621	69.2951	0.0832	70.7091	0.1046	80.3442	0.0926	90.0003	0.0000
78.5641	0.0472	62.9659	0.0621	69.2951	0.1199	70.7091	0.1046	80.3443	0.0926	90.0003	0.0000
78.5641	0.0720	62.9659	0.0621	61.1210	0.1199	70.7091	0.1046	80.3443	0.0926	90.0003	0.0000
57.2021	0.0720	62.9659	0.0826	61.1210	0.1199	70.7091	0.1213	80.3443	0.0926	90.0003	0.0000
57.2021	0.0720	62.9659	0.1289	61.1210	0.1199	70.7092	0.1213	80.3443	0.0961	90.0003	0.0000
57.2021	0.0720	51.6192	0.1289	61.1210	0.1199	70.7092	0.1213	80.3443	0.1100	90.0003	0.0000
57.2021	0.0924	51.6192	0.1289	61.1210	0.1400	70.7092	0.1213	82.9472	0.1163	90.0003	0.0000
57.2021	0.1501	51.6192	0.1289	61.1211	0.1400	70.7092	0.1213	82.9472	0.1252	90.0003	0.0000
42.2735	0.1501	51.6192	0.1289	61.1211	0.1400	70.7092	0.1379	82.9472	0.1366	90.0003	0.0000
42.2735	0.1501	51.6192	0.1535	61.1211	0.1400	76.0048	0.1379	82.9472	0.1493	90.0003	0.0000
42.2735	0.1501	51.6193	0.1535	61.1211	0.1400	76.0048	0.1428	82.9472	0.1620	90.0003	0.0000
42.2735	0.1501	51.6193	0.1535	61.1211	0.1601	76.0048	0.1549	87.4243	0.1667	90.0003	0.0000
42.2735	0.1779	51.6193	0.1535	69.2954	0.1601	76.0048	0.1744	87.4243	0.1713	90.0003	0.0000
42.2736	0.1779	51.6193	0.1535	69.2954	0.1601	76.0048	0.1988	87.4243	0.1760	0.0003	0.0937
42.2736	0.1779	51.6193	0.1780	69.2954	0.1674	84.9217	0.2068	87.4243	0.1806	0.0003	0.1875
42.2736	0.1779	62.9662	0.1780	69.2954	0.1894	84.9217	0.2157	87.4243	0.1853	0.0003	0.2812
42.2736	0.1779	62.9662	0.1780	69.2954	0.2262	84.9217	0.2247	10.0000	0.2616	0.0003	0.3749
42.2736	0.2057	62.9662	0.1780	82.5647	0.2316	84.9217	0.2336	10.0000	0.3380	0.0003	0.4686
57.2024	0.2057	62.9662	0.1986	82.5647	0.2396	84.9217	0.2425	10.0000	0.4143	0.0003	0.5623
57.2024	0.2057	62.9662	0.2448	82.5647	0.2531	20.0000	0.3135	10.0000	0.4907	0.0003	0.6561
57.2024	0.2057	80.4236	0.2448	82.5647	0.2665	20.0000	0.3845	10.0000	0.5671	0.0003	0.7498
57.2024	0.2260	80.4236	0.2524	82.5647	0.2800	20.0000	0.4555	10.0000	0.6434	0.0003	1.0000
57.2024	0.2837	80.4236	0.2693	30.0000	0.3475	20.0000	0.5265	10.0000	0.7198		
78.5646	0.2837	80.4236	0.2881	30.0000	0.4149	20.0000	0.5975	10.0000	0.7961		
78.5646	0.2887	80.4236	0.3069	30.0000	0.4824	20.0000	0.6685	10.0000	1.0000		
78.5646	0.3061	40.0001	0.3719	30.0000	0.5499	20.0000	0.7395	88.7073	0.0025		
78.5646	0.3309	40.0001	0.4368	30.0000	0.6174	20.0000	0.8105	88.7073	0.0050		
78.5646	0.3557	40.0001	0.5018	30.0000	0.6849	20.0000	1.0000	88.7073	0.0074		
50.0001	0.4161	40.0001	0.5668	30.0000	0.7524	86.1589	0.0068	88.7073	0.0099		
50.0001	0.4765	40.0001	0.6317	30.0000	0.8198	86.1589	0.0137	88.7073	0.0124		
50.0001	0.5369	40.0001	0.6967	30.0000	1.0000	86.1589	0.0205	86.4667	0.0185		
50.0001	0.5973	40.0001	0.7616	83.7201	0.0078	86.1589	0.0274	86.4667	0.0249		
50.0001	0.6576	40.0001	0.8266	83.7201	0.0190	86.1589	0.0342	86.4667	0.0317		
50.0001	0.7180	40.0001	1.0000	83.7201	0.0301	79.4547	0.0361	86.4667	0.0385		

APPENDIX K

PLOG.DAT Data File

Obliquity (degrees)	Cum. Prob.
74.9998	0.0112
44.9998	0.0417
14.9998	0.0833
15.0001	0.1250
45.0002	0.1555
75.0002	0.1667
105.0002	0.1667
135.0002	0.1667
165.0002	0.1667
164.9997	0.1667
134.9997	0.1667
104.9997	0.1667
74.9998	0.1778
44.9998	0.2083
14.9998	0.2500
15.0002	0.2917
45.0002	0.3222
75.0002	0.3333
105.0002	0.3333
135.0002	0.3333
165.0002	0.3333
164.9997	0.3333
134.9997	0.3333
104.9997	0.3333
74.9998	0.3445
44.9998	0.3750
14.9998	0.4167
15.0002	0.4583
45.0002	0.4888
75.0002	0.5000
105.0002	0.5000
135.0002	0.5000
165.0002	0.5000
164.9997	0.5000
134.9997	0.5000
104.9997	0.5000
74.9998	0.5112
44.9998	0.5417
14.9998	0.5833
15.0002	0.6250
45.0002	0.6555
75.0002	0.6667
105.0002	0.6667
135.0002	0.6667
165.0002	0.6667
164.9997	0.6667
134.9997	0.6667
104.9997	0.6667
74.9998	0.6778
44.9998	0.7083
14.9998	0.7500
15.0002	0.7917
45.0002	0.8222
75.0002	0.8333
105.0002	0.8333
135.0002	0.8333
165.0002	0.8333
164.9997	0.8333
134.9997	0.8333
104.9997	0.8333
74.9998	0.8445
44.9998	0.8750
14.9998	0.9167
15.0002	0.9583
45.0002	0.9888
75.0002	1.0000
105.0002	1.0000
135.0002	1.0000
165.0002	1.0000
164.9997	1.0000
134.9997	1.0000
104.9997	1.0000
79.9998	0.0075
49.9998	0.0354
19.9998	0.0760
10.0003	0.1187
40.0002	0.1519
70.0002	0.1667
100.0001	0.1667
130.0001	0.1667
160.0001	0.1667
169.9995	0.1667
139.9997	0.1667
109.9997	0.1667
79.9998	0.1742
49.9998	0.2020
19.9998	0.2427
10.0003	0.2854
40.0002	0.3185
70.0002	0.3333
100.0001	0.3333
130.0001	0.3333
160.0001	0.3333
169.9995	0.3333
139.9997	0.3333
109.9997	0.3333
79.9998	0.3409
49.9998	0.3687
19.9998	0.4094
10.0003	0.4520
40.0002	0.4852
70.0002	0.5000
100.0001	0.5000
130.0001	0.5000
160.0001	0.5000
169.9995	0.5000
139.9997	0.5000
109.9997	0.5000
79.9998	0.5075
49.9998	0.5354
19.9998	0.5760
10.0003	0.6187
40.0002	0.6519
70.0002	0.6667
100.0001	0.6667
130.0001	0.6667
160.0001	0.6667
169.9995	0.6667
139.9997	0.6667
109.9997	0.6667
79.9998	0.6742
49.9998	0.7020
19.9998	0.7427
10.0003	0.7854
40.0002	0.8185
70.0002	0.8333
100.0001	0.8333
130.0001	0.8333
160.0001	0.8333
169.9995	0.8333
139.9997	0.8333
109.9997	0.8333
79.9998	0.8409
49.9998	0.8687
19.9998	0.9094
10.0003	0.9520
40.0002	0.9852
70.0002	1.0000
100.0001	1.0000
130.0001	1.0000
160.0001	1.0000
169.9995	1.0000
139.9997	1.0000
109.9997	1.0000
84.9998	0.0038
54.9998	0.0289
24.9999	0.0686
5.0007	0.1123
35.0002	0.1482
65.0002	0.1667
95.0002	0.1667
125.0001	0.1667
155.0001	0.1667
174.9989	0.1667
144.9997	0.1667
114.9997	0.1667
84.9998	0.1705
54.9998	0.1956
24.9999	0.2353
5.0004	0.2789
35.0002	0.3148
65.0002	0.3333
95.0002	0.3333
125.0001	0.3333
155.0001	0.3333
174.9989	0.3333
144.9997	0.3333
114.9997	0.3333
84.9998	0.3372
54.9998	0.3623
24.9999	0.4020
5.0004	0.4456
35.0002	0.4815
65.0002	0.5000
95.0002	0.5000
125.0001	0.5000
155.0001	0.5000
174.9989	0.5000
144.9997	0.5000
114.9997	0.5000
84.9998	0.5038
54.9998	0.5289
24.9999	0.5686
5.0004	0.6123
35.0002	0.6482
65.0002	0.6667
95.0002	0.6667
125.0001	0.6667
155.0001	0.6667
174.9989	0.6667
144.9997	0.6667
114.9997	0.6667
84.9998	0.6705
54.9998	0.6956
24.9999	0.7353
5.0004	0.7789
35.0002	0.8148
65.0002	0.8333
95.0002	0.8333
125.0001	0.8333
155.0001	0.8333
174.9989	0.8333
144.9997	0.8333
114.9997	0.8333
84.9998	0.8372
54.9998	0.8623
24.9999	0.9020
5.0004	0.9456
35.0002	0.9815
65.0002	1.0000
95.0002	1.0000
125.0001	1.0000
155.0001	1.0000
174.9989	1.0000
144.9997	1.0000
114.9997	1.0000
89.9998	0.0000
59.9999	0.0223
29.9999	0.0610
0.0966	0.1057
30.0002	0.1443
60.0002	0.1667
90.0002	0.1667
120.0001	0.1667
150.0000	0.1667
179.8880	0.1667
149.9996	0.1667
119.9998	0.1667
89.9998	0.1667
59.9999	0.1890
29.9999	0.2277
0.0621	0.2723
30.0002	0.3110
60.0002	0.3333
90.0002	0.3333
120.0001	0.3333
150.0000	0.3333
179.8880	0.3333
149.9996	0.3333
119.9998	0.3333
89.9998	0.3333
59.9999	0.3557
29.9999	0.3943
0.0621	0.4390
30.0002	0.4777
60.0002	0.5000
90.0002	0.5000
120.0001	0.5000
150.0000	0.5000
179.8880	0.5000
149.9996	0.5000
119.9998	0.5000
89.9998	0.5000
59.9999	0.5223
29.9999	0.5610
0.0621	0.6057
30.0002	0.6443
60.0002	0.6667
90.0002	0.6667
120.0001	0.6667
150.0000	0.6667
179.8880	0.6667
149.9996	0.6667
119.9998	0.6667
89.9998	0.6667
59.9999	0.6890
29.9999	0.7277
0.0621	0.7723
30.0002	0.8110
60.0002	0.8333
90.0002	0.8333
120.0001	0.8333
150.0000	0.8333
179.8880	0.8333
149.9996	0.8333
119.9998	0.8333
89.9998	0.8333
59.9999	0.8557
29.9999	0.8943
0.0621	0.9390
30.0002	0.9777
60.0002	1.0000
90.0002	1.0000
120.0001	1.0000
150.0000	1.0000
179.8880	1.0000
149.9996	1.0000
119.9998	1.0000
94.9999	0.0000
64.9999	0.0185
34.9999	0.0544
5.0011	0.0980
25.0002	0.1377
55.0002	0.1628
85.0001	0.1667
115.0001	0.1667
145.0000	0.1667
174.9987	0.1667
154.9996	0.1667
124.9998	0.1667
94.9999	0.1667
64.9999	0.1852
34.9999	0.2211
5.0004	0.2647
25.0002	0.3044
55.0002	0.3295
85.0001	0.3333
115.0001	0.3333
145.0000	0.3333
174.9987	0.3333
154.9996	0.3333
124.9998	0.3333
94.9999	0.3333
64.9999	0.3518
34.9999	0.3877
5.0004	0.4314
25.0002	0.4711
55.0002	0.4962
85.0001	0.5000
115.0001	0.5000
145.0000	0.5000
174.9987	0.5000
154.9996	0.5000
124.9998	0.5000
94.9999	0.5000
64.9999	0.5185
34.9999	0.5544
5.0004	0.5980
25.0002	0.6377
55.0002	0.6628
85.0001	0.6667
115.0001	0.6667
145.0000	0.6667
174.9987	0.6667
154.9996	0.6667
124.9998	0.6667
94.9999	0.6667
64.9999	0.6852
34.9999	0.7211
5.0004	0.7647
25.0002	0.8044
55.0002	0.8295
85.0001	0.8333
115.0001	0.8333
145.0000	0.8333
174.9987	0.8333
154.9996	0.8333
124.9998	0.8333
94.9999	0.8333
64.9999	0.8518
34.9999	0.8877
5.0004	0.9314
25.0002	0.9711
55.0002	0.9962
85.0001	1.0000
115.0001	1.0000
145.0000	1.0000
174.9987	1.0000
154.9996	1.0000
124.9998	1.0000
99.9999	0.0000
69.9999	0.0148
40.0000	0.0480
10.0007	0.0906
20.0002	0.1313
50.0002	0.1591
80.0001	0.1667
110.0000	0.1667
140.0000	0.1667
169.9994	0.1667
159.9994	0.1667
129.9998	0.1667
99.9999	0.1667
69.9999	0.1815
40.0000	0.2146
10.0002	0.2573
20.0002	0.2980
50.0002	0.3258
80.0001	0.3333
110.0000	0.3333
140.0000	0.3333
169.9994	0.3333
159.9994	0.3333
129.9998	0.3333
99.9999	0.3333
69.9999	0.3481
40.0000	0.3813
10.0002	0.4240
20.0002	0.4646
50.0002	0.4925
80.0001	0.5000
110.0000	0.5000
140.0000	0.5000
169.9994	0.5000
159.9994	0.5000
129.9998	0.5000
99.9999	0.5000
69.9999	0.5148
40.0000	0.5480
10.0002	0.5906
20.0002	0.6313
50.0002	0.6591
80.0001	0.6667
110.0000	0.6667
140.0000	0.6667
169.9994	0.6667
159.9994	0.6667
129.9998	0.6667
99.9999	0.6667
69.9999	0.6815
40.0000	0.7146
10.0002	0.7573
20.0002	0.7980
50.0002	0.8258
80.0001	0.8333
110.0000	0.8333
140.0000	0.8333
169.9994	0.8333
159.9994	0.8333
129.9998	0.8333
99.9999	0.8333
69.9999	0.8481
40.0000	0.8813
10.0002	0.9240
20.0002	0.9646
50.0002	0.9925
80.0001	1.0000
110.0000	1.0000
140.0000	1.0000
169.9994	1.0000
159.9994	1.0000
129.9998	1.0000
104.9999	0.0000
74.9999	0.0112
45.0000	0.0417
15.0005	0.0833
15.0003	0.1250
45.0001	0.1555
75.0001	0.1667
105.0000	0.1667
135.0000	0.1667
164.9996	0.1667
164.9992	0.1667
134.9998	0.1667
104.9999	0.1667
74.9999	0.1778
45.0000	0.2083
15.0001	0.2500
15.0003	0.2917
45.0001	0.3222
75.0001	0.3333
105.0000	0.3333
135.0000	0.3333
164.9996	0.3333
164.9992	0.3333
134.9998	0.3333
104.9999	0.3333
74.9999	0.3445
45.0000	0.3750
15.0001	0.4167
15.0003	0.4583
45.0001	0.4888
75.0001	0.5000
105.0000	0.5000
135.0000	0.5000
164.9996	0.5000
164.9992	0.5000
134.9998	0.5000
104.9999	0.5000
74.9999	0.5112
45.0000	0.5417
15.0001	0.5833
15.0003	0.6250
45.0001	0.6555
75.0001	0.6667
105.0000	0.6667
135.0000	0.6667
164.9996	0.6667
164.9992	0.6667
134.9998	0.6667
104.9999	0.6667
74.9999	0.6778
45.0000	0.7083

15.0001	0.7500	109.9997	0.8333	155.0001	1.0000	55.0000	0.1628	40.0001	0.2146	135.0000	0.3333
15.0003	0.7917	79.9998	0.8409	174.9989	1.0000	85.0000	0.1667	10.0004	0.2573	105.0000	0.3333
45.0001	0.8222	49.9998	0.8687	144.9997	1.0000	114.9999	0.1667	20.0001	0.2980	75.0001	0.3445
75.0001	0.8333	19.9998	0.9094	119.9999	0.0000	144.9997	0.1667	50.0000	0.3258	45.0001	0.3750
105.0000	0.8333	10.0003	0.9520	90.0000	0.0000	174.9976	0.1667	80.0000	0.3333	15.0003	0.4167
135.0000	0.8333	40.0002	0.9852	60.0000	0.0223	154.9997	0.1667	109.9999	0.3333	15.0001	0.4583
164.9996	0.8333	70.0002	1.0000	30.0003	0.0610	124.9999	0.1667	139.9997	0.3333	45.0000	0.4888
164.9992	0.8333	100.0001	1.0000	0.0878	0.1057	95.0000	0.1667	169.9988	0.3333	74.9999	0.5000
134.9998	0.8333	130.0001	1.0000	30.0001	0.1443	65.0001	0.1852	159.9996	0.3333	104.9999	0.5000
104.9999	0.8333	160.0001	1.0000	60.0000	0.1667	35.0001	0.2211	130.0000	0.3333	134.9998	0.5000
74.9999	0.8445	169.9995	1.0000	90.0000	0.1667	5.0008	0.2647	100.0000	0.3333	164.9992	0.5000
45.0000	0.8750	139.9997	1.0000	119.9999	0.1667	25.0001	0.3044	70.0001	0.3481	164.9996	0.5000
15.0001	0.9167	114.9997	0.0000	149.9997	0.1667	55.0000	0.3295	40.0001	0.3813	135.0000	0.5000
15.0003	0.9583	84.9998	0.0038	179.8416	0.1667	85.0000	0.3333	10.0004	0.4240	105.0000	0.5000
45.0001	0.9888	54.9998	0.0289	149.9997	0.1667	114.9999	0.3333	20.0001	0.4646	75.0001	0.5112
75.0001	1.0000	24.9999	0.0686	119.9999	0.1667	144.9997	0.3333	50.0000	0.4925	45.0001	0.5417
105.0000	1.0000	5.0007	0.1123	90.0000	0.1667	174.9976	0.3333	80.0000	0.5000	15.0003	0.5833
135.0000	1.0000	35.0002	0.1482	60.0000	0.1890	154.9997	0.3333	109.9999	0.5000	15.0001	0.6250
164.9996	1.0000	65.0002	0.1667	30.0001	0.2277	124.9999	0.3333	139.9997	0.5000	45.0000	0.6555
164.9992	1.0000	95.0002	0.1667	0.0878	0.2723	95.0000	0.3333	169.9988	0.5000	74.9999	0.6667
134.9998	1.0000	125.0001	0.1667	30.0001	0.3110	65.0001	0.3518	159.9996	0.5000	104.9999	0.6667
109.9997	0.0000	155.0001	0.1667	60.0000	0.3333	35.0001	0.3877	130.0000	0.5000	134.9998	0.6667
79.9998	0.0075	174.9989	0.1667	90.0000	0.3333	5.0008	0.4314	100.0000	0.5000	164.9992	0.6667
49.9998	0.0354	144.9997	0.1667	119.9999	0.3333	25.0001	0.4711	70.0001	0.5148	164.9996	0.6667
19.9998	0.0760	114.9997	0.1667	149.9997	0.3333	55.0000	0.4962	40.0001	0.5480	135.0000	0.6667
10.0003	0.1187	84.9998	0.1705	179.8416	0.3333	85.0000	0.5000	10.0004	0.5906	105.0000	0.6667
40.0002	0.1519	54.9998	0.1956	149.9997	0.3333	114.9999	0.5000	20.0001	0.6313	75.0001	0.6778
70.0002	0.1667	24.9999	0.2353	119.9999	0.3333	144.9997	0.5000	50.0000	0.6591	45.0001	0.7083
100.0001	0.1667	5.0004	0.2789	90.0000	0.3333	174.9976	0.5000	80.0000	0.6667	15.0003	0.7500
130.0001	0.1667	35.0002	0.3148	60.0000	0.3557	154.9997	0.5000	109.9999	0.6667	15.0001	0.7917
160.0001	0.1667	65.0002	0.3333	30.0001	0.3943	124.9999	0.5000	139.9997	0.6667	45.0000	0.8222
169.9995	0.1667	95.0002	0.3333	0.0878	0.4390	95.0000	0.5000	169.9988	0.6667	74.9999	0.8333
139.9997	0.1667	125.0001	0.3333	30.0001	0.4777	65.0001	0.5185	159.9996	0.6667	104.9999	0.8333
109.9997	0.1667	155.0001	0.3333	60.0000	0.5000	35.0001	0.5544	130.0000	0.6667	134.9998	0.8333
79.9998	0.1742	174.9989	0.3333	90.0000	0.5000	5.0008	0.5980	100.0000	0.6667	164.9992	0.8333
49.9998	0.2020	144.9997	0.3333	119.9999	0.5000	25.0001	0.6377	70.0001	0.6815	164.9996	0.8333
19.9998	0.2427	114.9997	0.3333	149.9997	0.5000	55.0000	0.6628	40.0001	0.7146	135.0000	0.8333
10.0003	0.2854	84.9998	0.3372	179.8416	0.5000	85.0000	0.6667	10.0004	0.7573	105.0000	0.8333
40.0002	0.3185	54.9998	0.3623	149.9997	0.5000	114.9999	0.6667	20.0001	0.7980	75.0001	0.8445
70.0002	0.3333	24.9999	0.4020	119.9999	0.5000	144.9997	0.6667	50.0000	0.8258	45.0001	0.8750
100.0001	0.3333	5.0004	0.4456	90.0000	0.5000	174.9976	0.6667	80.0000	0.8333	15.0003	0.9167
130.0001	0.3333	35.0002	0.4815	60.0000	0.5223	154.9997	0.6667	109.9999	0.8333	15.0001	0.9583
160.0001	0.3333	65.0002	0.5000	30.0001	0.5610	124.9999	0.6667	139.9997	0.8333	45.0000	0.9888
169.9995	0.3333	95.0002	0.5000	0.0878	0.6057	95.0000	0.6667	169.9988	0.8333	74.9999	1.0000
139.9997	0.3333	125.0001	0.5000	30.0001	0.6443	65.0001	0.6852	159.9996	0.8333	104.9999	1.0000
109.9997	0.3333	155.0001	0.5000	60.0000	0.6667	35.0001	0.7211	130.0000	0.8333	134.9998	1.0000
79.9998	0.3409	174.9989	0.5000	90.0000	0.6667	5.0008	0.7647	100.0000	0.8333	164.9992	1.0000
49.9998	0.3687	144.9997	0.5000	119.9999	0.6667	25.0001	0.8044	70.0001	0.8481	164.9996	1.0000
19.9998	0.4094	114.9997	0.5000	149.9997	0.6667	55.0000	0.8295	40.0001	0.8813	140.0000	0.0000
10.0003	0.4520	84.9998	0.5038	179.8416	0.6667	85.0000	0.8333	10.0004	0.9240	110.0000	0.0000
40.0002	0.4852	54.9998	0.5289	149.9997	0.6667	114.9999	0.8333	20.0001	0.9646	80.0001	0.0075
70.0002	0.5000	24.9999	0.5686	119.9999	0.6667	144.9997	0.8333	50.0000	0.9925	50.0003	0.0354
100.0001	0.5000	5.0004	0.6123	90.0000	0.6667	174.9976	0.8333	80.0000	1.0000	20.0002	0.0760
130.0001	0.5000	35.0002	0.6482	60.0000	0.6890	154.9997	0.8333	109.9999	1.0000	10.0002	0.1187
160.0001	0.5000	65.0002	0.6667	30.0001	0.7277	124.9999	0.8333	139.9997	1.0000	40.0000	0.1519
169.9995	0.5000	95.0002	0.6667	0.0878	0.7723	95.0000	0.8333	169.9988	1.0000	69.9999	0.1667
139.9997	0.5000	125.0001	0.6667	30.0001	0.8110	65.0001	0.8518	159.9996	1.0000	99.9999	0.1667
109.9997	0.5000	155.0001	0.6667	60.0000	0.8333	35.0001	0.8877	135.0000	0.0000	129.9998	0.1667
79.9998	0.5075	174.9989	0.6667	90.0000	0.8333	5.0008	0.9314	105.0000	0.0000	159.9994	0.1667
49.9998	0.5354	144.9997	0.6667	119.9999	0.8333	25.0001	0.9711	75.0001	0.0112	169.9994	0.1667
19.9998	0.5760	114.9997	0.6667	149.9997	0.8333	55.0000	0.9962	45.0003	0.0417	140.0000	0.1667
10.0003	0.6187	84.9998	0.6705	179.8416	0.8333	85.0000	1.0000	15.0003	0.0833	110.0000	0.1667
40.0002	0.6519	54.9998	0.6956	149.9997	0.8333	114.9999	1.0000	15.0001	0.1250	80.0001	0.1742
70.0002	0.6667	24.9999	0.7353	119.9999	0.8333	144.9997	1.0000	45.0000	0.1555	50.0002	0.2020
100.0001	0.6667	5.0004	0.7789	90.0000	0.8333	174.9976	1.0000	74.9999	0.1667	20.0002	0.2427
130.0001	0.6667	35.0002	0.8148	60.0000	0.8557	154.9997	1.0000	104.9999	0.1667	10.0002	0.2854
160.0001	0.6667	65.0002	0.8333	30.0001	0.8943	130.0000	0.0000	134.9998	0.1667	40.0000	0.3185
169.9995	0.6667	95.0002	0.8333	0.0878	0.9390	100.0000	0.0000	164.9992	0.1667	69.9999	0.3333
139.9997	0.6667	125.0001	0.8333	30.0001	0.9777	70.0001	0.0148	164.9996	0.1667	99.9999	0.3333
109.9997	0.6667	155.0001	0.8333	60.0000	1.0000	40.0003	0.0480	135.0000	0.1667	129.9998	0.3333
79.9998	0.6742	174.9989	0.8333	90.0000	1.0000	10.0004	0.0906	105.0000	0.1667	159.9994	0.3333
49.9998	0.7020	144.9997	0.8333	119.9999	1.0000	20.0001	0.1313	75.0001	0.1778	169.9994	0.3333
19.9998	0.7427	114.9997	0.8333	149.9997	1.0000	50.0000	0.1591	45.0001	0.2083	140.0000	0.3333
10.0003	0.7854	84.9998	0.8372	179.8416	1.0000	80.0000	0.1667	15.0003	0.2500	110.0000	0.3333
40.0002	0.8185	54.9998	0.8623	149.9997	1.0000	109.9999	0.1667	15.0001	0.2917	80.0001	0.3409
70.0002	0.8333	24.9999	0.9020	124.9999	0.0000	139.9997	0.1667	45.0000	0.3222	50.0002	0.3687
100.0001	0.8333	5.0004	0.9456	95.0000	0.0000	169.9988	0.1667	74.9999	0.3333	20.0002	0.4094
130.0001	0.8333	35.0002	0.9815	65.0001	0.0185	159.9996	0.1667	104.9999	0.3333	10.0002	0.4520
160.0001	0.8333	65.0002	1.0000	35.0003	0.0544	130.0000	0.1667	134.9998	0.3333	40.0000	0.4852
169.9995	0.8333	95.0002	1.0000	5.0008	0.0980	100.0000	0.1667	164.9992	0.3333	69.9999	0.5000
139.9997	0.8333	125.0001	1.0000	25.0001	0.1377	70.0001	0.1815	164.9996	0.3333	99.9999	0.5000

129.9998	0.5000
159.9994	0.5000
169.9994	0.5000
140.0000	0.5000
110.0000	0.5000
80.0001	0.5075
50.0002	0.5354
20.0002	0.5760
10.0002	0.6187
40.0000	0.6519
69.9999	0.6667
99.9999	0.6667
129.9998	0.6667
159.9994	0.6667
169.9994	0.6667
140.0000	0.6667
110.0000	0.6667
80.0001	0.6742
50.0002	0.7020
20.0002	0.7427
10.0002	0.7854
40.0000	0.8185
69.9999	0.8333
99.9999	0.8333
129.9998	0.8333
159.9994	0.8333
169.9994	0.8333
140.0000	0.8333
110.0000	0.8333
80.0001	0.8409
50.0002	0.8687
20.0002	0.9094
10.0002	0.9520
40.0000	0.9852
69.9999	1.0000
99.9999	1.0000
129.9998	1.0000
159.9994	1.0000
169.9994	1.0000
145.0000	0.0000
115.0001	0.0000
85.0001	0.0038
55.0002	0.0289
25.0002	0.0686
5.0004	0.1123
34.9999	0.1482
64.9999	0.1667
94.9999	0.1667
124.9998	0.1667
154.9996	0.1667
174.9987	0.1667
145.0000	0.1667
115.0001	0.1667
85.0001	0.1705
55.0002	0.1956
25.0002	0.2353
5.0004	0.2789
34.9999	0.3148
64.9999	0.3333
94.9999	0.3333
124.9998	0.3333
154.9996	0.3333
174.9987	0.3333
145.0000	0.3333
115.0001	0.3333
85.0001	0.3372
55.0002	0.3623
25.0002	0.4020
5.0004	0.4456
34.9999	0.4815
64.9999	0.5000
94.9999	0.5000
124.9998	0.5000
154.9996	0.5000
174.9987	0.5000
145.0000	0.5000
115.0001	0.5000
85.0001	0.5038
55.0002	0.5289
25.0002	0.5686
5.0004	0.6123
34.9999	0.6482
64.9999	0.6667
94.9999	0.6667
124.9998	0.6667
154.9996	0.6667
174.9987	0.6667
145.0000	0.6667
115.0001	0.6667
85.0001	0.6705
55.0002	0.6956
25.0002	0.7353
5.0004	0.7789
34.9999	0.8148
64.9999	0.8333
94.9999	0.8333
124.9998	0.8333
154.9996	0.8333
174.9987	0.8333
145.0000	0.8333
115.0001	0.8333
85.0001	0.8371
55.0002	0.8623
25.0002	0.9020
5.0004	0.9456
34.9999	0.9815
64.9999	1.0000
94.9999	1.0000
124.9998	1.0000
154.9996	1.0000
174.9987	1.0000
150.0000	0.0000
120.0001	0.0000
90.0002	0.0000
60.0002	0.0223
30.0002	0.0610
0.0621	0.1057
29.9999	0.1443
59.9999	0.1667
89.9998	0.1667
119.9998	0.1667
149.9996	0.1667
179.8880	0.1667
150.0000	0.1667
120.0001	0.1667
90.0002	0.1667
60.0002	0.1890
30.0002	0.2277
0.0621	0.2723
29.9999	0.3110
59.9999	0.3333
89.9998	0.3333
119.9998	0.3333
149.9996	0.3333
179.8880	0.3333
150.0000	0.3333
120.0001	0.3333
90.0002	0.3333
60.0002	0.3557
30.0002	0.3943
0.0621	0.4390
29.9999	0.4777
59.9999	0.5000
89.9998	0.5000
119.9998	0.5000
149.9996	0.5000
179.8880	0.5000
150.0000	0.5000
120.0001	0.5000
90.0002	0.5000
60.0002	0.5223
30.0002	0.5610
0.0621	0.6057
29.9999	0.6443
59.9999	0.6667
89.9998	0.6667
119.9998	0.6667
149.9996	0.6667
179.8880	0.6667
150.0000	0.6667
120.0001	0.6667
90.0002	0.6667
60.0002	0.6890
30.0002	0.7277
0.0621	0.7723
29.9999	0.8110
59.9999	0.8333
89.9998	0.8333
119.9998	0.8333
149.9996	0.8333
179.8880	0.8333
150.0000	0.8333
120.0001	0.8333
90.0002	0.8333
60.0002	0.8557
30.0002	0.8943
0.0621	0.9390
29.9999	0.9777
59.9999	1.0000
89.9998	1.0000
119.9998	1.0000
149.9996	1.0000
179.8880	1.0000
155.0001	0.0000
125.0001	0.0000
95.0002	0.0000
65.0002	0.0185
35.0002	0.0544
5.0004	0.0980
24.9999	0.1377
54.9998	0.1628
84.9998	0.1667
114.9997	0.1667
144.9997	0.1667
174.9989	0.1667
155.0001	0.1667
125.0001	0.1667
95.0002	0.1667
65.0002	0.1852
35.0002	0.2211
5.0004	0.2647
24.9999	0.3044
54.9998	0.3295
84.9998	0.3333
114.9997	0.3333
144.9997	0.3333
174.9989	0.3333
155.0001	0.3333
125.0001	0.3333
95.0002	0.3333
65.0002	0.3518
35.0002	0.3877
5.0004	0.4314
24.9999	0.4711
54.9998	0.4962
84.9998	0.5000
114.9997	0.5000
144.9997	0.5000
174.9989	0.5000
155.0001	0.5000
125.0001	0.5000
95.0002	0.5000
65.0002	0.5185
35.0002	0.5544
5.0004	0.5980
24.9999	0.6377
54.9998	0.6628
84.9998	0.6667
114.9997	0.6667
144.9997	0.6667
174.9989	0.6667
155.0001	0.6667
125.0001	0.6667
95.0002	0.6667
65.0002	0.6852
35.0002	0.7211
5.0004	0.7647
24.9999	0.8044
54.9998	0.8295
84.9998	0.8333
114.9997	0.8333
144.9997	0.8333
174.9989	0.8333
155.0001	0.8333
125.0001	0.8333
95.0002	0.8333
65.0002	0.8518
35.0002	0.8877
5.0004	0.9314
24.9999	0.9711
54.9998	0.9962
84.9998	1.0000
114.9997	1.0000
144.9997	1.0000
174.9989	1.0000
160.0001	0.0000
130.0001	0.0000
100.0001	0.0000
70.0002	0.0148
40.0002	0.0480
10.0003	0.0906
19.9998	0.1313
49.9998	0.1591
79.9998	0.1667
109.9997	0.1667
139.9997	0.1667
169.9995	0.1667
160.0001	0.1667
130.0001	0.1667
100.0001	0.1667
70.0002	0.1815
40.0002	0.2146
10.0003	0.2573
19.9998	0.2980
49.9998	0.3258
79.9998	0.3333
109.9997	0.3333
139.9997	0.3333
169.9995	0.3333
160.0001	0.3333
130.0001	0.3333
100.0001	0.3333
70.0002	0.3481
40.0002	0.3813
10.0003	0.4240
19.9998	0.4646
49.9998	0.4925
79.9998	0.5000
109.9997	0.5000
139.9997	0.5000
169.9995	0.5000
160.0001	0.5000
130.0001	0.5000
100.0001	0.5000
70.0002	0.5148
40.0002	0.5480
10.0003	0.5906
19.9998	0.6313
49.9998	0.6591
79.9998	0.6667
109.9997	0.6667
139.9997	0.6667
169.9995	0.6667
160.0001	0.6667
130.0001	0.6667
100.0001	0.6667
70.0002	0.6815
40.0002	0.7146
10.0003	0.7573
19.9998	0.7980
49.9998	0.8258
79.9998	0.8333
109.9997	0.8333
139.9997	0.8333
169.9995	0.8333
160.0001	0.8333
130.0001	0.8333
100.0001	0.8333
70.0002	0.8481
40.0002	0.8813
10.0003	0.9240
19.9998	0.9646
49.9998	0.9925
79.9998	1.0000
109.9997	1.0000
139.9997	1.0000
169.9995	1.0000
165.0002	0.0000
135.0002	0.0000
105.0002	0.0000
75.0002	0.0112
45.0002	0.0417
15.0002	0.0833
14.9998	0.1250
44.9998	0.1555
74.9998	0.1667
104.9997	0.1667
134.9997	0.1667
164.9997	0.1667
165.0002	0.1667
135.0002	0.1667
105.0002	0.1667
75.0002	0.1778
45.0002	0.2083
15.0002	0.2500
14.9998	0.2917
44.9998	0.3222
74.9998	0.3333
104.9997	0.3333
134.9997	0.3333
164.9997	0.3333
165.0002	0.3333
135.0002	0.3333
105.0002	0.3333
75.0002	0.3445
45.0002	0.3750
15.0002	0.4167
14.9998	0.4583
44.9998	0.4888
74.9998	0.5000
104.9997	0.5000
134.9997	0.5000
164.9997	0.5000
165.0002	0.5000
135.0002	0.5000
105.0002	0.5000
75.0002	0.5112
45.0002	0.5417
15.0002	0.5833
14.9998	0.6250
44.9998	0.6555
74.9998	0.6667
104.9997	0.6667
134.9997	0.6667
164.9997	0.6667
165.0002	0.6667
135.0002	0.6667
105.0002	0.6667
75.0002	0.6778
45.0002	0.7083
15.0002	0.7500
14.9998	0.7917
44.9998	0.8222
74.9998	0.8333
104.9997	0.8333
134.9997	0.8333
164.9997	0.8333
165.0002	0.8333
135.0002	0.8333
105.0002	0.8333
75.0002	0.8445
45.0002	0.8750
15.0002	0.9167
14.9998	0.9583
44.9998	0.9888
74.9998	1.0000
104.9997	1.0000
134.9997	1.0000
164.9997	1.0000
170.0002	0.0000
140.0002	0.0000
110.0002	0.0000
80.0002	0.0075
50.0002	0.0354
20.0002	0.0760
9.9997	0.1187
39.9998	0.1519
69.9998	0.1667
99.9998	0.1667
129.9998	0.1667
159.9998	0.1667
170.0002	0.1667
140.0002	0.1667
110.0002	0.1667
80.0002	0.1742
50.0002	0.2020
20.0002	0.2427
9.9997	0.2854
39.9998	0.3185
69.9998	0.3333
99.9998	0.3333
129.9998	0.3333
159.9998	0.3333
170.0002	0.3333
140.0002	0.3333
110.0002	0.3333
80.0002	0.3409
50.0002	0.3687
20.0002	0.4094
9.9997	0.4520
39.9998	0.4852
69.9998	0.5000
99.9998	0.5000
129.9998	0.5000
159.9998	0.5000
170.0002	0.5000
140.0002	0.5000
110.0002	0.5000
80.0002	0.5075
50.0002	0.5354
20.0002	0.5760
9.9997	0.6187
39.9998	0.6519
69.9998	0.6667
99.9998	0.6667
129.9998	0.6667
159.9998	0.6667
170.0002	0.6667
140.0002	0.6667
110.0002	0.6667
80.0002	0.6742
50.0002	0.7020
20.0002	0.7427
9.9997	0.7854
39.9998	0.8185
69.9998	0.8333
99.9998	0.8333
129.9998	0.8333
159.9998	0.8333
170.0002	0.8333
140.0002	0.8333
110.0002	0.8333
80.0002	0.8409
50.0002	0.8687
20.0002	0.9094
9.9997	0.9520
39.9998	0.9852
69.9998	1.0000
99.9998	1.0000
129.9998	1.0000
159.9998	1.0000
175.0005	0.0000
145.0002	0.0000
115.0002	0.0000
85.0002	0.0038
55.0002	0.0289
25.0002	0.0686
4.9995	0.1123
34.9997	0.1482
64.9998	0.1667
94.9998	0.1667
124.9998	0.1667
154.9999	0.1667
175.0005	0.1667
145.0002	0.1667
115.0002	0.1667

85.0002	0.1705	179.8764	0.3333	85.0004	0.5000	10.0010	0.5906	104.9996	0.6667	159.9997	0.8333
55.0002	0.1956	149.9993	0.3333	115.0003	0.5000	20.0010	0.6313	74.9998	0.6778	169.9979	0.8333
25.0002	0.2353	119.9995	0.3333	145.0002	0.5000	50.0005	0.6591	45.0000	0.7083	139.9993	0.8333
4.9995	0.2789	89.9996	0.3333	174.9985	0.5000	80.0004	0.6667	15.0007	0.7500	109.9996	0.8333
34.9997	0.3148	59.9997	0.3557	154.9992	0.5000	110.0003	0.6667	15.0013	0.7917	79.9998	0.8408
64.9998	0.3333	29.9999	0.3943	124.9995	0.5000	140.0002	0.6667	45.0006	0.8222	50.0000	0.8687
94.9998	0.3333	0.1237	0.4390	94.9996	0.5000	169.9993	0.6667	75.0004	0.8333	20.0006	0.9094
124.9998	0.3333	30.0006	0.4777	64.9997	0.5185	159.9990	0.6667	105.0003	0.8333	10.0020	0.9520
154.9999	0.3333	60.0005	0.5000	34.9999	0.5544	129.9994	0.6667	135.0002	0.8333	40.0006	0.9852
175.0005	0.3333	90.0004	0.5000	5.0017	0.5980	99.9996	0.6667	164.9995	0.8333	70.0004	1.0000
145.0002	0.3333	120.0003	0.5000	25.0007	0.6377	69.9997	0.6815	164.9986	0.8333	100.0003	1.0000
115.0002	0.3333	150.0002	0.5000	55.0005	0.6628	39.9999	0.7146	134.9994	0.8333	130.0002	1.0000
85.0002	0.3372	179.8764	0.5000	85.0004	0.6667	10.0010	0.7573	104.9996	0.8333	154.9995	0.0000
55.0002	0.3623	149.9993	0.5000	115.0003	0.6667	20.0010	0.7980	74.9998	0.8445	174.9958	0.0000
25.0002	0.4020	119.9995	0.5000	145.0002	0.6667	50.0005	0.8258	45.0000	0.8750	144.9993	0.0000
4.9995	0.4456	89.9996	0.5000	174.9985	0.6667	80.0004	0.8333	15.0007	0.9167	114.9994	0.0000
34.9997	0.4815	59.9997	0.5223	154.9992	0.6667	110.0003	0.8333	15.0013	0.9583	84.9998	0.0038
64.9998	0.5000	29.9999	0.5610	124.9995	0.6667	140.0002	0.8333	45.0006	0.9888	55.0000	0.0289
94.9998	0.5000	0.1237	0.6057	94.9996	0.6667	169.9993	0.8333	75.0004	1.0000	25.0005	0.0686
124.9998	0.5000	30.0006	0.6443	64.9997	0.6852	159.9990	0.8333	105.0003	1.0000	5.0041	0.1123
154.9999	0.5000	60.0005	0.6667	34.9999	0.7211	129.9994	0.8333	135.0002	1.0000	35.0007	0.1482
175.0005	0.5000	90.0004	0.6667	5.0017	0.7647	99.9996	0.8333	159.9995	0.0000	65.0004	0.1667
145.0002	0.5000	120.0003	0.6667	25.0007	0.8044	69.9997	0.8481	169.9979	0.0000	95.0003	0.1667
115.0002	0.5000	150.0002	0.6667	55.0005	0.8295	39.9999	0.8813	139.9993	0.0000	125.0001	0.1667
85.0002	0.5038	179.8764	0.6667	85.0004	0.8333	10.0010	0.9240	109.9994	0.0000	154.9997	0.1667
55.0002	0.5289	149.9993	0.6667	115.0003	0.8333	20.0010	0.9646	79.9998	0.0075	174.9958	0.1667
25.0002	0.5686	119.9995	0.6667	145.0002	0.8333	50.0005	0.9925	50.0000	0.0354	144.9993	0.1667
4.9995	0.6123	89.9996	0.6667	174.9985	0.8333	80.0004	1.0000	20.0006	0.0760	114.9996	0.1667
34.9997	0.6482	59.9997	0.6890	154.9992	0.8333	110.0003	1.0000	10.0020	0.1187	84.9998	0.1705
64.9998	0.6667	29.9999	0.7277	124.9995	0.8333	140.0002	1.0000	40.0006	0.1519	55.0000	0.1956
94.9998	0.6667	0.1237	0.7723	94.9996	0.8333	164.9995	0.0000	70.0004	0.1667	25.0005	0.2353
124.9998	0.6667	30.0006	0.8110	64.9997	0.8518	164.9986	0.0000	100.0003	0.1667	5.0041	0.2789
154.9999	0.6667	60.0005	0.8333	34.9999	0.8877	134.9994	0.0000	130.0002	0.1667	35.0007	0.3148
175.0005	0.6667	90.0004	0.8333	5.0017	0.9314	104.9995	0.0000	159.9997	0.1667	65.0004	0.3333
145.0002	0.6667	120.0003	0.8333	25.0007	0.9711	74.9998	0.0112	169.9979	0.1667	95.0003	0.3333
115.0002	0.6667	150.0002	0.8333	55.0005	0.9962	45.0000	0.0417	139.9993	0.1667	125.0001	0.3333
85.0002	0.6705	179.8764	0.8333	85.0004	1.0000	15.0007	0.0833	109.9996	0.1667	154.9997	0.3333
55.0002	0.6956	149.9993	0.8333	115.0003	1.0000	15.0013	0.1250	79.9998	0.1742	174.9958	0.3333
25.0002	0.7353	119.9995	0.8333	145.0002	1.0000	45.0006	0.1555	50.0000	0.2020	144.9993	0.3333
4.9995	0.7789	89.9996	0.8333	169.9995	0.0000	75.0004	0.1667	20.0006	0.2427	114.9996	0.3333
34.9997	0.8148	59.9997	0.8557	159.9990	0.0000	105.0003	0.1667	10.0020	0.2854	84.9998	0.3371
64.9998	0.8333	29.9999	0.8943	129.9994	0.0000	135.0002	0.1667	40.0006	0.3185	55.0000	0.3623
94.9998	0.8333	0.1237	0.9390	99.9995	0.0000	164.9995	0.1667	70.0004	0.3333	25.0005	0.4020
124.9998	0.8333	30.0006	0.9777	69.9997	0.0148	164.9986	0.1667	100.0003	0.3333	5.0041	0.4456
154.9999	0.8333	60.0005	1.0000	39.9999	0.0480	134.9994	0.1667	130.0002	0.3333	35.0007	0.4815
175.0005	0.8333	90.0004	1.0000	10.0010	0.0906	104.9996	0.1667	159.9997	0.3333	65.0004	0.5000
145.0002	0.8333	120.0003	1.0000	20.0010	0.1313	74.9998	0.1778	169.9979	0.3333	95.0003	0.5000
115.0002	0.8333	150.0002	1.0000	50.0005	0.1591	45.0000	0.2083	139.9993	0.3333	125.0001	0.5000
85.0002	0.8372	174.9994	0.0000	80.0004	0.1667	15.0007	0.2500	109.9996	0.3333	154.9997	0.5000
55.0002	0.8623	154.9992	0.0000	110.0003	0.1667	15.0013	0.2917	79.9998	0.3409	174.9958	0.5000
25.0002	0.9020	124.9995	0.0000	140.0002	0.1667	45.0006	0.3222	50.0000	0.3687	144.9993	0.5000
4.9995	0.9456	94.9995	0.0000	169.9993	0.1667	75.0004	0.3333	20.0006	0.4094	114.9996	0.5000
34.9997	0.9815	64.9997	0.0185	159.9990	0.1667	105.0003	0.3333	10.0020	0.4520	84.9998	0.5038
64.9998	1.0000	34.9999	0.0544	129.9994	0.1667	135.0002	0.3333	40.0006	0.4852	55.0000	0.5289
94.9998	1.0000	5.0017	0.0980	99.9996	0.1667	164.9995	0.3333	70.0004	0.5000	25.0005	0.5686
124.9998	1.0000	25.0007	0.1377	69.9997	0.1815	164.9986	0.3333	100.0003	0.5000	5.0041	0.6123
154.9999	1.0000	55.0005	0.1628	39.9999	0.2146	134.9994	0.3333	130.0002	0.5000	35.0007	0.6482
179.9836	0.0000	85.0004	0.1667	10.0010	0.2573	104.9996	0.3333	159.9997	0.5000	65.0004	0.6667
149.9993	0.0000	115.0003	0.1667	20.0010	0.2980	74.9998	0.3445	169.9979	0.5000	95.0003	0.6667
119.9995	0.0000	145.0002	0.1667	50.0005	0.3258	45.0000	0.3750	139.9993	0.5000	125.0001	0.6667
89.9996	0.0000	174.9985	0.1667	80.0004	0.3333	15.0007	0.4167	109.9996	0.5000	154.9997	0.6667
59.9997	0.0223	154.9992	0.1667	110.0003	0.3333	15.0013	0.4583	79.9998	0.5075	174.9958	0.6667
29.9999	0.0610	124.9995	0.1667	140.0002	0.3333	45.0006	0.4888	50.0000	0.5354	144.9993	0.6667
0.1237	0.1057	94.9996	0.1667	169.9993	0.3333	75.0004	0.5000	20.0006	0.5760	114.9996	0.6667
30.0006	0.1443	64.9997	0.1852	159.9990	0.3333	105.0003	0.5000	10.0020	0.6187	84.9998	0.6705
60.0005	0.1667	34.9999	0.2211	129.9994	0.3333	135.0002	0.5000	40.0006	0.6519	55.0000	0.6956
90.0004	0.1667	5.0017	0.2647	99.9996	0.3333	164.9995	0.5000	70.0004	0.6667	25.0005	0.7353
120.0003	0.1667	25.0007	0.3044	69.9997	0.3481	164.9986	0.5000	100.0003	0.6667	5.0041	0.7789
150.0002	0.1667	55.0005	0.3295	39.9999	0.3813	134.9994	0.5000	130.0002	0.6667	35.0007	0.8148
179.8764	0.1667	85.0004	0.3333	10.0010	0.4240	104.9996	0.5000	159.9997	0.6667	65.0004	0.8333
149.9993	0.1667	115.0003	0.3333	20.0010	0.4646	74.9998	0.5112	169.9979	0.6667	95.0003	0.8333
119.9995	0.1667	145.0002	0.3333	50.0005	0.4925	45.0000	0.5417	139.9993	0.6667	125.0001	0.8333
89.9996	0.1667	174.9985	0.3333	80.0004	0.5000	15.0007	0.5833	109.9996	0.6667	154.9997	0.8333
59.9997	0.1890	154.9992	0.3333	110.0003	0.5000	15.0013	0.6250	79.9998	0.6742	174.9958	0.8333
29.9999	0.2277	124.9995	0.3333	140.0002	0.5000	45.0006	0.6555	50.0000	0.7020	144.9993	0.8333
0.1237	0.2723	94.9996	0.3333	169.9993	0.5000	75.0004	0.6667	20.0006	0.7427	114.9996	0.8333
30.0006	0.3110	64.9997	0.3518	159.9990	0.5000	105.0003	0.6667	10.0020	0.7853	84.9998	0.8371
60.0005	0.3333	34.9999	0.3877	129.9994	0.5000	135.0002	0.6667	40.0006	0.8185	55.0000	0.8623
90.0004	0.3333	5.0017	0.4314	99.9996	0.5000	164.9995	0.6667	70.0004	0.8333	25.0005	0.9020
120.0003	0.3333	25.0007	0.4711	69.9997	0.5148	164.9986	0.6667	100.0003	0.8333	5.0041	0.9456
150.0002	0.3333	55.0005	0.4962	39.9999	0.5480	134.9994	0.6667	130.0002	0.8333	35.0007	0.9815

65.0004	1.0000	35.0005	0.0544	129.9996	0.1667	134.9998	0.3333	40.0004	0.4852	55.0004	0.5289
95.0003	1.0000	5.0042	0.0980	99.9999	0.1667	164.9989	0.3333	70.0002	0.5000	25.0008	0.5686
125.0001	1.0000	25.0009	0.1377	70.0001	0.1815	164.9987	0.3333	100.0000	0.5000	5.0031	0.6123
149.9995	0.0000	55.0004	0.1628	40.0004	0.2146	134.9997	0.3333	129.9998	0.5000	35.0003	0.6482
179.7963	0.0000	85.0003	0.1667	10.0021	0.2573	104.9999	0.3333	159.9992	0.5000	65.0002	0.6667
149.9992	0.0000	115.0001	0.1667	20.0010	0.2980	75.0002	0.3445	169.9982	0.5000	95.0001	0.6667
119.9994	0.0000	144.9998	0.1667	50.0004	0.3258	45.0004	0.3750	139.9997	0.5000	124.9999	0.6667
89.9999	0.0000	174.9961	0.1667	80.0003	0.3333	15.0014	0.4167	110.0000	0.5000	154.9994	0.6667
60.0001	0.0223	154.9991	0.1667	110.0001	0.3333	15.0013	0.4583	80.0002	0.5075	174.9969	0.6667
30.0005	0.0610	124.9996	0.1667	139.9998	0.3333	45.0004	0.4888	50.0004	0.5353	144.9997	0.6667
0.2038	0.1057	94.9999	0.1667	169.9982	0.3333	75.0002	0.5000	20.0010	0.5760	115.0000	0.6667
30.0008	0.1443	65.0001	0.1852	159.9989	0.3333	105.0001	0.5000	10.0017	0.6187	85.0002	0.6705
60.0004	0.1667	35.0005	0.2211	129.9996	0.3333	134.9998	0.5000	40.0004	0.6519	55.0004	0.6956
90.0003	0.1667	5.0042	0.2647	99.9999	0.3333	164.9989	0.5000	70.0002	0.6667	25.0008	0.7353
120.0001	0.1667	25.0009	0.3044	70.0001	0.3481	164.9987	0.5000	100.0000	0.6667	5.0031	0.7789
149.9998	0.1667	55.0004	0.3295	40.0004	0.3813	134.9997	0.5000	129.9998	0.6667	35.0003	0.8148
179.7963	0.1667	85.0003	0.3333	10.0021	0.4240	104.9999	0.5000	159.9992	0.6667	65.0002	0.8333
149.9992	0.1667	115.0001	0.3333	20.0010	0.4646	75.0002	0.5112	169.9982	0.6667	95.0001	0.8333
119.9996	0.1667	144.9998	0.3333	50.0004	0.4925	45.0004	0.5417	139.9997	0.6667	124.9999	0.8333
89.9999	0.1667	174.9961	0.3333	80.0003	0.5000	15.0014	0.5833	110.0000	0.6667	154.9994	0.8333
60.0001	0.1890	154.9991	0.3333	110.0001	0.5000	15.0013	0.6250	80.0002	0.6742	174.9969	0.8333
30.0005	0.2277	124.9996	0.3333	139.9998	0.5000	45.0004	0.6555	50.0004	0.7020	144.9997	0.8333
0.2038	0.2723	94.9999	0.3333	169.9982	0.5000	75.0002	0.6667	20.0010	0.7427	115.0000	0.8333
30.0008	0.3110	65.0001	0.3518	159.9989	0.5000	105.0001	0.6667	10.0017	0.7853	85.0002	0.8371
60.0004	0.3333	35.0005	0.3877	129.9996	0.5000	134.9998	0.6667	40.0004	0.8185	55.0004	0.8623
90.0003	0.3333	5.0042	0.4314	99.9999	0.5000	164.9989	0.6667	70.0002	0.8333	25.0008	0.9020
120.0001	0.3333	25.0009	0.4711	70.0001	0.5148	164.9987	0.6667	100.0000	0.8333	5.0031	0.9456
149.9998	0.3333	55.0004	0.4962	40.0004	0.5480	134.9997	0.6667	129.9998	0.8333	35.0003	0.9815
179.7963	0.3333	85.0003	0.5000	10.0021	0.5906	104.9999	0.6667	159.9992	0.8333	65.0002	1.0000
149.9992	0.3333	115.0001	0.5000	20.0010	0.6313	75.0002	0.6778	169.9982	0.8333	95.0001	1.0000
119.9996	0.3333	144.9998	0.5000	50.0004	0.6591	45.0004	0.7083	139.9997	0.8333	119.9995	0.0000
89.9999	0.3333	174.9961	0.5000	80.0003	0.6667	15.0014	0.7500	110.0000	0.8333	149.9996	0.0000
60.0001	0.3557	154.9991	0.5000	110.0001	0.6667	15.0013	0.7917	80.0002	0.8408	179.8381	0.0000
30.0005	0.3943	124.9996	0.5000	139.9998	0.6667	45.0004	0.8222	50.0004	0.8687	149.9995	0.0000
0.2038	0.4390	94.9999	0.5000	169.9982	0.6667	75.0002	0.8333	20.0010	0.9094	120.0001	0.0000
30.0008	0.4777	65.0001	0.5185	159.9989	0.6667	105.0001	0.8333	10.0017	0.9520	90.0003	0.0000
60.0004	0.5000	35.0005	0.5544	129.9996	0.6667	134.9998	0.8333	40.0004	0.9852	60.0004	0.0223
90.0003	0.5000	5.0042	0.5980	99.9999	0.6667	164.9989	0.8333	70.0002	1.0000	30.0007	0.0610
120.0001	0.5000	25.0009	0.6377	70.0001	0.6815	164.9987	0.8333	100.0000	1.0000	0.1620	0.1057
149.9998	0.5000	55.0004	0.6628	40.0004	0.7146	134.9997	0.8333	124.9995	0.0000	30.0003	0.1443
179.7963	0.5000	85.0003	0.6667	10.0021	0.7573	104.9999	0.8333	154.9994	0.0000	60.0001	0.1667
149.9992	0.5000	115.0001	0.6667	20.0010	0.7980	75.0002	0.8445	174.9969	0.0000	90.0000	0.1667
119.9996	0.5000	144.9998	0.6667	50.0004	0.8258	45.0004	0.8750	144.9994	0.0000	119.9999	0.1667
89.9999	0.5000	174.9961	0.6667	80.0003	0.8333	15.0014	0.9167	115.0000	0.0000	149.9996	0.1667
60.0001	0.5223	154.9991	0.6667	110.0001	0.8333	15.0013	0.9583	85.0002	0.0038	179.8381	0.1667
30.0005	0.5610	124.9996	0.6667	139.9998	0.8333	45.0004	0.9888	55.0004	0.0289	149.9998	0.1667
0.2038	0.6057	94.9999	0.6667	169.9982	0.8333	75.0002	1.0000	25.0008	0.0686	120.0001	0.1667
30.0008	0.6443	65.0001	0.6852	159.9989	0.8333	105.0001	1.0000	5.0031	0.1123	90.0003	0.1667
60.0004	0.6667	35.0005	0.7211	129.9996	0.8333	129.9995	0.0000	35.0003	0.1482	60.0004	0.1890
90.0003	0.6667	5.0042	0.7647	99.9999	0.8333	159.9992	0.0000	65.0002	0.1667	30.0007	0.2277
120.0001	0.6667	25.0009	0.8044	70.0001	0.8481	169.9982	0.0000	95.0001	0.1667	0.1620	0.2723
149.9998	0.6667	55.0004	0.8295	40.0004	0.8813	139.9994	0.0000	124.9999	0.1667	30.0003	0.3110
179.7963	0.6667	85.0003	0.8333	10.0021	0.9240	110.0000	0.0000	154.9994	0.1667	60.0001	0.3333
149.9992	0.6667	115.0001	0.8333	20.0010	0.9646	80.0002	0.0075	174.9969	0.1667	90.0000	0.3333
119.9996	0.6667	144.9998	0.8333	50.0004	0.9925	50.0004	0.0354	144.9997	0.1667	119.9999	0.3333
89.9999	0.6667	174.9961	0.8333	80.0003	1.0000	20.0010	0.0760	115.0000	0.1667	149.9996	0.3333
60.0001	0.6890	154.9991	0.8333	110.0001	1.0000	10.0017	0.1187	85.0002	0.1705	179.8381	0.3333
30.0005	0.7277	124.9996	0.8333	134.9995	0.0000	40.0004	0.1519	55.0004	0.1956	149.9998	0.3333
0.2038	0.7723	94.9999	0.8333	164.9989	0.0000	70.0002	0.1667	25.0008	0.2353	120.0001	0.3333
30.0008	0.8110	65.0001	0.8518	164.9987	0.0000	100.0000	0.1667	5.0031	0.2789	90.0003	0.3333
60.0004	0.8333	35.0005	0.8877	134.9994	0.0000	129.9998	0.1667	35.0003	0.3148	60.0004	0.3557
90.0003	0.8333	5.0042	0.9314	104.9999	0.0000	159.9992	0.1667	65.0002	0.3333	30.0007	0.3943
120.0001	0.8333	25.0009	0.9711	75.0002	0.0112	169.9982	0.1667	95.0001	0.3333	0.1620	0.4390
149.9998	0.8333	55.0004	0.9962	45.0004	0.0417	139.9997	0.1667	124.9999	0.3333	30.0003	0.4777
179.7963	0.8333	85.0003	1.0000	15.0014	0.0833	110.0000	0.1667	154.9994	0.3333	60.0001	0.5000
149.9992	0.8333	115.0001	1.0000	15.0013	0.1250	80.0002	0.1742	174.9969	0.3333	90.0000	0.5000
119.9996	0.8333	139.9995	0.0000	45.0004	0.1555	50.0004	0.2020	144.9997	0.3333	119.9999	0.5000
89.9999	0.8333	169.9982	0.0000	75.0002	0.1667	20.0010	0.2427	115.0000	0.3333	149.9996	0.5000
60.0001	0.8557	159.9989	0.0000	105.0001	0.1667	10.0017	0.2854	85.0002	0.3371	179.8381	0.5000
30.0005	0.8943	129.9994	0.0000	134.9998	0.1667	40.0004	0.3185	55.0004	0.3623	149.9998	0.5000
0.2038	0.9390	99.9999	0.0000	164.9989	0.1667	70.0002	0.3333	25.0008	0.4020	120.0001	0.5000
30.0008	0.9777	70.0001	0.0148	164.9987	0.1667	100.0000	0.3333	5.0031	0.4456	90.0003	0.5000
60.0004	1.0000	40.0004	0.0480	134.9997	0.1667	129.9998	0.3333	35.0003	0.4815	60.0004	0.5223
90.0003	1.0000	10.0021	0.0906	104.9999	0.1667	159.9992	0.3333	65.0002	0.5000	30.0007	0.5610
120.0001	1.0000	20.0010	0.1313	75.0002	0.1778	169.9982	0.3333	95.0001	0.5000	0.1620	0.6057
144.9995	0.0000	50.0004	0.1591	45.0004	0.2083	139.9997	0.3333	124.9999	0.5000	30.0003	0.6443
174.9961	0.0000	80.0003	0.1667	15.0014	0.2500	110.0000	0.3333	154.9994	0.5000	60.0001	0.6667
154.9991	0.0000	110.0001	0.1667	15.0013	0.2917	80.0002	0.3408	174.9969	0.5000	90.0000	0.6667
124.9994	0.0000	139.9998	0.1667	45.0004	0.3222	50.0004	0.3687	144.9997	0.5000	119.9999	0.6667
94.9999	0.0000	169.9982	0.1667	75.0002	0.3333	20.0010	0.4094	115.0000	0.5000	149.9996	0.6667
65.0001	0.0185	159.9989	0.1667	105.0001	0.3333	10.0017	0.4520	85.0002	0.5038	179.8381	0.6667

149.9998	0.6667	114.9999	0.8333	20.0001	0.9646
120.0001	0.6667	144.9997	0.8333	50.0000	0.9925
90.0003	0.6667	174.9981	0.8333	80.0000	1.0000
60.0004	0.6890	154.9999	0.8333	104.9996	0.0000
30.0007	0.7277	125.0001	0.8333	134.9999	0.0000
0.1620	0.7723	95.0003	0.8333	164.9999	0.0000
30.0003	0.8110	65.0004	0.8518	164.9998	0.0000
60.0001	0.8333	35.0005	0.8877	135.0003	0.0000
90.0000	0.8333	5.0022	0.9314	105.0003	0.0000
119.9999	0.8333	25.0002	0.9711	75.0004	0.0112
149.9996	0.8333	55.0001	0.9962	45.0004	0.0417
179.8381	0.8333	85.0000	1.0000	15.0004	0.0833
149.9998	0.8333	109.9995	0.0000	14.9999	0.1250
120.0001	0.8333	139.9998	0.0000	44.9999	0.1555
90.0003	0.8333	169.9994	0.0000	74.9999	0.1667
60.0004	0.8557	159.9996	0.0000	104.9999	0.1667
30.0007	0.8943	130.0002	0.0000	134.9999	0.1667
0.1620	0.9390	100.0003	0.0000	164.9999	0.1667
30.0003	0.9777	70.0004	0.0148	165.0003	0.1667
60.0001	1.0000	40.0004	0.0480	135.0003	0.1667
90.0000	1.0000	10.0008	0.0906	105.0003	0.1667
114.9995	0.0000	20.0001	0.1313	75.0004	0.1778
144.9997	0.0000	50.0000	0.1591	45.0004	0.2083
174.9981	0.0000	80.0000	0.1667	15.0004	0.2500
154.9995	0.0000	109.9999	0.1667	14.9999	0.2917
125.0001	0.0000	139.9998	0.1667	44.9999	0.3222
95.0003	0.0000	169.9994	0.1667	74.9999	0.3333
65.0004	0.0185	160.0001	0.1667	104.9999	0.3333
35.0005	0.0544	130.0002	0.1667	134.9999	0.3333
5.0022	0.0980	100.0003	0.1667	164.9999	0.3333
25.0002	0.1377	70.0004	0.1815	165.0003	0.3333
55.0001	0.1628	40.0004	0.2146	135.0003	0.3333
85.0000	0.1667	10.0008	0.2573	105.0003	0.3333
114.9999	0.1667	20.0001	0.2980	75.0004	0.3445
144.9997	0.1667	50.0000	0.3258	45.0004	0.3750
174.9981	0.1667	80.0000	0.3333	15.0004	0.4167
154.9999	0.1667	109.9999	0.3333	14.9999	0.4583
125.0001	0.1667	139.9998	0.3333	44.9999	0.4888
95.0003	0.1667	169.9994	0.3333	74.9999	0.5000
65.0004	0.1852	160.0001	0.3333	104.9999	0.5000
35.0005	0.2211	130.0002	0.3333	134.9999	0.5000
5.0022	0.2647	100.0003	0.3333	164.9999	0.5000
25.0002	0.3044	70.0004	0.3481	165.0003	0.5000
55.0001	0.3295	40.0004	0.3813	135.0003	0.5000
85.0000	0.3333	10.0008	0.4240	105.0003	0.5000
114.9999	0.3333	20.0001	0.4646	75.0004	0.5112
144.9997	0.3333	50.0000	0.4925	45.0004	0.5417
174.9981	0.3333	80.0000	0.5000	15.0004	0.5833
154.9999	0.3333	109.9999	0.5000	14.9999	0.6250
125.0001	0.3333	139.9998	0.5000	44.9999	0.6555
95.0003	0.3333	169.9994	0.5000	74.9999	0.6667
65.0004	0.3518	160.0001	0.5000	104.9999	0.6667
35.0005	0.3877	130.0002	0.5000	134.9999	0.6667
5.0022	0.4314	100.0003	0.5000	164.9999	0.6667
25.0002	0.4711	70.0004	0.5148	165.0003	0.6667
55.0001	0.4962	40.0004	0.5480	135.0003	0.6667
85.0000	0.5000	10.0008	0.5906	105.0003	0.6667
114.9999	0.5000	20.0001	0.6313	75.0004	0.6778
144.9997	0.5000	50.0000	0.6591	45.0004	0.7083
174.9981	0.5000	80.0000	0.6667	15.0004	0.7500
154.9999	0.5000	109.9999	0.6667	14.9999	0.7917
125.0001	0.5000	139.9998	0.6667	44.9999	0.8222
95.0003	0.5000	169.9994	0.6667	74.9999	0.8333
65.0004	0.5185	160.0001	0.6667	104.9999	0.8333
35.0005	0.5544	130.0002	0.6667	134.9999	0.8333
5.0022	0.5980	100.0003	0.6667	164.9999	0.8333
25.0002	0.6377	70.0004	0.6815	165.0003	0.8333
55.0001	0.6628	40.0004	0.7146	135.0003	0.8333
85.0000	0.6667	10.0008	0.7573	105.0003	0.8333
114.9999	0.6667	20.0001	0.7980	75.0004	0.8445
144.9997	0.6667	50.0000	0.8258	45.0004	0.8750
174.9981	0.6667	80.0000	0.8333	15.0004	0.9167
154.9999	0.6667	109.9999	0.8333	14.9999	0.9583
125.0001	0.6667	139.9998	0.8333	44.9999	0.9888
95.0003	0.6667	169.9994	0.8333	74.9999	1.0000
65.0004	0.6852	160.0001	0.8333		
35.0005	0.7211	130.0002	0.8333		
5.0022	0.7647	100.0003	0.8333		
25.0002	0.8044	70.0004	0.8481		
55.0001	0.8295	40.0004	0.8813		
85.0000	0.8333	10.0008	0.9240		

APPENDIX L

AL.DAT Data File

Obliquity (degrees)	Cum. Prob.
74.9998	0.0223
44.9998	0.0833
14.9998	0.1667
15.0001	0.2500
45.0002	0.3110
75.0002	0.3333
105.0002	0.3333
135.0002	0.3333
165.0002	0.3333
164.9997	0.3333
134.9997	0.3333
104.9997	0.3333
74.9998	0.3557
44.9998	0.4167
14.9998	0.5000
15.0002	0.5833
45.0002	0.6443
75.0002	0.6667
105.0002	0.6667
135.0002	0.6667
165.0002	0.6667
164.9997	0.6667
134.9997	0.6667
104.9997	0.6667
74.9998	0.6890
44.9998	0.7500
14.9998	0.8333
15.0002	0.9167
45.0002	0.9777
75.0002	1.0000
105.0002	1.0000
135.0002	1.0000
165.0002	1.0000
164.9997	1.0000
134.9997	1.0000
104.9997	1.0000
79.9998	0.0150
49.9998	0.0707
19.9998	0.1521
10.0003	0.2374
40.0002	0.3037
70.0002	0.3333
100.0001	0.3333
130.0001	0.3333
160.0001	0.3333
169.9995	0.3333
139.9997	0.3333
109.9997	0.3333
79.9998	0.3484
49.9998	0.4040
19.9998	0.4854
10.0003	0.5707
40.0002	0.6370
70.0002	0.6667
100.0001	0.6667
130.0001	0.6667
160.0001	0.6667
169.9995	0.6667
139.9997	0.6667
109.9997	0.6667
79.9998	0.6817
49.9998	0.7374
19.9998	0.8188
10.0003	0.9040
40.0002	0.9704
70.0002	1.0000
100.0001	1.0000
130.0001	1.0000
160.0001	1.0000
169.9995	1.0000
139.9997	1.0000
109.9997	1.0000
84.9998	0.0076
54.9998	0.0579
24.9999	0.1373
5.0007	0.2246
35.0002	0.2963
65.0002	0.3333
95.0002	0.3333
125.0001	0.3333
155.0001	0.3333
174.9989	0.3333
144.9997	0.3333
114.9997	0.3333
84.9998	0.3410
54.9998	0.3912
24.9999	0.4706
5.0004	0.5579
35.0002	0.6296
65.0002	0.6667
95.0002	0.6667
125.0001	0.6667
155.0001	0.6667
174.9989	0.6667
144.9997	0.6667
114.9997	0.6667
84.9998	0.6743
54.9998	0.7246
24.9999	0.8039
5.0004	0.8912
35.0002	0.9630
65.0002	1.0000
95.0002	1.0000
125.0001	1.0000
155.0001	1.0000
174.9989	1.0000
144.9997	1.0000
114.9997	1.0000
89.9998	0.0000
59.9999	0.0447
29.9999	0.1220
0.0966	0.2113
30.0002	0.2887
60.0002	0.3333
90.0002	0.3333
120.0001	0.3333
150.0000	0.3333
179.8880	0.3333
149.9996	0.3333
119.9998	0.3333
89.9998	0.3333
59.9999	0.3780
29.9999	0.4553
0.0621	0.5447
30.0002	0.6220
60.0002	0.6667
90.0002	0.6667
120.0001	0.6667
150.0000	0.6667
179.8880	0.6667
149.9996	0.6667
119.9998	0.6667
89.9998	0.6667
59.9999	0.7113
29.9999	0.7887
0.0621	0.8780
30.0002	0.9553
60.0002	1.0000
90.0002	1.0000
120.0001	1.0000
150.0000	1.0000
179.8880	1.0000
149.9996	1.0000
119.9998	1.0000
94.9999	0.0000
64.9999	0.0370
34.9999	0.1088
5.0011	0.1961
25.0002	0.2755
55.0002	0.3257
85.0001	0.3333
115.0001	0.3333
145.0000	0.3333
174.9987	0.3333
154.9996	0.3333
124.9998	0.3333
94.9999	0.3333
64.9999	0.3704
34.9999	0.4421
5.0004	0.5294
25.0002	0.6088
55.0002	0.6590
85.0001	0.6667
115.0001	0.6667
145.0000	0.6667
174.9987	0.6667
154.9996	0.6667
124.9998	0.6667
94.9999	0.6667
64.9999	0.7037
34.9999	0.7755
5.0004	0.8627
25.0002	0.9421
55.0002	0.9924
85.0001	1.0000
115.0001	1.0000
145.0000	1.0000
174.9987	1.0000
154.9996	1.0000
124.9998	1.0000
99.9999	0.0000
69.9999	0.0296
40.0000	0.0960
10.0007	0.1812
20.0002	0.2626
50.0002	0.3183
80.0001	0.3333
110.0000	0.3333
140.0000	0.3333
169.9994	0.3333
159.9994	0.3333
129.9998	0.3333
99.9999	0.3333
69.9999	0.3630
40.0000	0.4293
10.0002	0.5146
20.0002	0.5960
50.0002	0.6516
80.0001	0.6667
110.0000	0.6667
140.0000	0.6667
169.9994	0.6667
159.9994	0.6667
129.9998	0.6667
99.9999	0.6667
69.9999	0.6963
40.0000	0.7626
10.0002	0.8479
20.0002	0.9293
50.0002	0.9850
80.0001	1.0000
110.0000	1.0000
140.0000	1.0000
169.9994	1.0000
159.9994	1.0000
129.9998	1.0000
104.9999	0.0000
74.9999	0.0223
45.0000	0.0833
15.0005	0.1667
15.0003	0.2500
45.0001	0.3110
75.0001	0.3333
105.0000	0.3333
135.0000	0.3333
164.9996	0.3333
164.9992	0.3333
134.9998	0.3333
104.9999	0.3333
74.9999	0.3557
45.0000	0.4167
15.0001	0.5000
15.0003	0.5833
45.0001	0.6443
75.0001	0.6667
105.0000	0.6667
135.0000	0.6667
164.9996	0.6667
164.9992	0.6667
134.9998	0.6667
104.9999	0.6667
74.9999	0.6890
45.0000	0.7500
15.0001	0.8333
15.0003	0.9167
45.0001	0.9777
75.0001	1.0000
105.0000	1.0000
135.0000	1.0000
164.9996	1.0000
164.9992	1.0000
134.9998	1.0000
109.9997	0.0000
79.9998	0.0150
49.9998	0.0707
19.9998	0.1521
10.0003	0.2374
40.0002	0.3037
70.0002	0.3333
100.0001	0.3333
130.0001	0.3333
160.0001	0.3333
169.9995	0.3333
139.9997	0.3333
109.9997	0.3333
79.9998	0.3484
49.9998	0.4040
19.9998	0.4854
10.0003	0.5707
40.0002	0.6370
70.0002	0.6667
100.0001	0.6667
130.0001	0.6667
160.0001	0.6667
169.9995	0.6667
139.9997	0.6667
109.9997	0.6667
79.9998	0.6817
49.9998	0.7374
19.9998	0.8188
10.0003	0.9040
40.0002	0.9704
70.0002	1.0000
100.0001	1.0000
130.0001	1.0000
160.0001	1.0000
169.9995	1.0000
139.9997	1.0000
114.9997	0.0000
84.9998	0.0076
54.9998	0.0579
24.9999	0.1373
5.0007	0.2246
35.0002	0.2963
65.0002	0.3333
95.0002	0.3333
125.0001	0.3333
155.0001	0.3333
174.9989	0.3333
144.9997	0.3333
114.9997	0.3333
84.9998	0.3410
54.9998	0.3912
24.9999	0.4706
5.0004	0.5579
35.0002	0.6296
65.0002	0.6667
95.0002	0.6667
125.0001	0.6667
155.0001	0.6667
174.9989	0.6667
144.9997	0.6667
114.9997	0.6667
84.9998	0.6743
54.9998	0.7246
24.9999	0.8039
5.0004	0.8912
35.0002	0.9630
65.0002	1.0000
95.0002	1.0000
125.0001	1.0000
155.0001	1.0000
174.9989	1.0000
144.9997	1.0000
119.9999	0.0000
90.0000	0.0000
60.0000	0.0447
30.0003	0.1220
0.0878	0.2113
30.0001	0.2887
60.0000	0.3333
90.0000	0.3333
119.9999	0.3333
149.9997	0.3333
179.8416	0.3333
149.9997	0.3333
119.9999	0.3333
90.0000	0.3333
60.0000	0.3780
30.0001	0.4553
0.0878	0.5447
30.0001	0.6220
60.0000	0.6667
90.0000	0.6667
119.9999	0.6667
149.9997	0.6667
179.8416	0.6667
149.9997	0.6667
119.9999	0.6667
90.0000	0.6667
60.0000	0.7113
30.0001	0.7887
0.0878	0.8780
30.0001	0.9553
60.0000	1.0000
90.0000	1.0000
119.9999	1.0000
149.9997	1.0000
179.8416	1.0000
149.9997	1.0000
124.9999	0.0000
95.0000	0.0000
65.0001	0.0370
35.0003	0.1088
5.0008	0.1961
25.0001	0.2755
55.0000	0.3257
85.0000	0.3333
114.9999	0.3333
144.9997	0.3333
174.9976	0.3333
154.9997	0.3333
124.9999	0.3333
95.0000	0.3333
65.0001	0.3704
35.0001	0.4421
5.0008	0.5294
25.0001	0.6088
55.0000	0.6590
85.0000	0.6667
114.9999	0.6667
144.9997	0.6667
174.9976	0.6667
154.9997	0.6667
124.9999	0.6667
95.0000	0.6667
65.0001	0.7037
35.0001	0.7755
5.0008	0.8627
25.0001	0.9421
55.0000	0.9924
85.0000	1.0000
114.9999	1.0000
144.9997	1.0000
174.9976	1.0000
154.9997	1.0000
130.0000	0.0000
100.0000	0.0000
70.0001	0.0296
40.0003	0.0960
10.0004	0.1812
20.0001	0.2626
50.0000	0.3183
80.0000	0.3333
109.9999	0.3333
139.9997	0.3333
169.9988	0.3333
159.9996	0.3333
130.0000	0.3333
100.0000	0.3333
70.0001	0.3630
40.0001	0.4293
10.0004	0.5146
20.0001	0.5960
50.0000	0.6516
80.0000	0.6667
109.9999	0.6667
139.9997	0.6667
169.9988	0.6667
159.9996	0.6667
130.0000	0.6667
100.0000	0.6667
70.0001	0.6963
40.0001	0.7626
10.0004	0.8479
20.0001	0.9293
50.0000	0.9850
80.0000	1.0000
109.9999	1.0000
139.9997	1.0000
169.9988	1.0000
159.9996	1.0000
135.0000	0.0000
105.0000	0.0000
75.0001	0.0223
45.0003	0.0833
15.0003	0.1667
15.0001	0.2500
45.0000	0.3110
74.9999	0.3333
104.9999	0.3333
134.9998	0.3333
164.9992	0.3333
164.9996	0.3333
135.0000	0.3333
105.0000	0.3333
75.0001	0.3557
45.0001	0.4167
15.0003	0.5000
15.0001	0.5833
45.0000	0.6443
74.9999	0.6667
104.9999	0.6667
134.9998	0.6667
164.9992	0.6667
164.9996	0.6667
135.0000	0.6667
105.0000	0.6667
75.0001	0.6890
45.0001	0.7500
15.0003	0.8333
15.0001	0.9167
45.0000	0.9777
74.9999	1.0000
104.9999	1.0000
134.9998	1.0000
164.9992	1.0000
164.9996	1.0000
140.0000	0.0000
110.0000	0.0000
80.0000	0.0150
50.0003	0.0707
20.0002	0.1521
10.0002	0.2374
40.0000	0.3037
69.9999	0.3333
99.9999	0.3333
129.9998	0.3333
159.9994	0.3333
169.9994	0.3333
140.0000	0.3333
110.0000	0.3333
80.0001	0.3484

50.0002	0.4040	150.0000	0.6667	109.9997	1.0000	4.9995	0.2245	94.9996	0.3333	164.9995	0.6667
20.0002	0.4854	120.0001	0.6667	139.9997	1.0000	34.9997	0.2963	64.9997	0.3704	164.9986	0.6667
10.0002	0.5707	90.0002	0.6667	169.9995	1.0000	64.9998	0.3333	34.9999	0.4421	134.9994	0.6667
40.0000	0.6370	60.0002	0.7113	165.0002	0.0000	94.9998	0.3333	5.0017	0.5294	104.9996	0.6667
69.9999	0.6667	30.0002	0.7887	135.0002	0.0000	124.9998	0.3333	25.0007	0.6088	74.9998	0.6890
99.9999	0.6667	0.0621	0.8780	105.0002	0.0000	154.9999	0.3333	55.0005	0.6590	45.0000	0.7500
129.9998	0.6667	29.9999	0.9553	75.0002	0.0223	175.0005	0.3333	85.0004	0.6667	15.0007	0.8333
159.9994	0.6667	59.9999	1.0000	45.0002	0.0833	145.0002	0.3333	115.0003	0.6667	15.0013	0.9167
169.9994	0.6667	89.9998	1.0000	15.0002	0.1667	115.0002	0.3333	145.0002	0.6667	45.0006	0.9777
140.0000	0.6667	119.9998	1.0000	14.9998	0.2500	85.0002	0.3410	174.9985	0.6667	75.0004	1.0000
110.0000	0.6667	149.9996	1.0000	44.9998	0.3110	55.0002	0.3912	154.9992	0.6667	105.0003	1.0000
80.0001	0.6817	179.8880	1.0000	74.9998	0.3333	25.0002	0.4706	124.9995	0.6667	135.0002	1.0000
50.0002	0.7374	155.0001	0.0000	104.9997	0.3333	4.9995	0.5579	94.9996	0.6667	159.9995	0.0000
20.0002	0.8188	125.0001	0.0000	134.9997	0.3333	34.9997	0.6296	64.9997	0.7037	169.9979	0.0000
10.0002	0.9040	95.0002	0.0000	164.9997	0.3333	64.9998	0.6667	34.9999	0.7754	139.9993	0.0000
40.0000	0.9704	65.0002	0.0370	165.0002	0.3333	94.9998	0.6667	5.0017	0.8627	109.9994	0.0000
69.9999	1.0000	35.0002	0.1088	135.0002	0.3333	124.9998	0.6667	25.0007	0.9421	79.9998	0.0150
99.9999	1.0000	5.0004	0.1961	105.0002	0.3333	154.9999	0.6667	55.0005	0.9924	50.0000	0.0707
129.9998	1.0000	24.9999	0.2755	75.0002	0.3557	175.0005	0.6667	85.0004	1.0000	20.0006	0.1521
159.9994	1.0000	54.9998	0.3257	45.0002	0.4167	145.0002	0.6667	115.0003	1.0000	10.0020	0.2374
169.9994	1.0000	84.9998	0.3333	15.0002	0.5000	115.0002	0.6667	145.0002	1.0000	40.0006	0.3037
145.0000	0.0000	114.9997	0.3333	14.9998	0.5833	85.0002	0.6743	169.9995	0.0000	70.0004	0.3333
115.0001	0.0000	144.9997	0.3333	44.9998	0.6443	55.0002	0.7246	159.9990	0.0000	100.0003	0.3333
85.0001	0.0076	174.9989	0.3333	74.9998	0.6667	25.0002	0.8039	129.9994	0.0000	130.0002	0.3333
55.0002	0.0579	155.0001	0.3333	104.9997	0.6667	4.9995	0.8912	99.9995	0.0000	159.9997	0.3333
25.0002	0.1373	125.0001	0.3333	134.9997	0.6667	34.9997	0.9630	69.9997	0.0296	169.9979	0.3333
5.0004	0.2245	95.0002	0.3333	164.9997	0.6667	64.9998	1.0000	39.9999	0.0960	139.9993	0.3333
34.9999	0.2963	65.0002	0.3704	165.0002	0.6667	94.9998	1.0000	10.0010	0.1812	109.9996	0.3333
64.9999	0.3333	35.0002	0.4421	135.0002	0.6667	124.9998	1.0000	20.0010	0.2626	79.9998	0.3484
94.9999	0.3333	5.0004	0.5294	105.0002	0.6667	154.9999	1.0000	50.0005	0.3183	50.0000	0.4040
124.9998	0.3333	24.9999	0.6088	75.0002	0.6890	179.9836	0.0000	80.0004	0.3333	20.0006	0.4854
154.9996	0.3333	54.9998	0.6590	45.0002	0.7500	149.9993	0.0000	110.0003	0.3333	10.0020	0.5707
174.9987	0.3333	84.9998	0.6667	15.0002	0.8333	119.9995	0.0000	140.0002	0.3333	40.0006	0.6370
145.0000	0.3333	114.9997	0.6667	14.9998	0.9167	89.9996	0.0000	169.9993	0.3333	70.0004	0.6667
115.0001	0.3333	144.9997	0.6667	44.9998	0.9777	59.9997	0.0447	159.9990	0.3333	100.0003	0.6667
85.0001	0.3410	174.9989	0.6667	74.9998	1.0000	29.9999	0.1220	129.9994	0.3333	130.0002	0.6667
55.0002	0.3912	155.0001	0.6667	104.9997	1.0000	0.1237	0.2113	99.9996	0.3333	159.9997	0.6667
25.0002	0.4706	125.0001	0.6667	134.9997	1.0000	30.0006	0.2887	69.9997	0.3630	169.9979	0.6667
5.0004	0.5579	95.0002	0.6667	164.9997	1.0000	60.0005	0.3333	39.9999	0.4293	139.9993	0.6667
34.9999	0.6296	65.0002	0.7037	170.0002	0.0000	90.0004	0.3333	10.0010	0.5146	109.9996	0.6667
64.9999	0.6667	35.0002	0.7755	140.0002	0.0000	120.0003	0.3333	20.0010	0.5960	79.9998	0.6817
94.9999	0.6667	5.0004	0.8627	110.0002	0.0000	150.0002	0.3333	50.0005	0.6516	50.0000	0.7374
124.9998	0.6667	24.9999	0.9421	80.0002	0.0150	179.8764	0.3333	80.0004	0.6667	20.0006	0.8188
154.9996	0.6667	54.9998	0.9924	50.0002	0.0707	149.9993	0.3333	110.0003	0.6667	10.0020	0.9040
174.9987	0.6667	84.9998	1.0000	20.0002	0.1521	119.9995	0.3333	140.0002	0.6667	40.0006	0.9704
145.0000	0.6667	114.9997	1.0000	9.9997	0.2374	89.9996	0.3333	169.9993	0.6667	70.0004	1.0000
115.0001	0.6667	144.9997	1.0000	39.9998	0.3037	59.9997	0.3780	159.9990	0.6667	100.0003	1.0000
85.0001	0.6743	174.9989	1.0000	69.9998	0.3333	29.9999	0.4553	129.9994	0.6667	130.0002	1.0000
55.0002	0.7246	160.0001	0.0000	99.9998	0.3333	0.1237	0.5447	99.9996	0.6667	154.9995	0.0000
25.0002	0.8039	130.0001	0.0000	129.9998	0.3333	30.0006	0.6220	69.9997	0.6963	174.9958	0.0000
5.0004	0.8912	100.0001	0.0000	159.9998	0.3333	60.0005	0.6667	39.9999	0.7626	144.9993	0.0000
34.9999	0.9630	70.0002	0.0296	170.0002	0.3333	90.0004	0.6667	10.0010	0.8479	114.9994	0.0000
64.9999	1.0000	40.0002	0.0960	140.0002	0.3333	120.0003	0.6667	20.0010	0.9293	84.9998	0.0076
94.9999	1.0000	10.0003	0.1812	110.0002	0.3333	150.0002	0.6667	50.0005	0.9850	55.0000	0.0579
124.9998	1.0000	19.9998	0.2626	80.0002	0.3484	179.8764	0.6667	80.0004	1.0000	25.0005	0.1373
154.9996	1.0000	49.9998	0.3183	50.0002	0.4040	149.9993	0.6667	110.0003	1.0000	5.0041	0.2245
174.9987	1.0000	79.9998	0.3333	20.0002	0.4854	119.9995	0.6667	140.0002	1.0000	35.0007	0.2963
150.0000	0.0000	109.9997	0.3333	9.9997	0.5707	89.9996	0.6667	164.9995	0.0000	65.0004	0.3333
120.0001	0.0000	139.9997	0.3333	39.9998	0.6370	59.9997	0.7113	164.9986	0.0000	95.0003	0.3333
90.0002	0.0000	169.9995	0.3333	69.9998	0.6667	29.9999	0.7887	134.9994	0.0000	125.0001	0.3333
60.0002	0.0447	160.0001	0.3333	99.9998	0.6667	0.1237	0.8780	104.9995	0.0000	154.9997	0.3333
30.0002	0.1220	130.0001	0.3333	129.9998	0.6667	30.0006	0.9553	74.9998	0.0223	174.9958	0.3333
0.0621	0.2113	100.0001	0.3333	159.9998	0.6667	60.0005	1.0000	45.0000	0.0833	144.9993	0.3333
29.9999	0.2887	70.0002	0.3630	170.0002	0.6667	90.0004	1.0000	15.0007	0.1667	114.9996	0.3333
59.9999	0.3333	40.0002	0.4293	140.0002	0.6667	120.0003	1.0000	15.0013	0.2500	84.9998	0.3410
89.9998	0.3333	10.0003	0.5146	110.0002	0.6667	150.0002	1.0000	45.0006	0.3110	55.0000	0.3912
119.9998	0.3333	19.9998	0.5960	80.0002	0.6817	174.9994	0.0000	75.0004	0.3333	25.0005	0.4706
149.9996	0.3333	49.9998	0.6516	50.0002	0.7374	154.9992	0.0000	105.0003	0.3333	5.0041	0.5579
179.8880	0.3333	79.9998	0.6667	20.0002	0.8188	124.9995	0.0000	135.0002	0.3333	35.0007	0.6296
150.0000	0.3333	109.9997	0.6667	9.9997	0.9040	94.9995	0.0000	164.9995	0.3333	65.0004	0.6667
120.0001	0.3333	139.9997	0.6667	39.9998	0.9704	64.9997	0.0370	164.9986	0.3333	95.0003	0.6667
90.0002	0.3333	169.9995	0.6667	69.9998	1.0000	34.9999	0.1088	134.9994	0.3333	125.0001	0.6667
60.0002	0.3780	160.0001	0.6667	99.9998	1.0000	5.0017	0.1961	104.9996	0.3333	154.9997	0.6667
30.0002	0.4553	130.0001	0.6667	129.9998	1.0000	25.0007	0.2755	74.9998	0.3557	174.9958	0.6667
0.0621	0.5447	100.0001	0.6667	159.9998	1.0000	55.0005	0.3257	45.0000	0.4167	144.9993	0.6667
29.9999	0.6220	70.0002	0.6963	175.0005	0.0000	85.0004	0.3333	15.0007	0.5000	114.9996	0.6667
59.9999	0.6667	40.0002	0.7626	145.0002	0.0000	115.0003	0.3333	15.0013	0.5833	84.9998	0.6743
89.9998	0.6667	10.0003	0.8479	115.0002	0.0000	145.0002	0.3333	45.0006	0.6443	55.0000	0.7245
119.9998	0.6667	19.9998	0.9293	85.0002	0.0076	174.9985	0.3333	75.0004	0.6667	25.0005	0.8039
149.9996	0.6667	49.9998	0.9850	55.0002	0.0579	154.9992	0.3333	105.0003	0.6667	5.0041	0.8912
179.8880	0.6667	79.9998	1.0000	25.0002	0.1373	124.9995	0.3333	135.0002	0.6667	35.0007	0.9630

65.0004	1.0000
95.0003	1.0000
125.0001	1.0000
149.9995	0.0000
179.7963	0.0000
149.9992	0.0000
119.9994	0.0000
89.9999	0.0000
60.0001	0.0447
30.0005	0.1220
0.2038	0.2113
30.0008	0.2887
60.0004	0.3333
90.0003	0.3333
120.0001	0.3333
149.9998	0.3333
179.7963	0.3333
149.9992	0.3333
119.9996	0.3333
89.9999	0.3333
60.0001	0.3780
30.0005	0.4553
0.2038	0.5447
30.0008	0.6220
60.0004	0.6667
90.0003	0.6667
120.0001	0.6667
149.9998	0.6667
179.7963	0.6667
149.9992	0.6667
119.9996	0.6667
89.9999	0.6667
60.0001	0.7113
30.0005	0.7887
0.2038	0.8780
30.0008	0.9553
60.0004	1.0000
90.0003	1.0000
120.0001	1.0000
144.9995	0.0000
174.9961	0.0000
154.9991	0.0000
124.9994	0.0000
94.9999	0.0000
65.0001	0.0370
35.0005	0.1088
5.0042	0.1961
25.0009	0.2754
55.0004	0.3257
85.0003	0.3333
115.0001	0.3333
144.9998	0.3333
174.9961	0.3333
154.9991	0.3333
124.9996	0.3333
94.9999	0.3333
65.0001	0.3704
35.0005	0.4421
5.0042	0.5294
25.0009	0.6088
55.0004	0.6590
85.0003	0.6667
115.0001	0.6667
144.9998	0.6667
174.9961	0.6667
154.9991	0.6667
124.9996	0.6667
94.9999	0.6667
65.0001	0.7037
35.0005	0.7754
5.0042	0.8627
25.0009	0.9421
55.0004	0.9924
85.0003	1.0000
115.0001	1.0000
139.9995	0.0000
169.9982	0.0000
159.9989	0.0000
129.9994	0.0000
99.9999	0.0000
70.0001	0.0296
40.0004	0.0960
10.0021	0.1812
20.0010	0.2626
50.0004	0.3183
80.0003	0.3333
110.0001	0.3333
139.9998	0.3333
169.9982	0.3333
159.9989	0.3333
129.9996	0.3333
99.9999	0.3333
70.0001	0.3630
40.0004	0.4293
10.0021	0.5146
20.0010	0.5960
50.0004	0.6516
80.0003	0.6667
110.0001	0.6667
139.9998	0.6667
169.9982	0.6667
159.9989	0.6667
129.9996	0.6667
99.9999	0.6667
70.0001	0.6963
40.0004	0.7626
10.0021	0.8479
20.0010	0.9293
50.0004	0.9850
80.0003	1.0000
110.0001	1.0000
134.9995	0.0000
164.9989	0.0000
164.9987	0.0000
134.9994	0.0000
104.9999	0.0000
75.0002	0.0223
45.0004	0.0833
15.0014	0.1667
15.0013	0.2500
45.0004	0.3110
75.0002	0.3333
105.0001	0.3333
134.9998	0.3333
164.9989	0.3333
164.9987	0.3333
134.9997	0.3333
104.9999	0.3333
75.0002	0.3557
45.0004	0.4167
15.0014	0.5000
15.0013	0.5833
45.0004	0.6443
75.0002	0.6667
105.0001	0.6667
134.9998	0.6667
164.9989	0.6667
164.9987	0.6667
134.9997	0.6667
104.9999	0.6667
75.0002	0.6890
45.0004	0.7500
15.0014	0.8333
15.0013	0.9167
45.0004	0.9777
75.0002	1.0000
105.0001	1.0000
129.9995	0.0000
159.9992	0.0000
169.9982	0.0000
139.9994	0.0000
110.0000	0.0000
80.0002	0.0150
50.0004	0.0707
20.0010	0.1521
10.0017	0.2374
40.0004	0.3037
70.0002	0.3333
100.0000	0.3333
129.9998	0.3333
159.9992	0.3333
169.9982	0.3333
139.9997	0.3333
110.0000	0.3333
80.0002	0.3484
50.0004	0.4040
20.0010	0.4854
10.0017	0.5707
40.0004	0.6370
70.0002	0.6667
100.0000	0.6667
129.9998	0.6667
159.9992	0.6667
169.9982	0.6667
139.9997	0.6667
110.0000	0.6667
80.0002	0.6817
50.0004	0.7374
20.0010	0.8187
10.0017	0.9040
40.0004	0.9704
70.0002	1.0000
100.0000	1.0000
124.9995	0.0000
154.9994	0.0000
174.9969	0.0000
144.9994	0.0000
115.0000	0.0000
85.0002	0.0076
55.0004	0.0579
25.0008	0.1373
5.0031	0.2245
35.0003	0.2963
65.0002	0.3333
95.0001	0.3333
124.9999	0.3333
154.9994	0.3333
174.9969	0.3333
144.9997	0.3333
115.0000	0.3333
85.0002	0.3410
55.0004	0.3912
25.0008	0.4706
5.0031	0.5579
35.0003	0.6296
65.0002	0.6667
95.0001	0.6667
124.9999	0.6667
154.9994	0.6667
174.9969	0.6667
144.9997	0.6667
115.0000	0.6667
85.0002	0.6743
55.0004	0.7245
25.0008	0.8039
5.0031	0.8912
35.0003	0.9630
65.0002	1.0000
95.0001	1.0000
119.9995	0.0000
149.9996	0.0000
179.8381	0.0000
149.9995	0.0000
120.0001	0.0000
90.0003	0.0000
60.0004	0.0447
30.0007	0.1220
0.1620	0.2113
30.0003	0.2887
60.0001	0.3333
90.0000	0.3333
119.9999	0.3333
149.9996	0.3333
179.8381	0.3333
149.9998	0.3333
120.0001	0.3333
90.0003	0.3333
60.0004	0.3780
30.0007	0.4553
0.1620	0.5447
30.0003	0.6220
60.0001	0.6667
90.0000	0.6667
119.9999	0.6667
149.9996	0.6667
179.8381	0.6667
149.9998	0.6667
120.0001	0.6667
90.0003	0.6667
60.0004	0.7113
30.0007	0.7887
0.1620	0.8780
30.0003	0.9553
60.0001	1.0000
90.0000	1.0000
114.9995	0.0000
144.9997	0.0000
174.9981	0.0000
154.9995	0.0000
125.0001	0.0000
95.0003	0.0000
65.0004	0.0370
35.0005	0.1088
5.0022	0.1961
25.0002	0.2754
55.0001	0.3257
85.0000	0.3333
114.9999	0.3333
144.9997	0.3333
174.9981	0.3333
154.9999	0.3333
125.0001	0.3333
95.0003	0.3333
65.0004	0.3704
35.0005	0.4421
5.0022	0.5294
25.0002	0.6088
55.0001	0.6590
85.0000	0.6667
114.9999	0.6667
144.9997	0.6667
174.9981	0.6667
154.9999	0.6667
125.0001	0.6667
95.0003	0.6667
65.0004	0.7037
35.0005	0.7754
5.0022	0.8627
25.0002	0.9421
55.0001	0.9924
85.0000	1.0000
109.9995	0.0000
139.9998	0.0000
169.9994	0.0000
159.9996	0.0000
130.0002	0.0000
100.0003	0.0000
70.0004	0.0296
40.0004	0.0960
10.0008	0.1812
20.0001	0.2626
50.0000	0.3183
80.0000	0.3333
109.9999	0.3333
139.9998	0.3333
169.9994	0.3333
160.0001	0.3333
130.0002	0.3333
100.0003	0.3333
70.0004	0.3630
40.0004	0.4293
10.0008	0.5146
20.0001	0.5960
50.0000	0.6516
80.0000	0.6667
109.9999	0.6667
139.9998	0.6667
169.9994	0.6667
160.0001	0.6667
130.0002	0.6667
100.0003	0.6667
70.0004	0.6963
40.0004	0.7626
10.0008	0.8479
20.0001	0.9293
50.0000	0.9850
80.0000	1.0000

APPENDIX M

Basis for Oblique Hole Size Distribution

National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812
AC(205)544-2121

NASA

APR 27 1993

Reply to Attn of: ED52(93-21)

TO: Space Station Freedom Program Office
Attn: MSS/Acting Manager System Engineering Office

FROM: ED52/Joel Williamsen

SUBJECT: Meteoroid/Orbital Debris Oblique Hole Size Distribution for Space Station Freedom

On March 24-25, Structural Development Branch/ED52 personnel attended a briefing by the Space Station Level II Program Office and the Space Station Engineering Integration Contractor (SSEIC) on their approach for meeting probability of no catastrophic failure (PNCF) requirements. A critical portion of the Level II/SSEIC approach is its assumption of the hole size distribution for orbital debris that penetrates the manned modules.

SSEIC currently uses the Level II developed Goodwin "normal" hole size model (enclosure 1) and Kessler's orbital debris distribution to form a probability distribution of hole sizes for a laboratory module following a penetration (enclosure 2). This distribution assumes (incorrectly) that all penetrations occur normal to the surface of the manned modules; in fact, almost all impacts on the manned modules will occur at oblique angles (enclosure 3). Further, the Goodwin "normal" model largely assumes the size of the hole to be dependent upon the area of the debris cloud impact on the rear wall. Following this logic, one can expect an oblique penetration to produce a larger elliptical "footprint" on the rear wall, and thus a larger hole following a penetration (enclosure 4). Therefore, because oblique penetrations occur more often and would produce (by the logic of the Goodwin model) larger holes following a penetration, an increasing number of holes above 6 inches in diameter should be expected from a hole size model that includes the important effect of obliquity.

Over the last several months, ED52 worked to modify the Goodwin hole size model and distribution to account for the effects of penetration obliquity. In modifying the Goodwin "normal" model to account for obliquity, the following assumptions were made:

a. Oblique impacts produce elliptical holes with a minor axis and a major axis dimension (as shown in enclosure 4).

b. At each specific velocity, the rate at which the minor axis of the hole grows with change in diameter above the oblique ballistic limit (hole size gradient) is based on the rate of change of hole size with change in diameter in the normal model (i.e., the dHole/dDia is constant), as shown in enclosure 5.

c. The major axis of the elliptical hole is equal to the minor axis divided by the cosine of the impact angle (obliquity).

d. The major axis of the hole stops growing with increasing obliquity above 60 degrees.

This model and its underlying assumptions should be viewed as optimistic in nature. That is, more conservative assumptions are possible that can dramatically increase the size of the oblique holes following a penetration. For example, in assumption "b," if the existing Goodwin hole size gradient was viewed as dependent on change in penetrating energy (not diameter), a much steeper increase in minor axis hole dimension could be expected for the oblique case (since penetrating energy increases with the cube of the penetrating diameter). In assumption "c," if the major axis dimension of the oblique hole was based upon the actual length of module wall impacted by the expanding debris cloud "footprint" cited in the Goodwin normal model, this dimension of the elliptical hole would generally be much larger than that produced by a simple division of the minor axis dimension by the cosine of impact angle (see enclosure 4). Finally, there is little basis for the "60-degree cutoff" assumption made here other than a desire to be consistent with existing MSFC and JSC ballistic limit equations for simple Whipple bumpers.

Using these assumptions, a new hole size model for oblique impacts was formed at MSFC based on Goodwin's normal model assumptions and input into a simulation routine to generate the distribution of hole sizes for each of 8 modules. This simulation routine (called MAGIC) selects random numbers to simulate orbital impact conditions of diameter, obliquity, and velocity based upon the Kessler orbital debris flux equations and the geometry of Freedom Station's permanently manned configuration. It then compares the ballistic limit of the Freedom Station manned modules (considering obliquity) to thousands of possible Kessler and geometry-based impact conditions and finds the corresponding hole size for all those impact conditions that penetrate the wall. Further information on the assumptions and construction of this simulation program is available from this office.

The oblique "effective" hole size and "major axis" probability distributions are given in enclosure 6. Note that there are no holes expected to be greater than 8 inches in effective diameter except for Node 2, where a penetration of the cupola windows would cause a 20-in hole. Because the major axis of the oblique holes is generally aligned with the long axis of the modules (and thus with the grain direction of the manned modules), the "major diameter" distribution should be used to perform critical crack "r" ratio analyses.

This oblique hole size model and distribution, while representing today's "best guess," is obviously very thin in supporting data. Much of the uncertainty in this model can be traced to its basis in the Goodwin "normal" distribution, which itself lacks supporting data. Obviously, additional test data on the relationship between hole size and penetration parameters is desperately needed in order to achieve measurable confidence in the results of either the normal or oblique model. Further, both the normal and oblique hole size models were formulated for a baseline Work Package 1 aluminum Whipple shield; any application of these distributions to other than this shield configuration will obviously subtract from the already low level of confidence in both models.

The aim of this exercise was to extend the existing SSEIC hole size model and distribution in a logical fashion to include oblique penetrations. As shown, even optimistic assumptions on the effect of obliquity on the existing SSEIC Goodwin hole size distribution will dramatically increase the proportion of holes above 6 inches in diameter. Considering the important effect of the manned module hole size distribution on the PNCF calculation, we strongly recommend that Level II allocate a significant proportion of its Forward Action Plan resources to a comprehensive test and analysis program supporting the formation of a verified hole size model.

Joel E Williamsen

Joel E. Williamsen
Aerospace Engineer

CONCURRENCE:

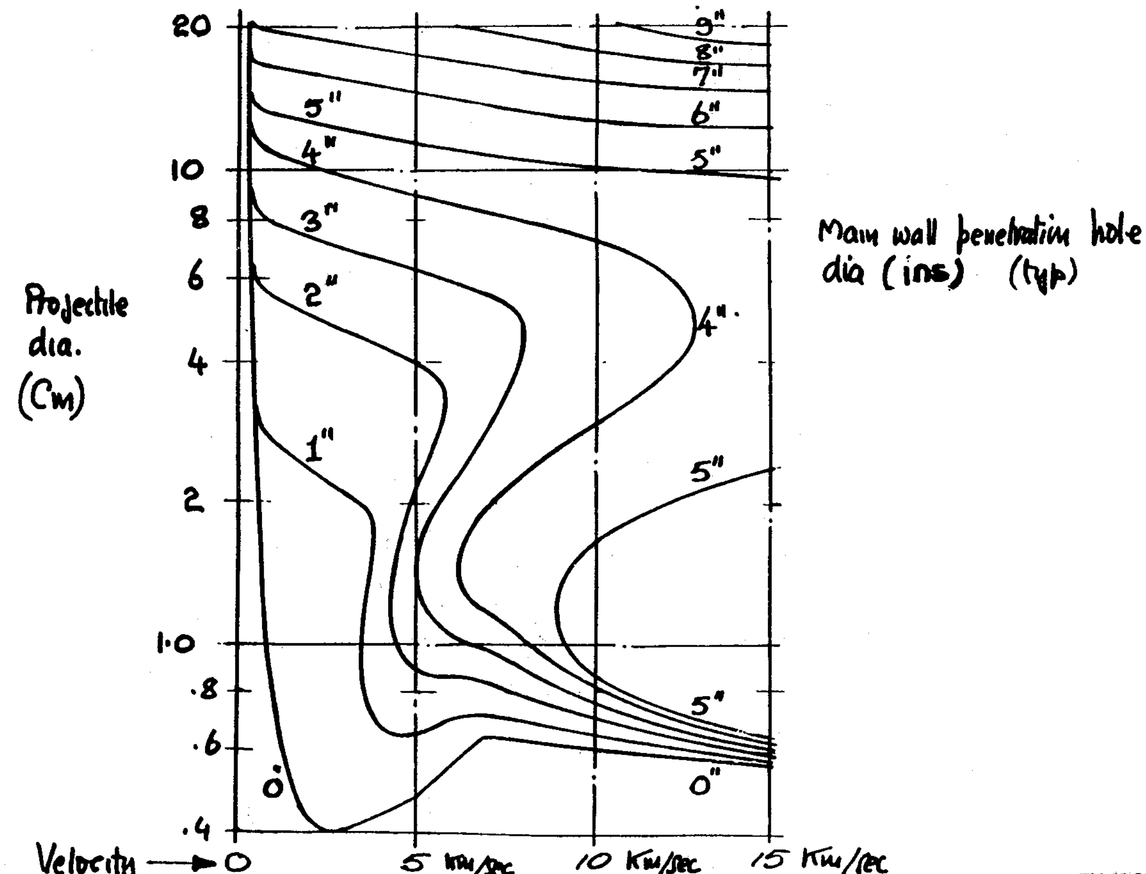
Richard E. Dotson

Richard E. Dotson
Chief
Structural Design Division

6 enclosures

FREEDOM

Goodwin Prediction of Main Wall Hole dia. - Normal Impact



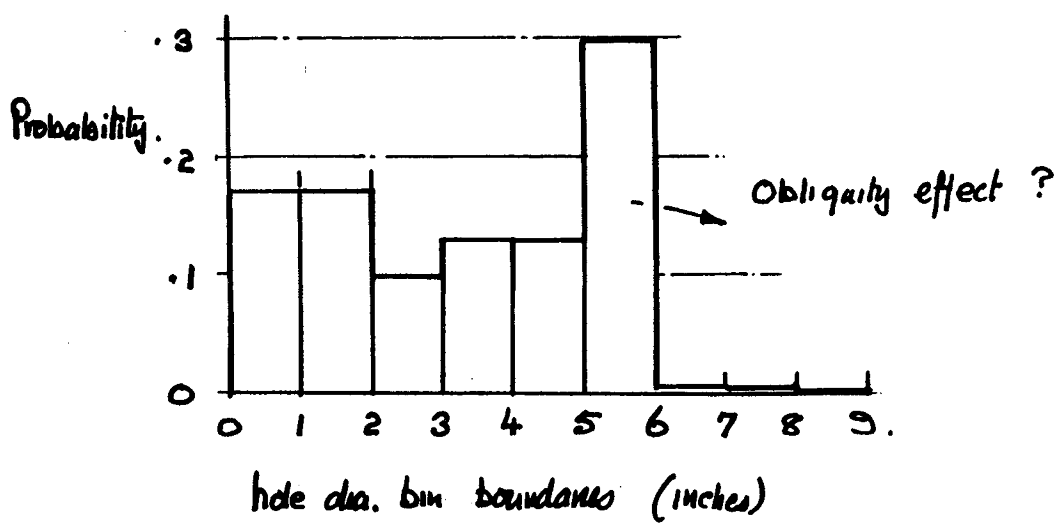
ENCLOSURE 1.

GRUMMAN

FREEDOM

HOLE DIA. PROBABILITY DISTRIBUTION — NORMAL IMPACT.

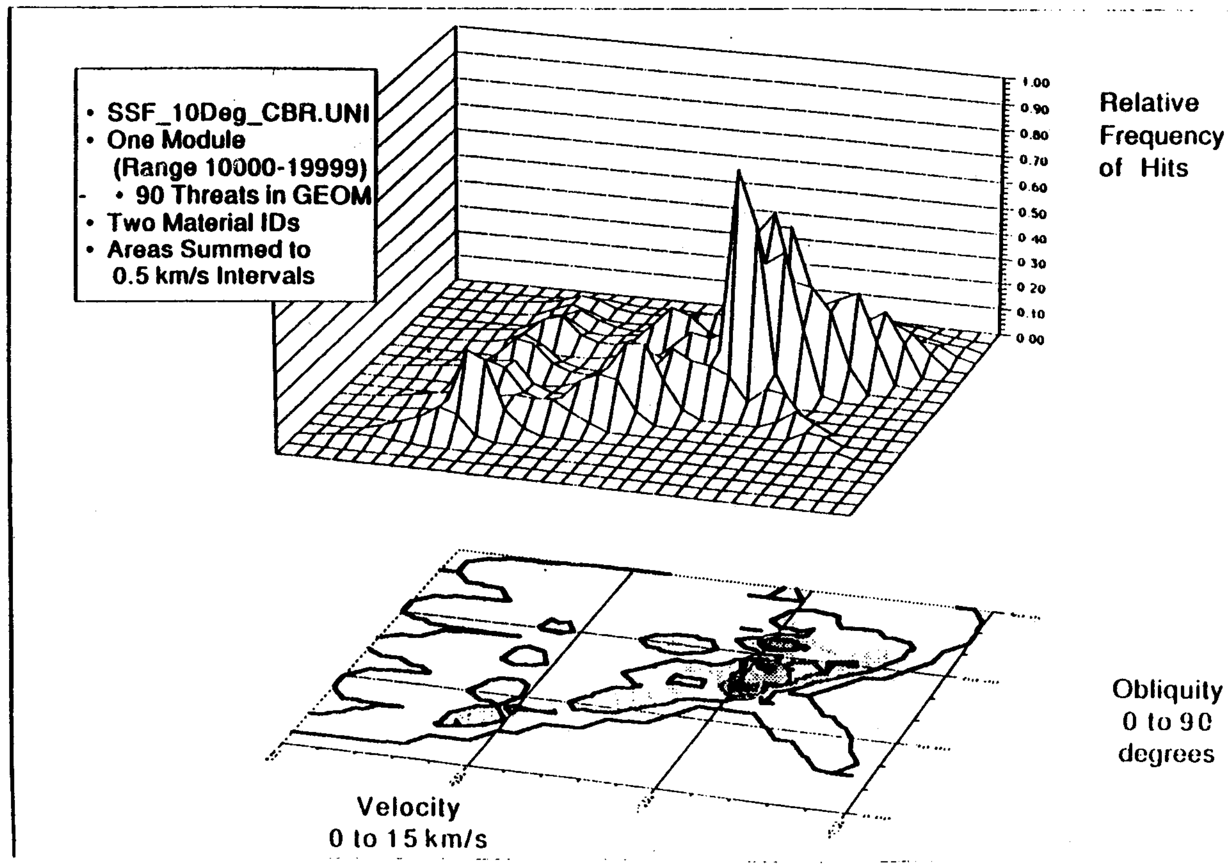
.05"/4.3"/.125"



ENCLOSURE 2.

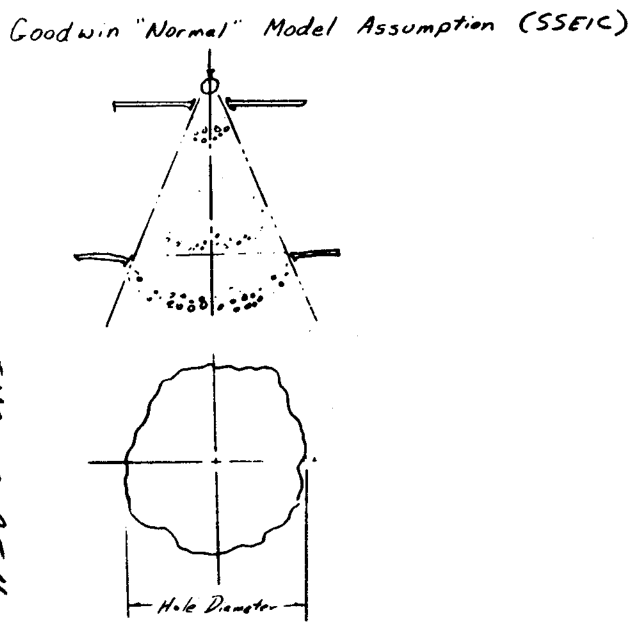
GRUMMAN

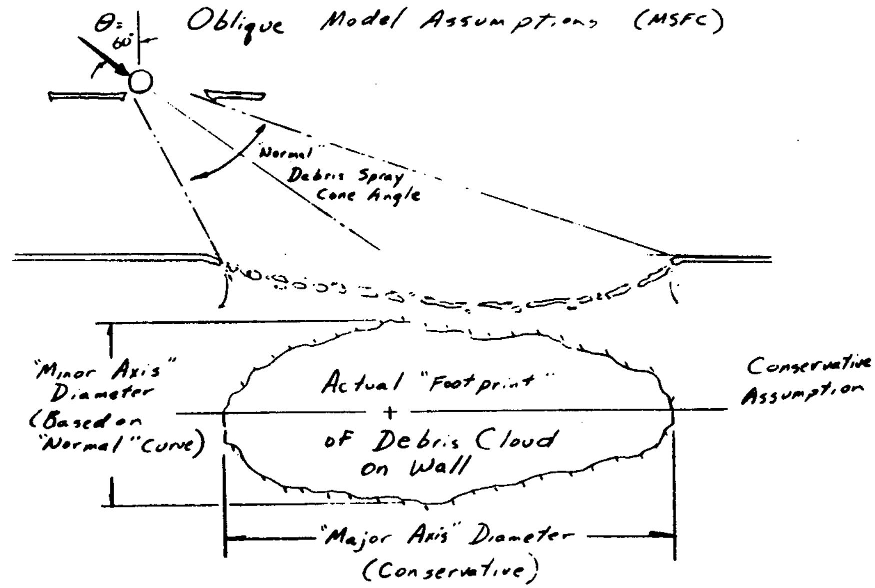
Relative Frequency of Debris Hits on a Common Module

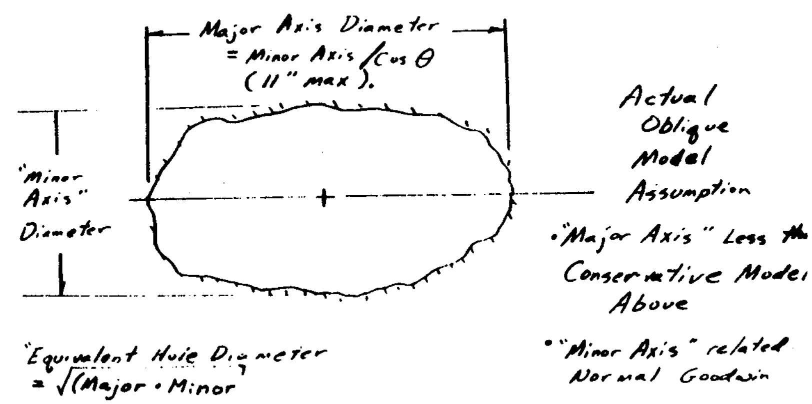


ENCLOSURE 3.

ENCLOSURE 4







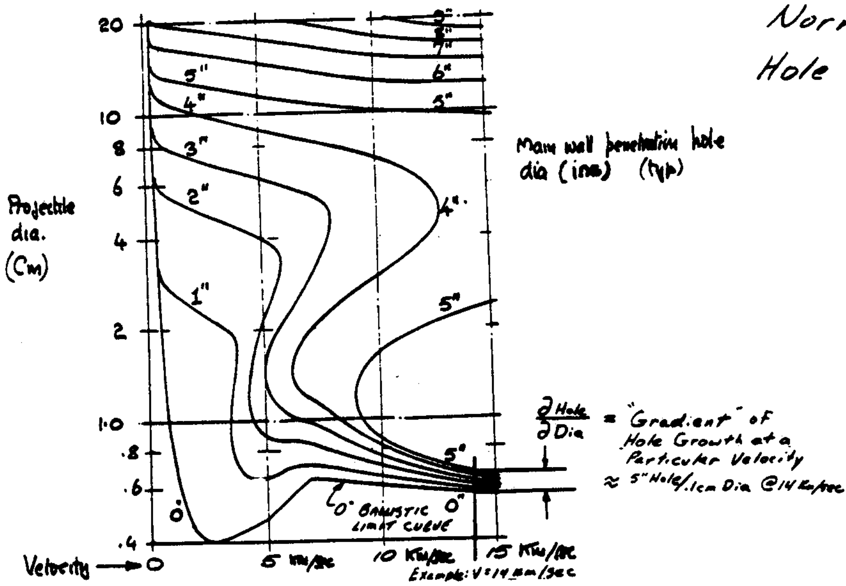
ENCLOSURE 4: Normal and Oblique Model Assumptions.

SSEIC BASELINE

Goodwin "Normal" Hole Model

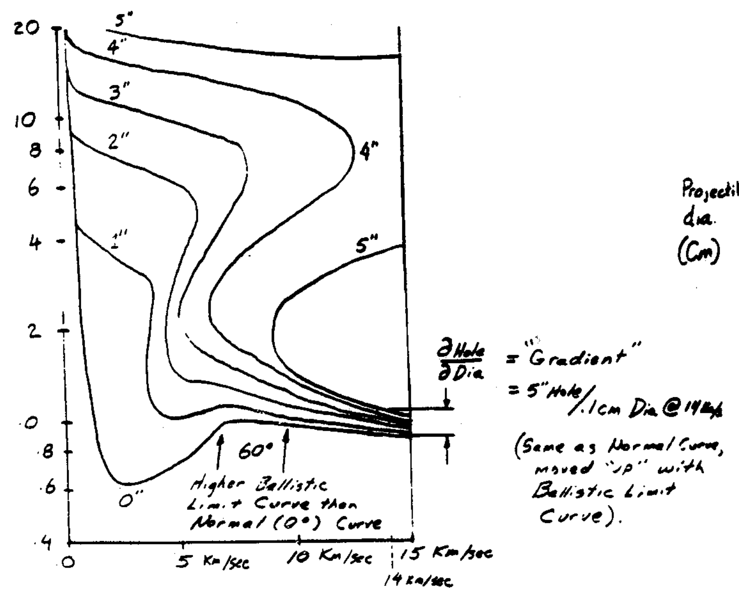
ENCLOSURE 5.

Normal vs. Oblique Hole Size Models



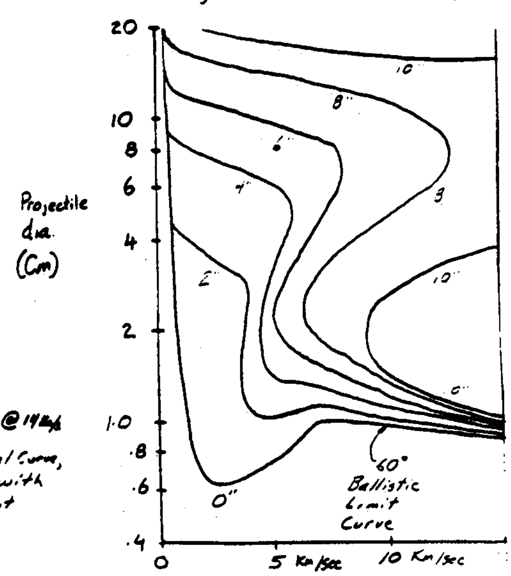
OBLIQUE HOLE MODEL

"Minor Axis" Hole Dimension, 60° Obliquity



OBLIQUE HOLE MODEL

Major Axis Hole Dimension, 60



ENCLOSURE 5

Oblique Hole Size Distribution (Williamsen, 3/25/93)

Effective Diameter = ((Minor Dia/Cos Obl)*(Minor Dia))**.5

Hole Size	LAB	HAB	ESA	JEM	N2	N1	PLM	A/L
0" to 1"	.15	.15	.19	.21	.14	.18	.16	.16
1" to 2"	.10	.10	.12	.12	.11	.13	.11	.11
2" to 3"	.10	.10	.10	.11	.08	.11	.12	.12
3" to 4"	.11	.11	.11	.10	.08	.10	.12	.12
4" to 5"	.09	.09	.09	.09	.08	.10	.12	.12
5" to 6"	.19	.19	.11	.10	.10	.12	.26	.26
6" to 7"	.13	.13	.13	.13	.15	.15	.07	.07
7" to 8"	.13	.13	.15	.15	.08	.12	.04	.04
Over 20"	0	0	0	0	.18	0	0	0

Distribution of Major Diameters for Oblique Holes

Basis for Crack Size Distribution (Williamsen, 3/25/93)

Hole Size	LAB	HAB	ESA	JEM	N2	N1	PLM	A/L
0" to 1"	.12	.12	.17	.17	.16	.16	.14	.14
1" to 2"	.09	.09	.12	.12	.13	.13	.11	.11
2" to 3"	.09	.09	.07	.07	.07	.07	.11	.11
3" to 4"	.09	.09	.08	.08	.09	.09	.12	.12
4" to 5"	.08	.08	.06	.06	.09	.09	.10	.10
5" to 6"	.11	.11	.09	.09	.09	.09	.22	.22
6" to 7"	.13	.13	.07	.07	.08	.08	.07	.07
7" to 8"	.08	.08	.06	.06	.07	.07	.05	.05
8" to 9"	.05	.05	.06	.06	.08	.08	.03	.03
9" to 10"	.06	.06	.07	.07	.06	.06	.02	.02
10" to 11"	.10	.10	.13	.13	.08	.08	.03	.03

ENCLOSURE 6.

APPENDIX N

SHIELD.DAT Data File

PAGE 196 INTENTIONALLY BLANK

PRECEDING PAGE BLANK NOT FILMED

Mod	Elem	Station	Shield	# 0.125" Equipment
1	1	1	1	2.0000
1	2	1	1	2.0000
1	3	1	1	2.0000
1	4	1	1	2.0000
1	5	1	1	2.0000
1	6	1	1	2.0000
1	7	2	1	2.0000
1	8	2	1	2.0000
1	9	2	1	2.0000
1	10	2	1	2.0000
1	11	2	1	2.0000
1	12	2	1	2.0000
1	13	3	1	2.0000
1	14	3	1	2.0000
1	15	3	1	2.0000
1	16	3	1	2.0000
1	17	3	1	2.0000
1	18	3	1	2.0000
1	19	4	1	2.0000
1	20	4	1	2.0000
1	21	4	1	2.0000
1	22	4	1	2.0000
1	23	4	1	2.0000
1	24	4	1	2.0000
1	25	5	1	2.0000
1	26	5	1	2.0000
1	27	5	1	2.0000
1	28	5	1	2.0000
1	29	5	1	2.0000
1	30	5	1	2.0000
1	31	6	1	2.0000
1	32	6	1	2.0000
1	33	6	1	2.0000
1	34	6	1	2.0000
1	35	6	1	2.0000
1	36	6	1	2.0000
1	37	7	1	2.0000
1	38	7	1	2.0000
1	39	7	1	2.0000
1	40	7	1	2.0000
1	41	7	1	2.0000
1	42	7	1	2.0000
1	43	8	1	2.0000
1	44	8	1	2.0000
1	45	8	1	2.0000
1	46	8	1	2.0000
1	47	8	1	2.0000
1	48	8	1	2.0000
1	49	1	1	2.0000
1	50	1	1	2.0000
1	51	1	1	2.0000
1	52	1	1	2.0000
1	53	1	1	2.0000
1	54	1	1	2.0000
1	55	2	1	2.0000
1	56	2	1	2.0000
1	57	2	1	2.0000
1	58	2	1	2.0000
1	59	2	1	2.0000
1	60	2	1	2.0000
1	61	3	1	2.0000
1	62	3	1	2.0000
1	63	3	1	2.0000
1	64	3	1	2.0000
1	65	3	1	2.0000
1	66	3	1	2.0000
1	67	4	1	2.0000
1	68	4	1	2.0000
1	69	4	1	2.0000
1	70	4	1	2.0000
1	71	4	1	2.0000
1	72	4	1	2.0000
1	73	5	1	2.0000
1	74	5	1	2.0000
1	75	5	1	2.0000
1	76	5	1	2.0000
1	77	5	1	2.0000
1	78	5	1	2.0000
1	79	6	1	2.0000
1	80	6	1	2.0000
1	81	6	1	2.0000
1	82	6	1	2.0000
1	83	6	1	2.0000
1	84	6	1	2.0000
1	85	7	1	2.0000
1	86	7	1	2.0000
1	87	7	1	2.0000
1	88	7	1	2.0000
1	89	7	1	2.0000
1	90	7	1	2.0000
1	91	8	1	2.0000
1	92	8	1	2.0000
1	93	8	1	2.0000
1	94	8	1	2.0000
1	95	8	1	2.0000
1	96	8	1	2.0000

1	97	1	1	2.0000
1	98	1	1	2.0000
1	99	1	1	2.0000
1	100	1	1	2.0000
2	1	1	1	2.0000
2	2	1	1	2.0000
2	3	1	1	2.0000
2	4	1	1	2.0000
2	5	1	1	2.0000
2	6	1	1	2.0000
2	7	2	1	2.0000
2	8	2	1	2.0000
2	9	2	1	2.0000
2	10	2	1	2.0000
2	11	2	1	2.0000
2	12	2	1	2.0000
2	13	3	1	2.0000
2	14	3	1	2.0000
2	15	3	1	2.0000
2	16	3	1	2.0000
2	17	3	1	2.0000
2	18	3	1	2.0000
2	19	4	1	2.0000
2	20	4	1	2.0000
2	21	4	1	2.0000
2	22	4	1	2.0000
2	23	4	1	2.0000
2	24	4	1	2.0000
2	25	5	1	2.0000
2	26	5	1	2.0000
2	27	5	1	2.0000
2	28	5	1	2.0000
2	29	5	1	2.0000
2	30	5	1	2.0000
2	31	6	1	2.0000
2	32	6	1	2.0000
2	33	6	1	2.0000
2	34	6	1	2.0000
2	35	6	1	2.0000
2	36	6	1	2.0000
2	37	7	1	2.0000
2	38	7	1	2.0000
2	39	7	1	2.0000
2	40	7	1	2.0000
2	41	7	1	2.0000
2	42	7	1	2.0000
2	43	8	1	2.0000
2	44	8	1	2.0000
2	45	8	1	2.0000
2	46	8	1	2.0000
2	47	8	1	2.0000
2	48	8	1	2.0000
2	49	1	1	2.0000
2	50	1	1	2.0000
2	51	1	1	2.0000
2	52	1	1	2.0000
2	53	1	1	2.0000
2	54	1	1	2.0000
2	55	2	1	2.0000
2	56	2	1	2.0000
2	57	2	1	2.0000
2	58	2	1	2.0000
2	59	2	1	2.0000
2	60	2	1	2.0000
2	61	3	1	2.0000
2	62	3	1	2.0000
2	63	3	1	2.0000
2	64	3	1	2.0000
2	65	3	1	2.0000
2	66	3	1	2.0000
2	67	4	1	2.0000
2	68	4	1	2.0000
2	69	4	1	2.0000
2	70	4	1	2.0000
2	71	4	1	2.0000
2	72	4	1	2.0000
2	73	5	1	2.0000
2	74	5	1	2.0000
2	75	5	1	2.0000
2	76	5	1	2.0000
2	77	5	1	2.0000
2	78	5	1	2.0000
2	79	6	1	2.0000
2	80	6	1	2.0000
2	81	6	1	2.0000
2	82	6	1	2.0000
2	83	6	1	2.0000
2	84	6	1	2.0000
2	85	7	1	2.0000
2	86	7	1	2.0000
2	87	7	1	2.0000
2	88	7	1	2.0000
2	89	7	1	2.0000
2	90	7	1	2.0000
2	91	8	1	2.0000
2	92	8	1	2.0000
2	93	8	1	2.0000
2	94	8	1	2.0000

2	95	8	1	2.0000
2	96	8	1	2.0000
2	97	1	1	2.0000
2	98	1	1	2.0000
2	99	1	1	2.0000
2	100	1	1	2.0000
3	1	8	1	2.0000
3	2	8	1	2.0000
3	3	8	1	2.0000
3	4	8	1	2.0000
3	5	8	1	2.0000
3	6	8	1	2.0000
3	7	7	1	2.0000
3	8	7	1	2.0000
3	9	7	1	2.0000
3	10	7	1	2.0000
3	11	7	1	2.0000
3	12	7	1	2.0000
3	13	6	1	2.0000
3	14	6	1	2.0000
3	15	6	1	2.0000
3	16	6	1	2.0000
3	17	6	1	2.0000
3	18	6	1	2.0000
3	19	5	1	2.0000
3	20	5	1	2.0000
3	21	5	1	2.0000
3	22	5	1	2.0000
3	23	5	1	2.0000
3	24	5	1	2.0000
3	25	4	1	2.0000
3	26	4	1	2.0000
3	27	4	1	2.0000
3	28	4	1	2.0000
3	29	4	1	2.0000
3	30	4	1	2.0000
3	31	3	1	2.0000
3	32	3	1	2.0000
3	33	3	1	2.0000
3	34	3	1	2.0000
3	35	3	1	2.0000
3	36	3	1	2.0000
3	37	2	1	2.0000
3	38	2	1	2.0000
3	39	2	1	2.0000
3	40	2	1	2.0000
3	41	2	1	2.0000
3	42	2	1	2.0000
3	43	1	1	2.0000
3	44	1	1	2.0000
3	45	1	1	2.0000
3	46	1	1	2.0000
3	47	1	1	2.0000
3	48	1	1	2.0000
4	1	12	1	2.0000
4	2	12	1	2.0000
4	3	12	1	2.0000
4	4	12	1	2.0000
4	5	12	1	2.0000
4	6	12	1	2.0000
4	7	11	1	2.0000
4	8	11	1	2.0000
4	9	11	1	2.0000
4	10	11	1	2.0000
4	11	11	1	2.0000
4	12	11	1	2.0000
4	13	10	1	2.0000
4	14	10	1	2.0000
4	15	10	1	2.0000
4	16	10	1	2.0000
4	17	10	1	2.0000
4	18	10	1	2.0000
4	19	9	1	2.0000
4	20	9	1	2.0000
4	21	9	1	2.0000
4	22	9	1	2.0000
4	23	9	1	2.0000
4	24	9	1	2.0000
4	25	8	1	2.0000
4	26	8	1	2.0000
4	27	8	1	2.0000
4	28	8	1	2.0000
4	29	8	1	2.0000
4	30	8	1	2.0000
4	31	7	1	2.0000
4	32	7	1	2.0000
4	33	7	1	2.0000
4	34	7	1	2.0000
4	35	7	1	2.0000
4	36	7	1	2.0000
4	37	6	1	2.0000
4	38	6	1	2.0000
4	39	6	1	2.0000
4	40	6	1	2.0000
4	41	6	1	2.0000
4	42	6	1	2.0000
4	43	5	1	2.0000
4	44	5	1	2.0000

4	45	5	1	2.0000
4	46	5	1	2.0000
4	47	5	1	2.0000
4	48	5	1	2.0000
4	49	4	1	2.0000
4	50	4	1	2.0000
4	51	4	1	2.0000
4	52	4	1	2.0000
4	53	4	1	2.0000
4	54	4	1	2.0000
4	55	3	1	2.0000
4	56	3	1	2.0000
4	57	3	1	2.0000
4	58	3	1	2.0000
4	59	3	1	2.0000
4	60	3	1	2.0000
4	61	2	1	2.0000
4	62	2	1	2.0000
4	63	2	1	2.0000
4	64	2	1	2.0000
4	65	2	1	2.0000
4	66	2	1	2.0000
4	67	1	1	2.0000
4	68	1	1	2.0000
4	69	1	1	2.0000
4	70	1	1	2.0000
4	71	1	1	2.0000
4	72	1	1	2.0000
4	73	4	1	2.0000
4	74	4	1	2.0000
4	75	4	1	2.0000
4	76	4	1	2.0000
4	77	4	1	2.0000
4	78	4	1	2.0000
4	79	3	1	2.0000
4	80	3	1	2.0000
4	81	3	1	2.0000
4	82	3	1	2.0000
4	83	3	1	2.0000
4	84	3	1	2.0000
4	85	2	1	2.0000
4	86	2	1	2.0000
4	87	2	1	2.0000
4	88	2	1	2.0000
4	89	2	1	2.0000
4	90	2	1	2.0000
4	91	1	1	2.0000
4	92	1	1	2.0000
4	93	1	1	2.0000
4	94	1	1	2.0000
4	95	1	1	2.0000
4	96	1	1	2.0000
5	1	5	1	2.0000
5	2	4	1	2.0000
5	3	3	1	2.0000
5	4	2	1	2.0000
5	5	1	1	2.0000
5	6	5	1	2.0000
5	7	4	1	2.0000
5	8	3	1	2.0000
5	9	2	1	2.0000
5	10	1	1	2.0000
5	11	5	1	2.0000
5	12	4	1	2.0000
5	13	3	1	2.0000
5	14	2	1	2.0000
5	15	1	1	2.0000
5	16	5	1	2.0000
5	17	4	1	2.0000
5	18	3	1	2.0000
5	19	2	1	2.0000
5	20	1	1	2.0000
5	21	5	1	2.0000
5	22	4	1	2.0000
5	23	3	1	2.0000
5	24	2	1	2.0000
5	25	1	1	2.0000
5	26	5	1	2.0000
5	27	4	1	2.0000
5	28	3	1	2.0000
5	29	2	1	2.0000
5	30	1	1	2.0000
5	31	1	1	2.0000
5	32	1	1	2.0000
5	33	1	1	2.0000
5	34	1	1	2.0000
5	35	1	1	2.0000
5	36	1	1	2.0000
5	37	1	1	2.0000
5	38	1	1	2.0000
5	39	1	1	2.0000
6	1	5	1	2.0000
6	2	4	1	2.0000
6	3	3	1	2.0000
6	4	2	1	2.0000
6	5	1	1	2.0000
6	6	5	1	2.0000
6	7	4	1	2.0000

6	8	3	1	2.0000
6	9	2	1	2.0000
6	10	1	1	2.0000
6	11	5	1	2.0000
6	12	4	1	2.0000
6	13	3	1	2.0000
6	14	2	1	2.0000
6	15	1	1	2.0000
6	16	5	1	2.0000
6	17	4	1	2.0000
6	18	3	1	2.0000
6	19	2	1	2.0000
6	20	1	1	2.0000
6	21	5	1	2.0000
6	22	4	1	2.0000
6	23	3	1	2.0000
6	24	2	1	2.0000
6	25	1	1	2.0000
6	26	5	1	2.0000
6	27	4	1	2.0000
6	28	3	1	2.0000
6	29	2	1	2.0000
6	30	1	1	2.0000
6	31	1	1	2.0000
6	32	1	1	2.0000
6	33	1	1	2.0000
6	34	1	1	2.0000
6	35	1	1	2.0000
6	36	1	1	2.0000
6	37	1	1	2.0000
6	38	1	1	2.0000
6	39	1	1	2.0000
7	1	6	1	2.0000
7	2	6	1	2.0000
7	3	6	1	2.0000
7	4	6	1	2.0000
7	5	6	1	2.0000
7	6	6	1	2.0000
7	7	6	1	2.0000
7	8	6	1	2.0000
7	9	6	1	2.0000
7	10	6	1	2.0000
7	11	6	1	2.0000
7	12	6	1	2.0000
7	13	5	1	2.0000
7	14	5	1	2.0000
7	15	5	1	2.0000
7	16	5	1	2.0000
7	17	5	1	2.0000
7	18	5	1	2.0000
7	19	5	1	2.0000
7	20	5	1	2.0000
7	21	5	1	2.0000
7	22	5	1	2.0000
7	23	5	1	2.0000
7	24	5	1	2.0000
7	25	4	1	2.0000
7	26	4	1	2.0000
7	27	4	1	2.0000
7	28	4	1	2.0000
7	29	4	1	2.0000
7	30	4	1	2.0000
7	31	4	1	2.0000
7	32	4	1	2.0000
7	33	4	1	2.0000
7	34	4	1	2.0000
7	35	4	1	2.0000
7	36	4	1	2.0000
7	37	3	1	2.0000
7	38	3	1	2.0000
7	39	3	1	2.0000
7	40	3	1	2.0000
7	41	3	1	2.0000
7	42	3	1	2.0000
7	43	3	1	2.0000
7	44	3	1	2.0000
7	45	3	1	2.0000
7	46	3	1	2.0000
7	47	3	1	2.0000
7	48	3	1	2.0000
7	49	2	1	2.0000
7	50	2	1	2.0000
7	51	2	1	2.0000
7	52	2	1	2.0000
7	53	2	1	2.0000
7	54	2	1	2.0000
7	55	2	1	2.0000
7	56	2	1	2.0000
7	57	2	1	2.0000
7	58	2	1	2.0000
7	59	2	1	2.0000
7	60	2	1	2.0000
7	61	1	1	2.0000
7	62	1	1	2.0000
7	63	1	1	2.0000
7	64	1	1	2.0000
7	65	1	1	2.0000
7	66	1	1	2.0000

7	67	1	1	2.0000
7	68	1	1	2.0000
7	69	1	1	2.0000
7	70	1	1	2.0000
7	71	1	1	2.0000
7	72	1	1	2.0000
8	1	1	1	2.0000
8	2	1	1	2.0000
8	3	1	1	2.0000
8	4	1	1	2.0000
8	5	1	1	2.0000
8	6	1	1	2.0000
8	7	1	1	2.0000
8	8	1	1	2.0000
8	9	1	1	2.0000
8	10	1	1	2.0000
8	11	1	1	2.0000
8	12	1	1	2.0000
8	13	2	1	2.0000
8	14	2	1	2.0000
8	15	2	1	2.0000
8	16	2	1	2.0000
8	17	2	1	2.0000
8	18	2	1	2.0000
8	19	2	1	2.0000
8	20	2	1	2.0000
8	21	2	1	2.0000
8	22	2	1	2.0000
8	23	2	1	2.0000
8	24	2	1	2.0000
8	25	3	1	2.0000
8	26	3	1	2.0000
8	27	3	1	2.0000
8	28	3	1	2.0000
8	29	3	1	2.0000
8	30	3	1	2.0000
8	31	3	1	2.0000
8	32	3	1	2.0000
8	33	3	1	2.0000
8	34	3	1	2.0000
8	35	3	1	2.0000
8	36	3	1	2.0000

APPENDIX O

PCREWMOD.DAT Data File

Cum. Prob.	Module That Each Crew Member Is Present In at Hour (i) Crew #1	Crew #2	Crew #3	Crew #4	Hour (i)
0.0417	2	2	6	6	1
0.0833	6	6	2	2	2
0.1250	2	2	2	2	3
0.1667	5	1	1	5	4
0.2083	5	1	1	5	5
0.2500	5	1	1	5	6
0.2917	5	1	1	5	7
0.3333	5	1	1	5	8
0.3750	6	1	1	5	9
0.4167	2	2	2	2	10
0.4583	2	1	4	5	11
0.5000	1	1	4	5	12
0.5417	4	1	4	5	13
0.5833	3	1	4	5	14
0.6250	6	6	2	2	15
0.6667	2	2	6	6	16
0.7083	2	2	2	2	17
0.7500	2	2	1	1	18
0.7917	2	2	1	1	19
0.8333	2	2	1	1	20
0.8750	2	2	1	1	21
0.9167	2	2	1	1	22
0.9583	2	2	1	1	23
1.0000	2	2	1	1	24

206

C-3.

APPENDIX P

POSITION.DAT Data File

PRECEDING PAGE BLANK NOT FILMED

208

Module	*Station*	*Cum. Prob.*
1	1	0.1250
1	2	0.2500
1	3	0.3750
1	4	0.5000
1	5	0.6250
1	6	0.7500
1	7	0.8750
1	8	1.0000
2	1	0.1250
2	2	0.2500
2	3	0.3750
2	4	0.5000
2	5	0.6250
2	6	0.7500
2	7	0.8750
2	8	1.0000
3	1	0.1250
3	2	0.2500
3	3	0.3750
3	4	0.5000
3	5	0.6250
3	6	0.7500
3	7	0.8750
3	8	1.0000
4	1	0.0833
4	2	0.1667
4	3	0.2500
4	4	0.3333
4	5	0.4167
4	6	0.5000
4	7	0.5833
4	8	0.6667
4	9	0.7500
4	10	0.8333
4	11	0.9167
4	12	1.0000
5	1	0.2000
5	2	0.4000
5	3	0.6000
5	4	0.8000
5	5	1.0000
6	1	0.2000
6	2	0.4000
6	3	0.6000
6	4	0.8000
6	5	1.0000
7	1	0.1667
7	2	0.3333
7	3	0.5000
7	4	0.6667
7	5	0.8333
7	6	1.0000
8	1	0.3330
8	2	0.6670
8	3	1.0000

APPENDIX Q

Alternative Data File PCREWMO2.DAT

	Module That Each Crew Member Is Present In at Hour (i)				
Cum. Prob.	Crew #1	Crew #2	Crew #3	Crew #4	Hour (i)
0.0417	2	2	6	6	1
0.0833	6	6	2	2	2
0.1250	2	2	2	2	3
0.1667	5	1	1	5	4
0.2083	5	1	1	5	5
0.2500	5	1	1	5	6
0.2917	5	1	1	5	7
0.3333	5	1	1	5	8
0.3750	6	1	1	5	9
0.4167	2	2	2	2	10
0.4583	2	1	4	5	11
0.5000	1	1	4	5	12
0.5417	4	1	4	5	13
0.5833	3	1	4	5	14
0.6250	6	6	2	2	15
0.6667	2	2	6	6	16
0.7083	2	2	2	2	17
0.7500	6	6	6	6	18
0.7917	6	6	6	6	19
0.8333	6	6	6	6	20
0.8750	6	6	6	6	21
0.9167	6	6	6	6	22
0.9583	6	6	6	6	23
1.0000	6	6	6	6	24

APPENDIX R

MSCSurv™ Program Input and Output Files for Baseline Study Parameters

PAGE 216 INTENTIONALLY BLANK

PRECEDING PAGE BLANK NOT FILMED

```
 ------------------------------------------------
| Manned Spacecraft Crew Survivability (MSCSurv) |
|                    Program                     |
|                 Copywrite 1993                 |
|                Joel Williamsen                 |
|          Marshall Space Flight Center          |
| National Aeronautics and Space Administration  |
 ------------------------------------------------

READING IN VELSTA.DAT
READING IN PROBDIA.DAT
READING IN LAB.DAT
READING IN HAB.DAT
READING IN JLAB.DAT
READING IN ESA.DAT
READING IN NODE2.DAT
READING IN NODE1.DAT
READING IN PLOG.DAT
READING IN ALOCK.DAT
READING IN PROBMOD.DAT
READING IN SHIELD.DAT
READING IN POSITION.DAT
READING IN PCREWMOD.DAT

 HOW MANY PENETRATIONS IN THIS MODEL RUN ?
10000

 INPUT CRITICAL LENGTH OF CRACK OR "0." FOR ENERGY MODEL.

7.

 INPUT HOLE SIZE CRACK MULTIPLIER, 0.3 FOR AVERAGE.

.3

 INPUT "1." FOR BASELINE SHIELD OR "2." FOR ADVANCED SHIELD.

1.

 INPUT MINIMUM CREW ESCAPE TIME (SECS) OR "0." FOR RATE-BASED ESCAPE RELATIOI

30.

 INPUT DELAY PRIOR TO INITIATING MOVEMENT IF AWAKE.

35.

 INPUT DELAY TO WAKE AND EXIT RESTRAINTS IF ASLEEP.

100.

 "1" TO MODEL HINDERED/INJURED TIMES; "2" FOR NO.

1

 INPUT HINDERED CREW ESCAPE TIME FROM MODULE.

60.

 INPUT (CONSCIOUS) INJURED CREW ESCAPE TIME FROM MODULE.
60.

 INPUT PROBABILITY THAT INJURED PERSON IS IMMEDIATELY LOST.
1.0.
```

```
TYPE "1" IF CREW SLEEPS NEAR HATCH, "2" IF NO.
2
INCLUDE RACK FACTORS? TYPE 1 FOR YES, 2 FOR NO.
2
TYPE 1 FOR WIDE DEBRIS CLOUD, 2 FOR NARROW.
1
INPUT CRITICAL DEPRESSURIZATION LIMIT (PSI).
7.5
INPUT PERCENTAGE OF MODULE FREE AIR (0. TO 1.0).
.70
TYPE "1" FOR OPEN HATCHES, "2" FOR CLOSED HATCHES,
 "3" FOR HATCHES CLOSED AT NIGHT.
1
   NOTE: HATCH CLOSURE TIME IS ASSUMED TO BE 30 SECONDS.
INPUT CD, 0.9 OR 0.7.
.9
TYPE "1" FOR OBLIQUE HOLE MODEL, "2" FOR BURCH.
1

TYPE "1" FOR SSEIC CREW MODEL, "2" IF CREW SLEEPS IN NODE 2.
1
TYPE "1" FOR UNIFORM CREW DISTRIBUTION BETWEEN MODULE STATIONS,
 TYPE "2" FOR TRIANGULAR DISTRIBUTION.
1

     1000 PENETRATIONS


FOR MODULE          1  PENS =      1745
NUMBER OF IMPACTS BETWEEN .3 AND 3 CM =      3571
INJURIES =       177 DEPRESS =        90 CRACKS =      1299
PENS WITH INJURIES =       153 PENS WITH DEPRESS =        12
PENS WITH AT LEAST ONE INJURY OR CRIT LOSS =       158


FOR MODULE          2  PENS =      1771
NUMBER OF IMPACTS BETWEEN .3 AND 3 CM =      3605
INJURIES =       241 DEPRESS =       121 CRACKS =      1293
PENS WITH INJURIES =       174 PENS WITH DEPRESS =         7
PENS WITH AT LEAST ONE INJURY OR CRIT LOSS =       177
```

FOR MODULE 3 PENS = 963

NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = 2122

INJURIES = 1 DEPRESS = 0 CRACKS = 651

PENS WITH INJURIES = 1 PENS WITH DEPRESS = 5

PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = 6

FOR MODULE 4 PENS = 1390

NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = 3335

INJURIES = 24 DEPRESS = 0 CRACKS = 932

PENS WITH INJURIES = 24 PENS WITH DEPRESS = 5

PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = 29

FOR MODULE 5 PENS = 372

NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = 782

INJURIES = 19 DEPRESS = 2 CRACKS = 280

PENS WITH INJURIES = 16 PENS WITH DEPRESS = 0

PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = 16

FOR MODULE 6 PENS = 375

NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = 777

INJURIES = 20 DEPRESS = 2 CRACKS = 240

PENS WITH INJURIES = 17 PENS WITH DEPRESS = 2

PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = 18

FOR MODULE 7 PENS = 2217

NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = 3987

INJURIES = 0 DEPRESS = 0 CRACKS = 1455

PENS WITH INJURIES = 0 PENS WITH DEPRESS = 15

PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = 15

FOR MODULE 8 PENS = 1167

NUMBER OF IMPACTS BETWEEN .3 AND 3 CM = 2046

INJURIES = 0 DEPRESS = 0 CRACKS = 778

PENS WITH INJURIES = 0 PENS WITH DEPRESS = 17

PENS WITH AT LEAST ONE INJURY OR CRIT LOSS = 17

MODULE:	TOTAL RATIO =	CRACK +	INJURY +	DEPRESS
1	.8350	.7444	.0877	.0029
2	.8300	.7301	.0982	.0017
3	.6822	.6760	.0010	.0052
4	.6914	.6705	.0173	.0036
5	.7957	.7527	.0430	.0000
6	.6880	.6400	.0453	.0027
7	.6631	.6563	.0000	.0068
8	.6812	.6667	.0000	.0146
TOTAL = (1 TO 6)	.7707	.7096	.0582	.0029

PERFORM ANOTHER ANALYSIS? TYPE 1 FOR YES, 2 FOR NO.
1

APPROVAL

VULNERABILITY OF MANNED SPACECRAFT TO CREW LOSS FROM ORBITAL DEBRIS PENETRATION

By J.E. Williamsen

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

J.C. BLAIR
Director, Structures and Dynamics Laboratory

☆ US. GOVERNMENT PRINTING OFFICE 1994—533-108 /00049