Methodology for Characterizing Potential Adversaries of Nuclear Material Safeguards Systems

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University of California
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PART I
SUMMARY

OBJECTIVES AND SCOPE OF STUDY

This report describes the results of a study by Woodward-Clyde Consultants to assist the University of California Lawrence Livermore Laboratory in the development of methods to analyze and evaluate Nuclear Material Safeguards (NMS) Systems. The overall objective of the study by Woodward-Clyde Consultants was to explore the usefulness of two specific approaches to modeling behavior of adversaries of Nuclear Material Safeguards Systems:

1. Analysis of data on situations that might be analogous to NMS Systems; and
2. Quantification of the judgment of experts about potential adversaries of NMS Systems.

To meet this overall objective, the following three tasks were carried out:

1. Development of a preliminary modeling structure for use in interviewing experts on adversary behavior;
2. Identification and analysis of situations potentially analogous to NMS Systems; and
3. Interviewing of experts and analysis of the results of the interviews.

The scope of work carried out to meet the overall study objective is discussed in more detail below.

1.1 Scope of Study

Woodward-Clyde Consultants' study concentrated on developing a methodology to assist experts in describing, in quantitative form, their judgments about the characteristics of potential adversaries of NMS Systems. Situations potentially analogous to threats to NMS Systems were studied in order to provide background information to assist the experts in quantifying their judgments. The study did not attempt to use the analysis of analogous situations directly to construct models of NMS System adversaries, nor did it attempt to determine the extent and type of threat an adversary with specified characteristics would pose to an NMS System.

During the methodology development, a preliminary characterization of NMS System adversaries was determined. Although this characterization is presented in this report, it is only a first-cut at adversary characterization. Its primary use was to aid in methodology development. It provides a basis for further discussion of adversaries, but does not represent a final recommendation by Woodward-Clyde Consultants regarding characterization of adversaries.

The scope of work under each of the three tasks identified above is discussed in the next section.

1.2 Scope of Tasks

Development of a preliminary modeling structure for use in interviewing experts on adversary behavior. A preliminary structure was developed based on the use of judgmental probability assessment methods. In addition, necessary written material was prepared for use in interviews with experts

on adversary behavior, and computer programs were written to analyze the results of the interviews. During the development of the modeling structures, sequence category definitions provided by Lawrence Livermore Laboratory were reviewed and modified for use in this Task.

Identification and analysis of situations potentially analogous to NMS Systems. Relevant literature and other data sources were analyzed in an attempt to identify quantities or characteristics that were invariant across a wide range of potentially analogous situations. The results were summarized in a briefing document for use by the adversary experts during their interviews; thus, they had this data available to aid them in estimating adversary characteristics.

Interviewing of experts on potential adversaries and analysis of the results of the interviews. Three experts from Lawrence Livermore Laboratory were interviewed using the materials and methods developed during the earlier two tasks. The results were analyzed with the assistance of computer programs also developed during the earlier tasks. Based on the interview results, some modifications were made in the interview procedure. In addition, conclusions were drawn regarding the strengths and limitations of the methodology, and recommendations made for possible future work.

The subjects referred to as "experts" in the paragraph above, and in the remainder of this report, are members of the Lawrence Livermore Laboratory Material Control and Accountability Project. They have some experience in analyzing the adversary problem but little substantive knowledge about adversaries. Their primary use was as subjects to develop interview procedures; the probability numbers that resulted from interviews with them are for illustrative purposes only and do not necessarily represent the views of Lawrence Livermore Laboratory or Woodward-Clyde Consultants.

Attributes were introduced that covered the various areas of concern for describing adversaries. These allow the systematic characterization of the various possible adversaries of a NMS System. The process used to determine these attributes is discussed in Section 4.0. The following eight attributes were arrived at: Motivation, NMS System Information, Technical Information, Consequence Information, Processing Capability, General Resources, Self-Risk Attitude, and Other's-Risk Attitude. The areas of concern covered by each of these is shown in Figure 2.1.

Four possible levels were defined for the Motivation attribute and two possible levels for each of the other attributes. The definitions of these are given in Figure 2.2. Using this structure, any particular adversary can be described by specifying levels for each of the eight attributes. Thus, for example, one possible adversary would have symbolic motivation; high NMS System, technical, and consequence information; high processing capability and general resources; and a risk-seeking attitude toward both himself and others.

The use of these attributes was motivated by the literature on adversaries [1, 2, 4], in which discussions use ideas or terms such as "motivation" or "processing capability" when describing adversaries. For convenient use, a methodology to quantify judgments about adversaries by experts should use a means of describing adversaries that is familiar to the experts.

Attribute	Area of Concern
1. Motivation	Reason a theft is attempted
2. NMS System Information	Level of knowledge about the operation of Nuclear Material Safeguards Systems
3. Technical Information	Level of knowledge about nuclear materials, their handling, and their processing
4. Consequence Information	Level of knowledge about possible legal, financial, social, and health consequences of a theft attempt
5. Processing Capability	Equipment and expertise available to process stolen nuclear material
6. General Resources	Resources, such as equipment and number of personnel, available to aid in theft attempt
7. Self-Risk Attitude	Willingness of adversary to risk his own life and welfare
8. Other's-Risk Attitude	Willingness of adversary to risk lives and welfare of those not in the adversary group

Figure 2.1 ADVERSARY ATTRIBUTES

Attribute	Levels
1. Motivation	<ol style="list-style-type: none"> 1. <u>Symbolic</u>: For example, game playing, prank, crazy, personal revenge, for principle, publicity for a cause, cover-up of material unaccounted for 2. <u>Money</u>: To make money by sale of the material or ransom for its safe return 3. <u>Extortion</u>: Theft for nonmonetary gain (e.g., political gain, job restitution, prisoner release) 4. <u>Weapon</u>: Theft to make a weapon for eventual use (e.g., explosive device or radiation dispersal weapon)
2. NMS System Information	<ol style="list-style-type: none"> 1. <u>High</u>: Considerable knowledge of and control over at least one aspect of the Nuclear Material Safeguards System 2. <u>Low</u>: Has only the knowledge available to someone outside the NMS System
3. Technical Information	<ol style="list-style-type: none"> 1. <u>High</u>: Has significant knowledge about nuclear science, computer technology, electronics and related areas 2. <u>Low</u>: Does not have significant knowledge about these areas
4. Consequence Information	<ol style="list-style-type: none"> 1. <u>High</u>: Full understanding of the possible legal, financial, social and health consequences of the theft attempt 2. <u>Low</u>: Incomplete understanding of the possible consequences
5. Processing Capability	<ol style="list-style-type: none"> 1. <u>High</u>: Has the equipment and expertise to process stolen material, either to make a weapon or to enrich or alter it for easier storage or sale 2. <u>Low</u>: Does not have such capabilities

Figure 2.2 DEFINITIONS OF ATTRIBUTE LEVELS

Attribute	Levels
6. General Resources	<ol style="list-style-type: none"> 1. <u>High</u>: A group of people with some experience in theft and criminal activity 2. <u>Low</u>: One or two people inexperienced in theft and criminal activity
7. Self-Risk Attitude	<ol style="list-style-type: none"> 1. <u>Seeking</u>: Adversary will take chances which threaten his own life or welfare 2. <u>Avoiding</u>: Adversary will not accept significant probability of loss of life or capture
8. Other's-Risk Attitude	<ol style="list-style-type: none"> 1. <u>Seeking</u>: Adversary is willing to risk lives and welfare of those not in adversary group 2. <u>Avoiding</u>: Adversary unwilling to do this

Figure 2.2 (concluded)

With the attribute levels shown in Figure 2.2, there are $4 \times 2^7 = 512$ different possible adversaries. Thus, to quantify completely an expert's judgments about the relative likelihoods that an NMS System adversary would have various characteristics, it would be necessary to collect 512 different probability judgments, one for each possible adversary. In our judgment, this would be difficult to do in a reasonable length of time and would most likely lead to inconsistent judgments. Therefore, we developed a methodology which allows partial information about these probabilities to be utilized.

The procedure to use partial probability information was directed at the final use intended for the quantitative information about adversary characteristics: to predict the possible behavior of adversaries toward an NMS System and the threat that this behavior poses. In particular, it is desired to find the relative likelihoods of various types of theft attempts (e.g., insider versus outsider thefts, or single individual versus group efforts). Thus, it is not necessary to have probabilities for all 512 different possible adversaries, but only probabilities for selected "types" of adversaries who pose threats of distinctly different theft attempts.

Using the process discussed in Section 4.0, nineteen adversary archetypes (see Figure 2.3) were defined to characterize the range of possible theft attempts that might be made against an NMS System. Each of these is a combination of some of the 512 different adversaries and each poses a distinctly different type of threat to the system. It is these archetypes for which probabilities are desired for use in the remainder of Lawrence Livermore Laboratory's work to analyze and evaluate NMS Systems. Since there are only nineteen of these, complete information about all of the 512 different adversaries is not necessary to bound the archetype probabilities tightly.

Archetype Names	Characteristics
1. Uninformed Outsider	Theft for symbolic reasons, prankster, crazy, for principle, but not planned; very little Nuclear Material Safeguards System (NMSS) knowledge; technically unsophisticated
2. Principled Outsider	Theft for symbolic reasons (e.g., game-playing, for principle); little or no NMSS knowledge, technically sophisticated; could have considerable diversion resources, but no inside contacts
3a. Disgruntled Employee 3b. Disgruntled Employees	Symbolic theft (e.g., labor unrest, revenge on the system, Material-Unaccounted-For coverup); NMS System low-level insider, such as guard, minor technician, maintenance worker, etc.; little technical knowledge
4. Principled Executive	Symbolic theft (e.g., for principle, revenge, coverup of present or future MUF); high level NMSS position and contacts (executive administrator, etc.); likely to understand consequences of theft; high technical knowledge, possibly a group
5a. Competent Outsider 5b. Competent Outsider Group	Theft for monetary gain (e.g., future sale); little or no NMSS information; technically sophisticated; has diversion resources
6a. Opportunistic Employee 6b. Opportunistic Employees	Crime of opportunity, for money; knows one area of NMSS (e.g., guard, loading dock worker, etc.); little technical sophistication
7. High-Level Embezzling Group	Possibly long-term diversion for profit; well-informed insiders; technically sophisticated; have NMSS contacts, control and equipment available

Figure 2.3 NMS SYSTEM ADVERSARY ARCHETYPES

Archetype Names	Characteristics
8. Embezzling Executive	Crime of opportunity, possibly long-term diversion; well-informed insider; technically sophisticated
9. Terrorist Group or Foreign National Group	Theft to build weapon; little or no NMS System information; high technical and processing capability; sophisticated arms and adequate manpower (likely to mount a direct frontal attack)
10. Terrorist Individual	Theft to build weapon; little or no NMS System information; technically sophisticated and capable of processing material; few theft resources (likely to attack fringe of system, such as material being transported)
11. Insider Terrorist Group	Theft to build weapon; well-informed insiders; technically sophisticated with processing capability; have NMS System contacts, control and equipment available (may be large group with theft equipment)
12. Insider Terrorist Individual	Theft to build weapon; well-informed insider; technically sophisticated with processing capability; little NMS System control and few contacts (small group or individual)
13. Outsider Extortionist Group	Theft for extortion; see (5b.) for other characteristics
14. Outside Expert	Theft for extortion; see (5a.) for other characteristics
15. Extorting Employee	Theft for extortion; see (6a.), (6b.) for other characteristics
16. Extorting Executive	Theft for extortion; see (8.) for other characteristics

Figure 2.3 (concluded)

A linear programming algorithm, discussed in Section 5.0, was developed and programmed for computer use to take as input partial information about the probabilities of different levels of the adversary attributes shown in Figure 2.2. This algorithm computes bounds imposed by the partial information on possible probabilities for each of the archetypes.

The rationale for collecting probability information about attribute levels, rather than directly about archetypes, is the supposition that experts are accustomed to thinking in terms of these attributes. Thus, if questions were asked about the archetypes, the experts would have to informally integrate their knowledge about the attribute probabilities to arrive at archetype probabilities. Asking probability questions directly about the attribute levels, and using the computer program to determine archetype probabilities from the attribute information, avoids the possibility of errors in the informal integration.

A questionnaire and supporting written material, discussed in Section 6.0, were developed to elicit probability information from experts. The results obtained by utilizing this questionnaire with three experts are discussed in Section 7.0. The work with the three experts showed the methodology can be implemented to collect probability data from experts. However, the fairly wide divergence of judgment among these experts raises doubt whether enough agreement can be reached among different experts to obtain archetype probabilities that can defensibly be used in further analyses of NMS Systems. This point, and recommendations for possible further study, are discussed in Section 8.0.

PART II

ANALOGOUS ACTIVITIES

ANALYSIS OF ACTIVITIES ANALOGOUS TO
NUCLEAR MATERIAL SAFEGUARDS SYSTEMS

The investigation of activities analogous to the nuclear material safeguard situation was designed to provide background information to use in briefing experts on adversaries before interviewing them to quantify their judgments. The results of the analogous activities study are summarized in the Briefing Document included as Appendix A1 to this report. In this section the data sources used are summarized along with the principal documents studied. Finally, some general remarks are made about the usefulness of data on analogous situations.

3.1 Data Sources

Because of the limited objectives of our study of analogous activities, only facts and figures already compiled by other analysts were utilized. The search for data on analogous activities was initiated by consulting general library sources including: Dissertation Abstracts; The New York Times Index; Guide to Periodic Literature; Congressional Information Service Abstracts; Encyclopedia of Organizations. This search identified a number of private and governmental organizations involved in research and/or data collection relevant to analogous security situations. All were contacted by phone. Some organizations requested official LLL or NRC contact before any information, if available, would be released. Other groups mailed the desired documents or declined to offer material for proprietary or security reasons.

Organizations Contacted

- a. Jewelers Security Alliance of the U.S. (New York City)
Compiles case histories of jewel thefts, advises business on protection of jewelry.
Contact: Mr. James B. White, President
- b. National Crime Prevention Institute (University of Louisville, Shelby Campus)
Has NRC contract to study threats to physical security systems at nuclear facilities.
Contact: Miss Bomar
- c. Burns Security Institute (Briarcliff Manor, N.Y.)
Advises the security industry; has conducted surveys of security in various industries, including banking and electric utilities.
Contact: Mr. Bill Burner
- d. Surety Association of America (New York City)
Compiles statistics on losses of assets in various industries.
Contact: Mr. Robert Hepburn, Jr.
- e. American Bankers Association (Washington, D.C.)
Insurance and Protection Division conducts annual survey of losses from member banks; more detailed data were not available despite repeated efforts to obtain more complete ABA data.
Contact: Mr. John Wolff
- f. U.S. Chamber of Commerce (Washington, D.C.)
Estimates costs of white collar crime to various industries.

- g. American Society for Industrial Security (Washington, D.C.)
Primary trade organization for security industry; has several standing committees (Public Utilities, Physical Security, Terrorism, Employee Theft, Computer Security) that are conducting research relevant to our effort.
- h. U.S. National Bureau of Standards (Gaithersburg, Md.)
Law Enforcement Standard Laboratory sponsors conference series on "The Role of Behavioral Sciences in Physical Security." Papers presented deal with statistical analysis of terrorism (primarily from RAND-Sandia studies) and general adversary studies. Three conferences have been held.
Contact: Joel Cramer.
- i. National Criminal Justice Reference Service (Washington, D.C.)
A clearinghouse for governmental and private criminal justice articles, reports, books, etc.; operated by the Department of Justice Law Enforcement Assistance Administration. NCJRS maintains computer-based bibliographies on private security, industrial security, terrorism, employee theft and embezzlement.
- j. Small Business Administration (Washington, D.C.)
Conducted extensive study of losses to small businesses in 1969. Theft from small businesses may not be directly analogous, although the data sources and study methodology provided guidelines for our study of "large" business theft.
- k. U.S. Department of Commerce
The Commerce Department is the federal agency most responsible for the study of business crime losses and it publishes many relevant documents. Commerce sponsors a "Crime Against Business" seminar series and publishes statistics on the costs of crime for selected industries and the economy as a whole.

1. Stanford Research Institute

The Business Intelligence Program of SRI is currently studying crime losses to business; however, release of this data is only sporadic, due to the proprietary nature of the program.

m. Center for Comparative Criminology (University of Montreal)

Publishes academic papers relating to international criminal trends. The publications list did not indicate any research directly related to the purposes of this study.

n. U.S. Department of Justice

The Law Enforcement Assistance Administration sponsors statistical studies of crime patterns.

3.2 Documents Obtained

a. Burns Security Institute

1. National Survey on Pharmaceutical Manufacturing Security, February 1978.
2. National Survey on Electric Utilities Security, January 1976.
3. National Survey on Exhibition Hall Security, January 1975
4. National Survey on Bank Security, March 1977.
5. National Survey on Library Security, September 1973.
6. National Survey on Shopping Center Security, May 1978.

b. American Bankers Association

1. Confidential Bank Insurance Survey, 1977 (first annual survey).

c. American Society for Industrial Security

1. Brian Parker, "Business: Victims of Crime," Security Management, March 1977, pg. 28.
2. Sterling D. Gosset, "Motive and Opportunity - Embezzlement," Security Management, March 1973.
3. U.S. Department of Commerce, "The Cost of Crimes Against Business," Security Management, March 1975.
4. Robert V. Jacobson, "Finding Hidden Computer Crime," Security Management, April 1978, pg. 16.

d. U.S. National Bureau of Standards

1. The Role of Behavioral Sciences in Physical Security, Proceedings, First Annual Symposium.
2. The Role of Behavioral Sciences in Physical Security, Proceedings, Second Annual Symposium.

e. National Criminal Justice Reference Service

1. Computer-based Bibliographies
 - Terrorism
 - Embezzlement and Employee Theft
 - Industrial Security
 - Private Security

2. Security Management Index, July 1957 to January 1977 (ASIS).
3. Industrial Security - a select bibliography compiled by A.R. Chambers, A.L.A., December 1973.
4. Holdup in Belgique, National Center of Criminology, Bruxelles Institute of Sociology, 1975.

f. Small Business Administration

1. Crimes Against Small Businesses: A Report of the Small Business Administration Transmitted to the Select Committee on Small Business, U.S. Senate, 1969, Senate Doc. No. 91-14.

g. U.S. Department of Commerce

1. Federal Government Sources on Crimes Against Business, Domestic and International Business Administration, 1977.
2. Crimes Against Business, Seminar Proceedings.
 - Cincinnati, Ohio, September 25, 1975
 - Los Angeles, California, February 5, 1976
 - Phoenix, Arizona, April 23, 1976
 - New York, New York, September 14, 1976
3. Crimes Against Business: The Cost of Security, Staff Study, May 1978.
4. Crime in Service Industries, September 1977.
5. Crime in Retailing, August 1975.
6. The Cost of Crimes Against Business, January 1976.
7. Federal Government Sources on Crimes Against Business, 1977.

h. Stanford Research Institute

1. Business Countermeasures to Crime Losses, Business Intelligence Program, Datalog File 75-34, June 1976.

(Note: We were unable to obtain this full report due to its proprietary nature)

i. Center for Comparative Criminology

1. Publications of the School of Criminology,
Universite de Montreal, April 1977.

j. U.S. Department of Justice (Law Enforcement Assistance Administration)

1. Harry A. Scarr, Patterns of Burglary, February 1972.
2. Carl E. Pope, Crime-Specific Analysis, An Empirical Examination of Burglary Offender Characteristics, Analytic Report No. 11, 1977.

3.3 Comments on the Usefulness of Analogous Activities Data

Our research indicates that the current state of the data sources for theft losses does not allow for accurate identification of invariant quantities across different studies. The Commerce Department highlights this situation in its most recent business crime loss report, referenced in the preceding section:

The most serious difficulty associated with analyzing the impact of crimes against business continues to be the sparseness or sporadic nature of the data available. Figures are seldom based on comparable definitions or time periods, and many data gaps exist. This drawback was highlighted in the 1968 report of the President's Commission on Law Enforcement and Administration of Justice, which stated:

The only comprehensive study of the cost of crime in this country was made by the Wickersham Commission in 1931....The lack of knowledge about which the Wickersham Commission complained 30 years ago is almost as great today.

Although many of the recommendations of this Commission have since been adopted, including the expansion of data gathering activities, there is still no comprehensive source for information about crimes against business property.

Although data sources may be internally consistent, comparisons among sources - even within the same industry - are suspect. The banking industry exemplifies this problem, as shown in the following table:

<u>Data Source</u>	<u>1976 Total Robbery and Burglary</u>	<u>1978 Fraud and Embezzlement</u>
SRI	\$73,900,000	\$368,300,000
ABA	22,300,000	88,000,000
Commerce	27,300,000	206,000,000

It appears the data does not allow for consistent comparisons of theft losses across industries, at least using published data sources.

In addition to difficulties comparing data across industries, it is necessary to be very careful in using data on other industries to draw conclusions about theft of special nuclear material. The potential of this material for use in military or terrorist activities means that there are potential adversaries, such as foreign nationalists or terrorists, that are almost unknown in other industries.

PART III
DESCRIPTION OF METHODOLOGY

4.0

CHARACTERIZATION OF
POTENTIAL ADVERSARIES

Section 2.0 discussed the procedure used to characterize potential adversaries of NMS Systems in this study. In particular, attributes are used to describe adversaries and elicit probability information from experts. This information is then used to calculate bounds on the probabilities of adversary archetypes.

The preliminary adversary attributes defined in Figures 2.1 and 2.2 were developed by Woodward-Clyde Consultants based on discussions over a six-month period at several meetings involving Lawrence Livermore Laboratory and subcontractor personnel. It is anticipated that these attributes will be refined in the future through further discussions involving a wider range of experts on adversary behavior.

The preliminary archetype definitions shown in Figure 2.3 were also developed by Woodward-Clyde Consultants based on discussions with Lawrence Livermore Laboratory and subcontractor personnel. It is anticipated that these definitions will also be refined further in the future.

The archetypes, for which verbal definitions were given in Figure 2.3, can be more explicitly defined as collections of the 512 different types of adversaries defined by the various possible combinations of attribute levels in Figure 2.2.

To conveniently represent the archetype definitions, a special coding procedure was developed, as shown in Figure 4.1. Each of the eight entries in the parentheses refers to one of the eight attributes defined in Figure 2.1, in the same order as given there. Thus, the first entry refers to the motivation attribute, the second entry to the NMS System information attribute, and so forth. If an entry is a number different than zero, it represents the attribute level with that number, as given in Figure 2.2. Thus, an adversary coded as (3,1,1,1,2,1) is one whose motivation is extortion, and who has high levels of NMS system information and technical information, low consequence information, high levels of processing capability and general resources, is risk-avoiding for himself, but is risk-seeking for others.

If an entry is zero, it indicates no restriction on that particular attribute, and so the code refers to a collection of some of the 512 possible adversaries. For example, the code (3,0,1,0,0,0) represents all adversaries who have extortion as a motivation and a high degree of technical information.

The first step of the process used to determine archetype definition was to identify those archetypes that are impossible or extremely unlikely. These are defined both verbally and by code in Figure 4.2.

After removing the adversary descriptions excluded by the rules in Figure 4.2, the adversary archetypes are a collectively exhaustive and mutually exclusive set over the remaining adversary descriptions. The coded description of the archetypes is given in Figure 4.3

1. Entries in parentheses are attribute levels as defined in Figure 2.2

or

2. If an entry is zero, the code represents no restriction on the level of that attribute.

Figure 4.1 CODING SCHEME FOR ADVERSARIES

- A. If an adversary has a low level of technical information about the object of diversion, he is not likely to have a high capability for processing.

Code: (0,0,2,0,1,0,0,0)

- B. For nonsymbolic diversion, both a low-level knowledge of NMS System and a low technical level produce an unlikely adversary.

Code: (2,2,2,0,0,0,0,0) + (3,2,2,0,0,0,0,0) + (4,2,2,0,0,0,0,0)

- C. Adversaries who seek a weapon are, by definition, not risk averse when it comes to others.

Code: (4,0,0,0,0,0,0,2)

- D. Adversaries who seek a weapon must have high technical information and processing capability.

Code: (4,0,0,0,2,0,0,0)

- E. If an adversary has a high level of information about NMS System and technical aspects, and has high processing capability and resources, he is not likely to have a low level of knowledge about consequences.

Code: (0,1,1,2,1,1,0,0)

- F. Extortionists are likely to have a high consequence knowledge.

Code: (3,0,0,2,0,0,0,0)

Notes:

1. Any of the 512 possible different types of adversaries that are included in one or more of the exclusion rules above are assumed to have zero probability of existing.
2. A total of 290 different types of adversaries are excluded by these rules.

Figure 4.2 EXCLUSION RULES FOR IMPOSSIBLE OR EXTREMELY UNLIKELY ADVERSARY DESCRIPTIONS

Archetype Names	Code
1. Uninformed Outsider	(1,2,2,0,0,0,0,0)
2. Principled Outsider	(1,2,1,0,0,0,0,0)
3a. Disgruntled Employee	(1,1,2,0,0,2,0,0)
3b. Disgruntled Employees	(1,1,2,0,0,1,0,0)
4. Principled Executive	(1,1,1,0,0,0,0,0)
5a. Competent Outsider	(2,2,1,0,0,2,0,0)
5b. Competent Outsider Group	(2,2,1,0,0,1,0,0)
6a. Opportunistic Employee	(2,1,2,0,0,2,0,0)
6b. Opportunistic Employees	(2,1,2,0,0,1,0,0)
7. High-Level Embezzling Group	(2,1,1,0,0,1,0,0)
8. Embezzling Executive	(2,1,1,0,0,2,0,0)
9. Terrorist Group or Foreign National Group	(4,2,1,0,1,1,0,0)
10. Terrorist Individual	(4,2,1,0,1,2,0,0)
11. Insider Terrorist Group	(4,1,1,0,1,1,0,0)
12. Insider Terrorist Individual	(4,1,1,0,1,2,0,0)
13. Outsider Extortionist Group	(3,2,1,0,0,1,0,0)
14. Outside Expert	(3,2,1,0,0,2,0,0)
15. Extorting Employee	(3,1,2,0,0,0,0,0)
16. Extorting Executive	(3,1,1,0,0,0,0,0)

Notes:

1. Verbal definitions of the archetypes are given in Figure 2.3, pp. 10-11.
2. Note that attributes 4 (Consequence Information), 7 (Self-Risk Attitude), and 8 (Other's-Risk Attitude) do not enter into the archetype definitions.

Figure 4.3 CODED DESCRIPTION OF ARCHETYPES

UTILIZATION OF JUDGMENTAL INFORMATION
ABOUT ADVERSARIES

With the attribute levels shown in Figure 2.2, there are 512 different possible adversaries. Thus, to quantify completely an expert's judgments about the relative likelihoods that an NMS System adversary would have various characteristics, it would be necessary to collect 512 different probability judgments. As discussed in Section 2.0, this appears to be difficult to do. Therefore, nineteen adversary archetypes were defined to characterize the range of possible theft attempts that might be made against an NMS System, and we developed a procedure to infer bounds on the probabilities of these archetypes from partial probability information elicited from adversary experts about the various attributes.

This section discusses the theoretical basis for using partial information about adversary characteristics, as well as a computer program to implement this theory. The motivation for using partial information to bound archetype probabilities was the expectation that a relatively small amount of information would lead to tight bounds on the archetype probabilities. In this case the derived (tightly bounded) archetype probabilities could be used as inputs to the NMS System model being developed by Lawrence Livermore Laboratory.

5.1 Theoretical Basis

The presentation in this section assumes the attributes, exclusion rules, and archetypes defined earlier* are being used. The mathematical notation used in Section 4.0 (see Figure 4.1) to represent different adversaries will also be used here.

Our elicitation procedures allow an expert to provide numerical values or upper or lower bounds for any of the following types of judgmental probabilities:

- i. Marginal probabilities for any adversary attribute,
- ii. Conditional probabilities for any single attribute, given information about the other attributes, and
- iii. Comparison of the magnitude of the probabilities of any two specified adversary descriptions.

For either i or ii above, specific numerical values may be specified for the probabilities, or bounds (either upper or lower) may be given.

5.1.1 Formulation of Bounding Problem

In this section the problem of bounding the archetype probabilities using the three types of partial probability information discussed above is shown to be a linear program [2]. This is advantageous, since computer programs exist to solve linear programs very efficiently.

*Modifications to these can be easily made.

For notational convenience let T represent the set of all 512 different adversary descriptions and let t represent a specific element of T . Further, let $A_1, A_2, \dots, A_n$ represent the collections of points in T in each of the n archetypes and $E_1, E_2, \dots, E_m$ represent the collections of points in T in each of the m exclusion rules. (The E_i 's and A_i 's are defined respectively in Figures 4.2 and 4.3.) Further, let p_t represent the probability of t , and $P(A)$ represent the probability of event A . Then, upper and lower bounds on the probability $P(A_1)$ of archetype A_1 can be found by solving the following two optimization problems:

Problem I: Upper Bound

$$\begin{array}{l} \text{maximize} \\ [p_t, t \in T] \end{array} \left\{ \sum_{t \in A_1} p_t \right\} \quad (5.1a)$$

subject to

$$p_t = 0, \quad t \in E_j; \quad j = 1, 2, \dots, m \quad (5.1b)$$

$$\left\{ \begin{array}{l} \text{constraints imposed by} \\ \text{probability assessments - discussed in} \\ \text{Section 5.1.2} \end{array} \right\} \quad (5.1c)$$

$$\sum_{t \in T} p_t = 1 \quad (5.1d)$$

$$p_t \geq 0, \quad t \in T \quad (5.1e)$$

The summation in (5.1a) is the probability of archetype A_1 . The upper bound is to be found for this, subject to the constraints placed on it by the exclusion rules and the assessed probabilities. Since any p_t must be non-negative, (5.1b) is equivalent to requiring that all p_t covered by an exclusion rule must be zero. Equation (5.1d) expresses the fact that the sum of the probabilities over all possible adversaries must add to one.

Problem II: Lower Bound

This problem is the same as Problem I, except that now the smallest possible value of each archetype is to be found subject to the various constraints placed on it.

$$\underset{[p_t, t \in T]}{\text{minimize}} \left\{ \sum_{t \in A_1} p_t \right\} \quad (5.2a)$$

subject to

$$p_t = 0, \quad t \in E_j; j = 1, 2, \dots, m \quad (5.2b)$$

$$\left\{ \begin{array}{l} \text{constraints imposed by} \\ \text{probability assessments - discussed in} \\ \text{Section 5.1.2} \end{array} \right\} \quad (5.2c)$$

$$\sum_{t \in T} p_t = 1 \quad (5.2d)$$

$$p_t \geq 0, \quad t \in T \quad (5.2e)$$

Since there are nineteen archetypes, it is necessary to solve thirty-eight optimization problems to determine upper and lower bounds for all

archetype probabilities. If probability elicitation is restricted to the three types discussed in Section 5.1, then the optimization problems are linear programs, as shown in the following section.

5.1.2 Formulation of Constraints

For notational convenience let K_{ij} represent all elements of T such that $e_i = j$, using the notation of Figure 4.1. That is, $K_{ij} = (0, 0, \dots, 0, j, 0, \dots, 0)$, where the only non-zero element in the vector is the i^{th} . Then, an assessed marginal probability, as discussed in item 1 of Section 5.1, imposes one of the following constraints:

$$\sum_{t \in K_{ij}} p_t \leq p, \quad (5.3a)$$

$$\sum_{t \in K_{ij}} p_t = p, \text{ or} \quad (5.3b)$$

$$\sum_{t \in K_{ij}} p_t \geq p, \quad (5.3c)$$

where p is the assessed marginal probability that attribute i is equal to j . Here (5.3a) corresponds to the case where the expert gives an upper bound on the probability, (5.3b) corresponds to the case where he gives a specific numerical value for the probability, and (5.3c) corresponds to the case where he gives a lower bound on the probability.

For notational convenience let $\bar{K}_i$ represent a specified collection of levels for all attributes except the i^{th} . Thus, for example, $\bar{K}_2$ might represent all levels of attributes 1, 3, 4, 5, 6, 7, and 8 such that attribute 1 (Motivation) is either 1 or 2 (Symbolic or Money), attribute 3 (NMS System Information) is either 1 or 2 (High or Low), and attributes 4 through 8 are all 1. The conditional probability

that the i^{th} attribute equals k_i given that an adversary is in $\bar{R}_i$ will be written $P(k_i|\bar{R}_i)$; further, $(k_i, \bar{R}_i)$ will symbolize all elements in T such that the i^{th} attribute equals k_i and $\bar{R}_i$ is true.

Using this notation an assessed conditional probability, as discussed in item ii of Section 5.1, imposes one of the following constraints:

$$P(k_i|\bar{R}_i) \leq p', \quad (5.4a)$$

$$P(k_i|\bar{R}_i) = p', \text{ or} \quad (5.4b)$$

$$P(k_i|\bar{R}_i) \geq p', \quad (5.4c)$$

where p' is the assessed conditional probability that the i^{th} attribute equals k_i given $\bar{R}_i$ is true. Here (5.4a) applies when an upper bound is given, (5.4b) when a specific numerical value is given, and (5.4c) when a lower bound is given.

From the definition of conditional probability

$$P(k_i|\bar{R}_i) = \frac{P(k_i, \bar{R}_i)}{P(\bar{R}_i)}. \quad (5.5a)$$

But

$$P(k_i, \bar{R}_i) = \sum_{t \in (k_i, \bar{R}_i)} p_t \quad (5.5b)$$

and

$$P(\bar{K}_1) = \sum_{t \in \bar{K}_1} p_t. \quad (5.5c)$$

Substituting (5.5) into (5.4) and rearranging terms results in

$$\sum_{t \in (k_1, \bar{K}_1)} p_t - p' \sum_{t \in \bar{K}_1} p_t \leq 0, \quad (5.6a)$$

$$\sum_{t \in (k_1, \bar{K}_1)} p_t - p' \sum_{t \in \bar{K}_1} p_t = 0, \text{ or} \quad (5.6b)$$

$$\sum_{t \in (k_1, \bar{K}_1)} p_t - p' \sum_{t \in \bar{K}_1} p_t \geq 0. \quad (5.6c)$$

Finally, the comparison of any two probabilities, as discussed in item iii of Section 5.1, imposes one of the following constraints:

$$p_{t_1} \leq p_{t_2}, \quad (5.7a)$$

$$p_{t_1} = p_{t_2}, \text{ or} \quad (5.7b)$$

$$p_{t_1} \geq p_{t_2}, \quad (5.7c)$$

where t_1 and t_2 are two different elements of T . Here (5.6a) applies for an upper bound, (5.6b) for a specific numerical value, and (5.6c) for a lower bound. (The ability to impose constraints of this type is included in the computer implementation discussed in the next section. However, because of the laboriousness of assessing information of this type, the elicitation procedure we developed does not use constraints of this form.)

Thus, to determine how the assessed probabilities restrict the possible values of the archetype probabilities, the appropriate constraints from among (5.3), (5.6), and (5.7) are substituted into (5.1c) and (5.2c) and the resulting optimization problems solved. (Note that there might be several different constraints of each of the three types depending on the information elicited.) Since (5.3), (5.6), and (5.7) are all linear constraints, the resulting optimization problems are linear programs. The computer program developed to solve this linear program is discussed in the following section.

5.2 Computer Implementation

Solution of (5.1) and (5.2) is conceptually straightforward since there are programs available on most computer systems that will solve linear programs much larger than the ones of interest here. However, manually entering the data for the optimization problems would be an extremely tedious task. There are 512 different p_t 's and, depending on the assessed probability data, perhaps several dozen constraints. Entering the necessary information, particularly if data is assessed for several different experts, would be time-consuming and subject to error.

To avoid these difficulties a preprocessor program was written in Fortran to take information about assessed probabilities and set up data representing the appropriate constraint equations. This preprocessor was written to work with the linear program solution package MPS, which is part of the IBM Mathematical Programming System, available on most IBM computer systems. The entire computer procedure to take elicited data and generate bounds on archetype probabilities has been implemented as an interactive program on the Michigan Terminal System (MTS) at the University of Michigan. A User's Guide giving instructions on how to use this is included in Appendix A3. Specific instructions on how to prepare responses to the questionnaire in Appendix A2 for input to the computer program are contained in Appendix A4.

To briefly summarize the use of the computer program, data is entered using the coded representation shown in Figure 4.1. Thus, for example, 10000000G .3 means:

the probability that Motivation is Symbolic is greater than .3.

Similarly, 20000000L30000000 means:

the probability that Motivation is Money is less than the probability that Motivation is Extortion.

Conditional probabilities are entered using a slight variation on this coding scheme. For example, PG=1G1=4G .7 means:

the probability that attribute 6 (General Resources) is High, given that attribute 1 (Motivation) is Weapon, must be greater than .7.

The preprocessor is interactive and provides extensive prompting to the user. However, the underlying programs, which are documented in Appendix A5, are fairly complex. It is necessary to handle and sort a number of large data files which are either created by the preprocessor or permanently stored for use by the program. These manipulations, of necessity, use system commands that are specific to the Michigan Terminal System. Although it would be possible to write similar programs to carry out the required tasks on most large computer systems, the current procedures cannot be moved easily from the Michigan system to another system.

PROCEDURE FOR ELICITING
JUDGMENTAL INFORMATION

The procedure for eliciting judgmental information concerning the relative likelihoods of various potential adversaries is built around the Briefing Document (included as Appendix A1 to this report) and the Questionnaire on Adversary Characteristics (included as Appendix A2).

The Briefing Document furnishes general background information on other theft situations that are analogous in some way to theft from a Nuclear Material Safeguards System. It is written as a relatively neutral presentation of facts; however, it will almost certainly impress the reader with the fact that in many industries theft by insiders is a significantly more serious problem than theft by outsiders.

The questionnaire is self-explanatory, but it is not designed to be self-administered. Someone familiar with the subject matter and who understands how the answers will be used should be present to answer questions raised by the expert filling out the questionnaire. Furthermore, in keeping with standard practice for the elicitation of judgmental probabilities, the expert should be closely examined to determine the reasons for the answers given, and to find inconsistencies in the responses.

The questionnaire was used to elicit judgments from three Lawrence Livermore Laboratory experts on adversaries. The results of this elicitation are discussed in Section 7.0.

PRELIMINARY ELICITATION RESULTS

This section reports the results of assessing judgmental probability information from three experts on adversary behavior at Lawrence Livermore Laboratory. The elicitation process resulted in probability information about adversaries, and, in addition, the experts made a number of suggestions regarding ways to improve the elicitation process. Both the suggested changes in the elicitation process and the actual assessment results are discussed below.

7.1 Recommended Improvements to Elicitation Process

The experts made a number of recommendations for clarifying the instructions for the questionnaire which have been incorporated into the questionnaire in Appendix A2. The most significant of these were to include in the introduction a more careful definition of the types of thefts of nuclear materials that were to be considered, and to include a more complete explanation of the purpose of the attributes.

The original questionnaire asked directly for probabilities, but the experts felt that questions should be asked in terms of relative likelihoods rather than probabilities, since they found it more natural to think in terms of relative likelihoods.

The experts also felt that the number of questions relating to conditional probabilities (Sections 4.0 through 7.0) should be cut. For example, in Question 4.0 the original questionnaire asked for probabilities

conditional on low, as well as high, levels of NMS System Information, Technical Information, and General Resources. The experts felt that too many questions were being asked, and that it would be preferable to cut down the number of questions so there was time to answer the ones that remained more carefully.

Finally, the experts felt that an additional section should be added which directly asked for archetype probabilities. Although a purpose of the methodology presented here is to avoid having to assess archetype probabilities directly, the experts felt it would be useful to assess these for comparison against the archetype probabilities indirectly determined from information on the attributes. Section 8.0 was added to the questionnaire in Appendix A2 to directly assess probabilities of archetypes.

The experts found that the attribute definitions were meaningful and that they could answer the questions. One expert noted that he found it difficult to think about the marginal probability questions in Section 3.0 of the questionnaire. He found it more natural to consider a more complete description of an adversary, including levels for several attributes. With hard thought, however, he could answer these questions.

The experts felt that the Briefing Document, included in Appendix A1, contained useful background material with which they, and probably other experts on adversary behavior, were not familiar.

The next section discusses the results of the elicitation.

7.2 Elicitation Results

Figures 7.1 and 7.2 show the results of responses produced by three experts - A, B, and C - to the questionnaire. Figure 7.1 shows their judgments on the relative likelihoods of the levels of the Motivation, NMS System Information, Technical Information, and General Resources attributes. Note that these differ significantly from one expert to another. Thus A judges money motivation to be 10 times as likely as symbolic, whereas B judges symbolic motivation to be 10 times as likely as money.

Figure 7.2 shows responses to Questions 4.0, 5.0, 6.0, and 7.0 of the questionnaire. The responses of A and B to Question 4 indicate that these experts regard knowledge about: a high level of NMS System Information, a high level of Technical Information, and a high level of General Resources to be equivalent in terms of adjusting the relative likelihoods of the four motivations. Expert C has chosen to use the qualitative option when he judges, for example, that knowing an adversary has a high level of NMSS information will make the likelihood of symbolic motivation greater ("G") than without this information.

7.3 Results: Probability Bounds

The judgments shown in Figures 7.1 and 7.2 were coded for entry into the preprocessing computer program (see Appendix A4 for the coded representation).

Using all the information provided by each expert resulted in the determination that each one was inconsistent in his own statements. That is, the judgments provided by a particular expert produce a set of constraints on the relevant probabilities that are not satisfied by any possible set of probabilities.

Question	Expert		
	A	B	C
<u>3.1 Motivation</u>			
1. Symbolic	1	1	1
2. Money	10	.1	1
3. Extortion	5	.5	3
4. Weapon	3	.1	1
<u>3.2 NMSS Information</u>			
1. High	.5	1	10
2. Low	.5	.5	1
<u>3.3 Technical Information</u>			
1. High	.7	1	3
2. Low	.3	.5	1
<u>3.4 General Resources</u>			
1. High	.7	1	10
2. Low	.3	1	1

Figure 7.1 MARGINAL RELATIVE LIKELIHOODS (RESPONSES OF THREE EXPERTS TO QUESTIONNAIRE)

Question		Given Additional Information								
		High			High			High		
4.0 Motivation		NMSS Information			Technical Information			General Resources		
		A	B	C	A	B	C	A	B	C
1. Symbolic		1	1	G	1	1	G	1	1	L
2. Money		10	1	L	10	1	L	10	1	G
3. Extortion		5	1	L	5	1	L	5	1	G
4. Weapon		2	1	L	2	1	G	2	1	L
5.0 NMS System Information		Money			Weapon			High Technical		
		Motivation			Motivation			Information		
		A	B	C	A	B	C	A	B	C
1. High		10	.5	L	2	1	G	1	1	G
2. Low		6	.05	G	3	.05	L	5	1	L
6.0 Technical Information		Money			Weapon			High NMSS		
		Motivation			Motivation			Information		
		A	B	C	A	B	C	A	B	C
1. High		10	.5	L	2	1	G	1	1	G
2. Low		6	.3	G	3	.5	L	0	1	L
7.0 General Resources		Money			Weapon			High NMSS		
		Motivation			Motivation			Information		
		A	B	C	A	B	C	A	B	C
1. High		5	1	E	2	2	G	4	1	G
2. Low		1	.1	E	0	.1	I	0	1	L

Figure 7.2 CONDITIONAL RELATIVE LIKELIHOODS (RESPONSES OF THREE EXPERTS - A, B, AND C - TO QUESTIONNAIRE)

For experts A and B, this infeasibility exists even when their judgments about the conditional likelihoods of Questions 4.0, 5.0, and 6.0 were ignored. For expert C, however, when the conditional likelihoods of Questions 5.0, 6.0, and 7.0 were not considered, but those of Question 4.0 were considered, archetype probability bounds resulted as shown in Figure 7.3. Also shown in this figure are the bounds resulting from the consideration of experts A and B's judgments about marginal likelihoods only (e.g., the responses to Questions 3.1, 3.2, 3.3, and 3.4).

These results lead us to some preliminary conclusions about the elicitation process:

- a. It appears to be extremely difficult to avoid a combination of likelihood judgments that lead to an inconsistent set of probabilities. For this reason, responses to Questions 4.0, 5.0, 6.0, and 7.0 should be used only if the expert is completely confident in his interpretation and his responses.
- b. Even though experts A and B have extremely different judgments concerning the relative likelihood of symbolic to money motivation, the resulting differences in upper bounds on the archetype probabilities are not as severe.
- c. Further development of the questionnaire should concentrate on finding ways to elicit conditional likelihoods (and/or comparison of likelihoods) in such a way as to avoid infeasibilities while still incorporating meaningful expert judgment. One possible cause of infeasibilities is that the experts may be informally excluding certain combinations of attribute values in their heads when they answer the questionnaire. Since there

Archetype Number	Using Judgments of Experts					
	A*		B*		C**	
	Max.	Min.	Max.	Min.	Max.	Min.
1	.0526	0	.3333	0	.01515	0
2	.0526	0	.3333	0	.01515	0
3A	.0526	0	.3333	0	.04167	0
3B	.0526	0	.3333	0	.04167	0
4	.0526	0	.4608	0	.1667	.10987
5A	.3	0	.0588	0	.01515	0
5B	.5	0	.0588	0	.04545	0
6A	.3	0	.0588	0	.01515	0
6B	.3	0	.0588	0	.125	.02652
7	.2526	0	.0588	0	.10987	0
8	.2526	0	.0588	0	.01515	0
9	.1579	0	.0589	0	.0303	0
10	.1579	0	.0589	0	.0303	0
11	.1579	0	.0589	0	.1666	.06056
12	.1579	0	.0589	0	.07575	0
13	.2632	0	.2941	0	.07575	0
14	.2632	0	.2941	0	.04545	0
15	.2632	0	.2941	0	.20833	.12500
16	.2632	0	.2941	0	.32955	.21593

* Using responses to questions 3.1, 3.2, 3.3, 3.4 only

**Using responses to questions 3.1, 3.2, 3.3, 3.4, and 4.0

Figure 7.3 BOUNDS ON ARCHETYPE PROBABILITIES

are formal exclusion rules built into the algorithm that calculates bounds on archetype probabilities, it may be that the exclusions are being double-counted.

For comparison, the directly assessed archetype probabilities (i.e., the answers to Question 8.0) are presented in Figure 7.4.

Archetype	Expert		
	A	B	C
1	.026	.028	.023
2	.026	.028	.006
3a	.052	.285	.023
3b	.042	.057	.023
4	.016	.142	.188
5a	.052	.0003	.023
5b	.104	.003	.094
6a	.052	.057	.047
6b	.042	.114	.023
7	.104	.028	.117
8	.208	.057	.070
9	.078	.011	.070
10	.026	.003	.005
11	.026	.003	.001
12	.026	.006	.003
13	.026	.014	.141
14	.016	.014	.023
15	.052	.142	.047
16	.026	.006	.070

Figure 7.4 DIRECTLY ASSESSED ARCHETYPE PROBABILITIES
(From Responses to Question 8.0 of
Questionnaire)

CONCLUDING COMMENTS

The methodology described in this report was applied to the elicitation and analysis of judgmental information from three experts. The questioning procedure was meaningful to the experts, and the computer programs were able to analyze the information from the experts. The results were either bounds on the archetype probabilities or indications of inconsistent responses.

Further development of the methodology would require that the adversary attributes, exclusion rules, and archetypes be refined. The current attributes, rules, and archetypes have proven to be meaningful for preliminary analysis; however, various individuals who have reviewed them have raised objections to some details, and have suggested some changes. This discussion should be widened to include experts at the Nuclear Regulatory Commission and elsewhere so that a wider range of expertise can be utilized in arriving at a final set of attributes, exclusion rules, and archetypes.

REFERENCES

Additional references relating specifically to the analysis of activities potentially analogous to Nuclear Material Safeguards Systems are included in Section 3.2.

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APPENDICES

APPENDIX A1

BRIEFING DOCUMENT

Briefing Document for
Questionnaire on Adversary Characteristics
Nuclear Material Safeguards Systems

September 1978

1.0 INTRODUCTION

Nuclear material is currently stored, used, reprocessed and transported between a relatively small number of sites, and an extremely limited number of attempts to divert material have been discovered and studied. Thus there is almost no directly relevant historical data on which to base statements about potential adversaries of Nuclear Material Safeguards (NMS) Systems.

However, situations that are analogous in some ways to nuclear material safeguarding are common and are discussed below. It should be recognized that the available data on crimes against business are limited. Furthermore, while the situations examined have characteristics analogous to a Nuclear Material Safeguards System, they also have important differences.

2.0 POTENTIALLY ANALOGOUS SITUATIONS

Protection of bank assets. This is similar to nuclear materials safeguarding in several ways: the assets are protected by both physical and accounting safeguards; they are usually kept in a relatively large facility; government regulations cover the safeguards. However, there are differences between the NMS System and bank situations. Physical removal of material is not necessary in a bank, and nuclear material presents unique handling and storage problems for a diverter. Also, the general public is more familiar with the operations of a bank than with those of a nuclear facility.

Air and motor cargo freight. This often involves high value assets with special handling and storage problems.

Pharmaceutical manufacturing. This involves high-value material.

Kidnapping. Both people and high value assets have been stolen in attempts to obtain money or nonfinancial ends (such as release of political prisoners). In virtually all cases the security systems are either nonexistent or less effective than those in a NMS System.

Terrorism. Since our concern in this study is with theft of special nuclear material, we are not directly interested in terrorist sabotage actions against an NMS System. However, terrorists might attempt a theft in order to obtain nuclear material for use in other terrorist activities.

3.0 INTERNAL VERSUS EXTERNAL THREATS

In 1976 the Stanford Research Institute (SRI) compiled loss statistics from the banking, air freight and motor freight industries on internal versus external crimes (see Figure 1a.) For banking, internal crime was defined as employee theft, embezzlement and fraud, while external crimes were robbery, burglary, larceny and extortion. For air and motor freight, internal losses were items reported as "shortages", while external losses were from hijacking, robbery, theft and pilferage. As Figure 1a shows, losses from insiders exceed those from outsiders by a substantial margin in all three categories.

Other data sources support the contention that internal crime losses exceed those due to outsiders. For example, a 1977 American Bankers Association survey (see Figure 1b) showed that unrecovered losses due to employee dishonesty and mysterious disappearances exceed those due to robbery and burglary by a factor of almost two.

(a) SRI Study

Category	Internal Loss	External Loss	Ratio of Internal to External Losses
Banking (FY 1974-75)	\$368,391,000	\$73,949,000	4.98
Air Freight (FY 1973-74)	9,354,000	2,441,000	3.83
Motor Freight	132,974,000	17,721,000	7.50

Source: B. Parker, "Business: Victims of Crime," Security Management, March, 1977, p. 29.

(b) American Bankers Association Survey

Category	Losses per Bank during 1976 (thousands of \$)	
Employee Dishonesty	29.96	} 60.65
Mysterious Disappearance	30.69	
Burglary	7.15	} 31.68
Robbery	24.53	

Source: American Bankers Association, Confidential Bank Insurance Survey, 1977, Figure 13.

Figure 1. INTERNAL VS. EXTERNAL LOSSES

A 1977 Commerce Department review of crimes against business [1] using F.B.I. statistics showed that external bank losses (robbery, burglary, and larceny) were \$27.3 million per year, while fraud and embezzlement losses (after subtracting \$50 million [2] due to check fraud, i.e., writing bad checks, which has no direct nuclear analogy) totaled \$156.3 million.

That study also notes that "85 percent of thefts and pilferage are traceable to persons authorized to handle freight." Similarly, it comments that for air cargo theft "76 percent of all [theft and pilferage] losses were [due to]...persons authorized to be on the premises...Armed robbery and hijackings were rare, comprising only one percent of thefts."

The Commerce Department estimates that 75 to 80 percent of inventory shortages in retail establishments are caused by employee theft [3] and that "the majority of inventory losses [in hospitals] are caused by employee theft [1]."

A Burns Security Institute survey of pharmaceutical manufacturers showed that nine manufacturers out of a total of 96 respondents listed employee theft as a major problem, while only one listed external theft as a major problem [4]. However, in a similar survey of electric utilities, the two-thirds of the 367 respondents who commented listed external theft as more prevalent than internal by a four-to-one margin [5].

4.0 COMPUTER CRIME

An SRI study reports that the average loss from a computer-aided embezzlement is \$450,000, compared with \$19,000 for the average "manual" embezzlement [6]. Commerce Department figures differ, however, showing

the average loss from a manual embezzlement to be \$100,000 and estimating the average computer embezzlement to be ten times this amount [1].

Estimates by several sources indicate that between 80 and 90 percent of computer crime is never detected. Furthermore, the Commerce Department estimates that for every five computer crimes detected, only one is reported [1].

5.0 FACILITY SIZE VERSUS TYPE OF THEFT

An American Bankers Association survey of bank losses [7] showed that employee dishonesty costs three times as much money as robberies for banks with more than \$1 billion in assets. However, banks with less than \$25 million in assets lost twice as much to robbery as to employee dishonesty.

Total losses per dollar deposited also appear to be related to bank size, with larger banks having considerably lower ratios of loss-to-deposit than small banks.

6.0 TERRORIST OR MILITARY-RELATED THEFT

The discussion above focuses primarily on activities where monetary gain is the principal objective. There are numerous reasons other than money for theft of nuclear materials. An important class of these might involve the same motivations that lead to terrorist activities of the type increasingly carried out around the world during the past two decades. Although data on these activities has not been included here, they should be kept in mind while answering the questionnaire. [This section was added to the briefing document after the elicitations reported in Section 7.0.

Another Lawrence Livermore Laboratory subcontractor is currently studying these types of activities. When his work is completed, this section should be expanded.]

7.0 CONCLUDING COMMENTS

There are substantial differences between nuclear material safeguards systems and those designed to protect the various other industries discussed above. However, there are also significant similarities. Hopefully, the material presented above has pointed out these similarities in a manner that will be useful to you as you answer the accompanying questionnaire.

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3. U.S. Department of Commerce, The Costs of Crime Against Business, January, 1976.
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5. Burns Security Institute, National Survey on Electric Utilities Security.
6. U.S. Department of Commerce, "Crimes Against Business," Conference Proceedings, February 3, 1976.
7. American Bankers Association, Confidential Bank Insurance Survey, 1977.

APPENDIX A2
QUESTIONNAIRE

Questionnaire on Adversary Characteristics

Nuclear Material Safeguards Systems

September 1978

1.0 INTRODUCTION

This questionnaire will elicit your judgments about potential adversaries of Nuclear Material Safeguards (NMS) Systems. When answering the questionnaire, you are to consider any attempts to divert special nuclear material from the nuclear fuel cycle within the United States. Special nuclear material includes all materials from which an explosive nuclear weapon could be constructed.

Possible motivations for theft of special nuclear material include (i) construction of a weapon, (ii) extortion for such purposes as political gain or prisoner release, (iii) monetary gain through sale of the material or ransom for its return, and (iv) symbolic reasons, such as publicity for a cause or personal revenge.

The eight attributes shown in Figure 1 have been defined to assist in describing NMS System adversaries. Four possible levels have been defined for the "motivation" attribute and two possible levels for each of the other attributes. The definitions of these are given in Figure 2. Using this structure, any particular adversary can be described by specifying levels for each of the eight attributes. Thus, for example, one possible adversary would have symbolic motivation, high NMS System technical and consequence information, high processing capability and general resources, and a risk-seeking attitude toward both himself and others. The questions you will consider below refer to these attribute levels, so you should make certain you understand these definitions.

The briefing document which accompanies this questionnaire contains a summary of research on theft situations that are analogous in some ways to the theft of nuclear material from a Nuclear Material Safeguards System.

2.0 GENERAL QUESTIONNAIRE INSTRUCTIONS

When answering the questions below, the following context should be assumed: An attempt to divert material has taken place, but its success or failure is not known. That is, you are asked to answer the questions for the potential adversaries who would actually attempt a theft. Putting this another way, we wish to obtain your judgments about the relative likelihoods of various adversary characteristics, but we do not want your judgment of the absolute likelihood that an attempt at theft will be made.

Note also that there are no correct or incorrect answers to the questions. Since the history of attempts to steal nuclear material is very limited, we have no meaningful statistics on adversary characteristics. This questionnaire provides a uniform procedure for eliciting information from experts on adversary behavior. The results will be analyzed by computer to determine the extent of agreement or disagreement among various experts.

3.0 QUESTIONS ABOUT INDIVIDUAL ATTRIBUTES

In this section you are asked to give your best judgment of the relative likelihoods that an adversary who attempts a theft will have various levels of the individual attributes. When answering a question for a particular attribute, you should make no assumptions about the levels of the other attributes. As an example, in Question 3.1 you may feel that "weapon" is the least likely motivation, "extortion" is twice as likely as weapon, and that "symbolic" and "money" are equally likely and each is six times as likely as weapon. In this case, you would answer Question 3.1 as follows:

1. Symbolic 6
2. Money 6
3. Extortion 2
4. Weapon 1

As a check on your answers, you should verify that the various responses are consistent with each other. For example, the answers given above imply that money is three times as likely a motivation as extortion.

3.1 Motivation: What are the relative likelihoods that an actual adversary will have each of the following motivations?

1. Symbolic ____
2. Money ____
3. Extortion ____
4. Weapon ____

3.2 NMS System Information: What are the relative likelihoods that an actual adversary will have the following information about the Nuclear Material Safeguards System:

1. High ____
2. Low ____

3.3 Technical Information: What are the relative likelihoods that an actual adversary will have the following levels of technical information?

1. High ____
2. Low ____

3.4 General Resources: What are the relative likelihoods that an actual adversary will have the following levels of general resources?

1. High _____
2. Low _____

4.0 QUESTIONS ABOUT MOTIVATION WITH ADDITIONAL INFORMATION KNOWN

The earlier question about the "Motivation" attribute (Question 3.1) asked you to give relative likelihoods without making any assumptions about the levels of the other attributes. In the question below, you will answer the same question, except now you are to assume some information is known about the levels of the other attributes. In particular, please give your relative likelihoods for the different levels of Motivation for each of the three cases (labeled a, b, and c) shown in the chart below. If you cannot provide numerical answers, please indicate whether the chances of a particular level are greater than (G), less than (L) or equal to (E), the corresponding chances in Question 3.1.

As an example, in column "a" you are to assume the adversary has "high" NMS System information. If you believe an adversary with high NMS System information is least likely to have money as a motivation, equally likely to have any of the other three motivations, and that each of these motivations is three times as likely as the money motivation, then you would fill in column "a" as follows:

Symbolic	<u>3</u>
Money	<u>1</u>
Extortion	<u>3</u>
Weapon	<u>3</u>

If you are unable to decide on relative likelihoods given this additional information but believe the chances the adversary's motivation is money are lessened by knowing he has high NMS System information from what they were without this information, while the chances of each of the other three motivations is increased, then you would fill in column "a" as follows:

Symbolic G
 Money L
 Extortion G
 Weapon G

Note that the answers in each of the three columns are separate, that is, in each column you are asked to assume different information is known.

Levels of Motivation	Given the Additional Information that:		
	The Level of NMSS System In- formation is High (a)	The Level of Technical Information is High (b)	The Level of General Resources is High (c)
Symbolic			
Money			
Extortion			
Weapon			

5.0 QUESTIONS ABOUT NMS SYSTEM INFORMATION WITH ADDITIONAL
INFORMATION KNOWN

This question is similar to 4.0 except that the "NMS System Information" attribute (considered in Question 3.2 above) is considered with additional information provided about the other attributes. Please answer in a manner analogous to Question 4.0.

Levels of NMS Information	Additional Information			
	Motivation		High Technical Information	High General Resources
	Money	Weapon		
	(a)	(b)	(c)	(d)
High				
Low				

6.0 QUESTIONS ABOUT TECHNICAL INFORMATION WITH ADDITIONAL INFORMATION KNOWN

Answer in a Manner Analogous to Questions 4.0 and 5.0

Levels of Technical Information	Additional Information			
	Motivation		High NMSS Information	High General Resources
	Money	Weapon		
	(a)	(b)	(c)	(d)
High				
Low				

7.0 QUESTIONS ABOUT GENERAL RESOURCES WITH ADDITIONAL INFORMATION KNOWN

Answer in a manner analogous to Questions 4.0, 5.0 and 6.0

Levels of General Resources	Additional Information		
	Motivation		High NMS System Information
	Money (a)	Weapon (b)	
High			Technical Information (d)
Low			

8.0 QUESTIONS ABOUT NMS SYSTEM ADVERSARY ARCHETYPES

This section considers composite adversaries rather than concentrating on various attributes of the adversaries as the previous sections did. In particular, nineteen archetypical adversaries are defined in Figure 3. These archetypes should be thought of as collectively exhaustive and mutually exclusive. That is, any adversary for an NMS System will be described by exactly one of these archetypes.

Please enter the relative likelihoods that an actual adversary will be described by each of the archetypes below. As you do this, consider the various factors which affect the likelihood that a theft would be instigated by each of the archetypes: their willingness to commit a theft, the strength of the motive for stealing special nuclear material, the relative value of accomplishing their goals through theft of special nuclear material as opposed to some other means, their perceived likelihood of a successful theft, and so forth.

Because of the large number of categories, it is particularly important that you check your answers for consistency in the manner discussed in Section 3.0.

1. Uninformed Outsider _____
2. Principled Outsider _____
- 3a. Disgruntled Employee _____
- 3b. Disgruntled Employees _____
4. Principled Executive _____
- 5a. Competent Outsider _____
- 5b. Competent Outsider Group _____
- 6a. Opportunistic Employee _____
- 6b. Opportunistic Employees _____
7. High-Level Embezzling Group _____
8. Embezzling Executive _____
9. Terrorist Group of Foreign National Group _____
10. Terrorist Individual _____
11. Insider Terrorist Group _____
12. Insider Terrorist Individual _____
13. Outsider Extortionist Group _____
14. Outside Expert _____
15. Extorting Employee _____
16. Extorting Executive _____

Attribute	Area of Concern
1. Motivation	Reason a theft is attempted
2. NMS System Information	Level of knowledge about the operation of Nuclear Material Safeguards Systems
3. Technical Information	Level of knowledge about nuclear materials, their handling, and their processing
4. Consequence Information	Level of knowledge about possible legal, financial, social, and health consequences of a theft attempt
5. Processing Capability	Equipment and expertise available to process stolen nuclear material
6. General Resources	Resources, such as equipment and number of personnel, available to aid in theft attempt
7. Self-Risk Attitude	Willingness of adversary to risk his own life and welfare
8. Other's-Risk Attitude	Willingness of adversary to risk lives and welfare of those not in the adversary group

Figure 1 ADVERSARY ATTRIBUTES

Attribute	Levels
1. Motivation	<ol style="list-style-type: none"> 1. <u>Symbolic</u>: For example, game playing, prank, crazy, personal revenge, for principle, publicity for a cause, cover-up of material unaccounted for 2. <u>Money</u>: To make money by sale of the material or ransom for its safe return 3. <u>Extortion</u>: Theft for nonmonetary gain (e.g., political gain, job restitution, prisoner release) 4. <u>Weapon</u>: Theft to make a weapon for eventual use (e.g., explosive device or radiation dispersal weapon)
2. NMS System Information	<ol style="list-style-type: none"> 1. <u>High</u>: Considerable knowledge of and control over at least one aspect of the Nuclear Material Safeguards System 2. <u>Low</u>: Has only the knowledge available to someone outside the NMS System
3. Technical Information	<ol style="list-style-type: none"> 1. <u>High</u>: Has significant knowledge about nuclear science, computer technology, electronics and related areas 2. <u>Low</u>: Does not have significant knowledge about these areas
4. Consequence Information	<ol style="list-style-type: none"> 1. <u>High</u>: Full understanding of the possible legal, financial, social and health consequences of the theft attempt 2. <u>Low</u>: Incomplete understanding of the possible consequences
5. Processing Capability	<ol style="list-style-type: none"> 1. <u>High</u>: Has the equipment and expertise to process stolen material, either to make a weapon or to enrich or alter it for easier storage or sale 2. <u>Low</u>: Does not have such capabilities

Figure 2 DEFINITIONS OF ATTRIBUTE LEVELS

Attribute	Levels
6. General Resources	<ol style="list-style-type: none"> 1. <u>High</u>: A group of people with some experience in theft and criminal activity 2. <u>Low</u>: One or two people inexperienced in theft and criminal activity
7. Self-Risk Attitude	<ol style="list-style-type: none"> 1. <u>Seeking</u>: Adversary will take chances which threaten his own life or welfare 2. <u>Avoiding</u>: Adversary will not accept significant probability of loss of life or capture
8. Other's-Risk Attitude	<ol style="list-style-type: none"> 1. <u>Seeking</u>: Adversary is willing to risk lives and welfare of those not in adversary group 2. <u>Avoiding</u>: Adversary unwilling to do this

Figure 2 (concluded)

Archetype Names	Characteristics
1. Uninformed Outsider	Theft for symbolic reasons, prankster, crazy, for principle, but not planned; very little Nuclear Material Safeguards System (NMSS) knowledge; technically unsophisticated
2. Principled Outsider	Theft for symbolic reasons (e.g., game-playing, for principle); little or no NMSS knowledge, technically sophisticated; could have considerable diversion resources, but no inside contacts
3a. Disgruntled Employee	Symbolic theft (e.g., labor unrest, revenge on the system, Material-Unaccounted-For coverup); NMS System low-level insider, such as guard, minor technician, maintenance worker, etc.; little technical knowledge
3b. Disgruntled Employees	
4. Principled Executive	Symbolic theft (e.g., for principle, revenge, coverup of present or future MUF); high level NMSS position and contacts (executive administrator, etc.); likely to understand consequences of theft; high technical knowledge, possibly a group
5a. Competent Outsider	Theft for monetary gain (e.g., future sale); little or no NMSS information; technically sophisticated; has diversion resources
5b. Competent Outsider Group	
6a. Opportunistic Employee	Crime of opportunity, for money; knows one area of NMSS (e.g., guard, loading dock worker, etc.); little technical sophistication
6b. Opportunistic Employees	
7. High-Level Embezzling Group	Possibly long-term diversion for profit; well-informed insiders; technically sophisticated; have NMSS contacts, control and equipment available

Figure 3 NMS SYSTEM ADVERSARY ARCHETYPES

Archetype Names	Characteristics
8. Embezzling Executive	Crime of opportunity, possibly long-term diversion; well-informed insider; technically sophisticated
9. Terrorist Group or Foreign National Group	Theft to build weapon; little or no NMS System information; high technical and processing capability; sophisticated arms and adequate manpower (likely to mount a direct frontal attack)
10. Terrorist Individual	Theft to build weapon; little or no NMS System information; technically sophisticated and capable of processing material; few theft resources (likely to attack fringe of system, such as material being transported)
11. Insider Terrorist Group	Theft to build weapon; well-informed insiders; technically sophisticated with processing capability; have NMS System contacts, control and equipment available (may be large group with theft equipment)
12. Insider Terrorist Individual	Theft to build weapon; well-informed insider; technically sophisticated with processing capability; little NMS System control and few contacts (small group or individual)
13. Outsider Extortionist Group	Theft for extortion; see (5b.) for other characteristics
14. Outside Expert	Theft for extortion; see (5a.) for other characteristics
15. Extorting Employee	Theft for extortion; see (6a.), (6b.) for other characteristics
16. Extorting Executive	Theft for extortion; see (8.) for other characteristics

Figure 3 (concluded)

APPENDIX A3
PROGRAM USER'S GUIDE

The interactive computer program, discussed in Section 5.2, takes judgmental probability information about adversary attributes and produces bounds on the probabilities of the various archetypes. The program is conversational and prompts the user for necessary information. Examples of two different program runs are included in Tables A3.1 and A3.2 and discussed below.

A3.1 Normal Program Run

The program run in Table A3.1 is fairly self-explanatory. The notes below expand on items that may be unclear. The notes are keyed to the table, with the number of the relevant note appearing in a circle in the left margin of the table.

1. During the sign-on process, a message is printed describing how to use the program.
2. With ECHO = OFF certain information describing the operations of the system is suppressed. This information would be distracting during the operation of the archetype probability bounding program.

3. This starts the preprocessor program that sets up data for the linear programming solution procedure. If incorrect data is entered at some point during the operation of the program, it is safest to start over again by hitting the attention key, and entering this command again.
4. The required format for data entry must be carefully followed.
5. At this point the user has the four options listed with regard to whether he wishes to use the standard archetypes (defined in Figure 4.3) and/or standard exclusion rules (defined in Figure 4.2) or whether he wishes to use a new archetype he has just defined.
6. At this point (after possibly a 1-2 minute wait) some temporary files set up by the preprocessor have been sorted for use by the linear programming package.
7. Before this line is printed, there may be a delay of 3 to 5 minutes while the linear programming solution package carries out its work.
8. At this point the IBM linear programming package MPS has completed multiple runs to find the upper bounds on each of the archetype probabilities using the procedure discussed in Section 5.1. Due to the peculiar way MPS prepares output, an extremely large file is generally created, containing much information in addition to the bounds we seek. This file is now scanned for the information needed. It is also possible that the input data is internally inconsistent. This case is discussed in Section A3.2.

9. This command scans the large output file to obtain the data desired. The numbers to the left of FUNCTIONAL should be disregarded. The output "." is shorthand for zero (0). Due to the large size of the output files, there may be a delay of 1 to 2 minutes until the entire list of upper bounds is produced. An additional delay of 1 to 2 minutes is possible before the printing of the lower bounds.
10. Faulty data entry may result in meaningless output. In this case the command suggested will reveal the difficulty.
11. The run has been completed and a new run may be started.

A3.2 Run With Inconsistent Input

The run shown in Table A3.2 illustrates what happens if the input data is internally inconsistent. The notes below are keyed to the table, with the number of the relevant note appearing in a circle in the left margin of the table.

11. The data just input is internally inconsistent. This means there is no feasible solution to the archetype bounding problem. Entering SOURCE INFEAS produces the output on the next few lines. The eight-digit labels toward the left of the page identify input probabilities using the code defined in Figure 5.1.
12. In this example the probability input for (3,1,2,1,1,1,0,0) appears to have contributed to the infeasibility.

I3. At this point the output was stopped by hitting the interrupt key, because it had progressed beyond the line where the cause of infeasibility was identified.

Table A3.1 NORMAL PROGRAM RUN

```

① #SIG K7CF
#ENTER USER PASSWORD.
?
#TERM,NORMAL,UNIV
***LAST SIGNON WAS: 20:58:32 MON SEP 25/78
# USER "K7CF" SIGNED ON AT 20:52:02 ON TUE SEP 25/78
>***** TO RUN THE MCC ADVERSARIES PROGRAM, ENTER:
>***** SOURCE SETUP
② >*****NOTE TO MTS USER: ECHO IS NOW SET OFF. REMEMBER TO SET ECHO-ON.
③ #SOURCE SETUP

④ ENTER MARGINAL AND JOINT PROBABILITIES:EVENT(BI1),E OR L OR G, BLANK,F12.6
EXAMPLE:130200000E .3 MEANS PROB(VAR1=3,VAR3=2) = .3
ENTER 9 IF NO MORE
?
100000000E .7
?
400000000G .15
?
010000000L .6
?
000100000G .55
?
000000111L .2
?
9
④ ENTER COMPARED MARGINAL OR JOINT EVENTS
EXAMPLE:10012000620012000 MEANS PROB(VAR1=1,VAR4=1,VAR5=2) IS GR. THAN PROB(VAR1=2,VAR4=1,VAR5=2)
ENTER 9 FOR NO MORE
?
20000000630000000
?
9
ENTER CONDITIONAL PROBABILITIES
④ EXAMPLE: P1=3G4=2E .J7 MEANS PROB(VAR1=3 GIVEN VAR4=2)=.37
ENTER 99 FOR NO MORE
?
P5=1G1=3G .5
?
99
TO ADD A NEW ARCHETYPE, ENTER 1, ELSE ENTER 0
1
④ ENTER ARCHETYPE NAME (FORMAT 8A--8 CHARACTERS )FOR WHICH YOU WISH PROBABILITY LOGNO,
NUMBER OF TYPES(12) AND -- ONE TO A LINE --THE TYPES(18)
EXAMPLE:
NEWARTYP 03
11221112
12211222
22211121
?
1ESTIYPE 02
?
11111111
?
22222222

```

Table A3.1 (continued)

```

TEMPORARY FILES HAVE BEEN CREATED WITH INFORMATION ON 5 NEW PROBABILITY CONSTRAINTS
                                                         1 CONDITIONAL PROBABILITIES
                                                         1 COMPARED EVENTS
                                                         1 NEW ARCHETYPES

>.....
>***** NOW ENTER:
>*****
>***** SOURCE FILENAME
>*****
>***** WHERE 'FILENAME' DEPENDS ON WHETHER YOU WISH TO USE THE
>***** STANDARD EXCLUSION RULES AND/OR THE 19 STANDARD ARCHETYPES--
>*****
>***** FILENAME STANDARD STANDARD
>***** ARCHETYPE EXRULES
>*****
>***** DATA1 NO NO
>***** DATA2 NO YES
>***** DATA3 YES NO
>***** DATA4 YES YES
⑤ $SOURCE DATA4
   SORT=CH,A7S,B INPUT=-IN OUTPUT=-SORTED
⑥ Statistics: 2576/ 2
⑦ >.....
⑧ >***** THE OUTPUT OF THE LINEAR PROGRAMMING PACKAGE MPS IS NOW IN FILE -LPMOUT
>***** THE MTS EDIT WILL NOW SCAN THIS FILE FOR INFEASIBLE CONDITIONS
>*****
>***** THE RESULTING OUTPUT WILL BE EITHER:
>***** SEARCH FAILED.....A)
>*****
>***** OR
>*****
>***** SOLUTION (INFEASIBLE).....B)
>*****
>***** IF A), ENTER:
>***** SOURCE SCAN2
>*****
>***** IF B), ENTER:
>***** SOURCE INFEAS
>***** SEARCH FAILED
⑨ $SOURCE SCAN2

```

Table A3.1 (continued)

			MAX FRUP.	ARCHETYPE	
:	132	0	FUNCTIONAL	.70000	ARTYPE1
:	721	0	FUNCTIONAL	.70000	ARTYPE2
:	1323	0	FUNCTIONAL	.60000	ARTYPE3A
:	1912	0	FUNCTIONAL	.60000	ARTYPE3B
:	3501	0	FUNCTIONAL	.60000	ARTYPE4
:	3089	0	FUNCTIONAL	.15000	ARTYPE5A
:	3676	0	FUNCTIONAL	.15000	ARTYPE5B
:	4263	0	FUNCTIONAL	.15000	ARTYPE6A
:	4850	0	FUNCTIONAL	.15000	ARTYPE6B
:	5437	0	FUNCTIONAL	.15000	ARTYPE7
:	6024	0	FUNCTIONAL	.15000	ARTYPE8
:	6611	0	FUNCTIONAL	.30000	ARTYPE9
:	7198	0	FUNCTIONAL	.30000	ARTYPE10
:	7785	0	FUNCTIONAL	.30000	ARTYPE11
:	8372	0	FUNCTIONAL	.30000	ARTYPE12
:	8966	0	FUNCTIONAL	.07500	ARTYPE13
:	9553	0	FUNCTIONAL	.07500	ARTYPE14
:	10141	0	FUNCTIONAL	.03750	ARTYPE15
:	10730	0	FUNCTIONAL	.07500	ARTYPE16

>				MIN FRQB.	ARCHETYPE
>					
:	129	0	FUNCTIONAL	.	ARTYPE1
:	717	0	FUNCTIONAL	.	ARTYPE2
:	1301	0	FUNCTIONAL	.	ARTYPE3A
:	1885	0	FUNCTIONAL	.	ARTYPE3B
:	2472	0	FUNCTIONAL	.	ARTYPE4
:	3056	0	FUNCTIONAL	.	ARTYPE5A
:	3640	0	FUNCTIONAL	.	ARTYPE5B
:	4224	0	FUNCTIONAL	.	ARTYPE6A
:	4808	0	FUNCTIONAL	.	ARTYPE6B
:	5392	0	FUNCTIONAL	.	ARTYPE7
:	5976	0	FUNCTIONAL	.	ARTYPE8
:	6560	0	FUNCTIONAL	.	ARTYPE9
:	7144	0	FUNCTIONAL	.	ARTYPE10
:	7728	0	FUNCTIONAL	.	ARTYPE11
:	8312	0	FUNCTIONAL	.	ARTYPE12
:	8896	0	FUNCTIONAL	.	ARTYPE13
:	9480	0	FUNCTIONAL	.	ARTYPE14
:	10064	0	FUNCTIONAL	.	ARTYPE15
:	10648	0	FUNCTIONAL	.	ARTYPE16

- *****
 IF 'SEARCH FAILED' COLUMN RANGE IS LISTED, THEN THERE IS PROBABLY A DATA ENTRY ERROR.
 ENTER:
 LIST -LPDUT(50,100)

 TO TRY TO DIAGNOSE THE PROBLEM
 TO RUN THE MCC ADVISORY/TEST PROGRAM, ENTER:
 SOURCE SETUP
 *****NOTE TO MTS USER: ECHO IS NOW SET OFF. REFER BACK TO SET UP FOR

Table A3.2 RUN WITH INCONSISTENT INPUT

ISOURCE SETUP

ENTER MARGINAL AND JOINT PROBABILITIES EVENT 31121 OR 1 OR 0 = BLANK FIELD

EXAMPLE: 1302000001 .5 MEANS PROB(0001-3) = .5

ENTER 9 IF NO MORE

31211001 .5

211220001 .5

ENTER COMPARED MARGINAL OR JOINT EVENTS

EXAMPLE: 10012000020012000 MEANS PROB(0001-1) = .0001200020002000 OR THAT PROB(0001-1) = .000120002000

ENTER 9 FOR NO MORE

100000000200000000

ENTER CONDITIONAL PROBABILITIES

EXAMPLE: 11-304-21 .5 MEANS PROB(0001-3 GIVEN 0001-1) = .5

ENTER 99 FOR NO MORE

TO ADD A NEW ARCHETYPE, ENTER 1, ELSE ENTER 0

ENTER ARCHETYPE NAME (FORMAT 80-13 CHARACTERS) FOR WHICH YOU WISH PROBABILITIES COMPUTED

NUMBER OF LINE(S) TO ADD -- ONE TO A LINE -- END -- 11111111

EXAMPLE:

ARCHETYPE 03

11221112

12211222

22211121

11211111 02

11111111

22212221

Table A3.2 (continued)

```

TEMPORARY FILES HAVE BEEN CREATED WITH INFORMATION ON
2 NEW PROBABILITY CONSTRAINTS
0 CONDITIONAL PRIORITIES
1 COMPARED EVENTS
1 NEW ARCHETYPES

*****
***** NOW ENTER:
*****
***** SOURCE FILENAME
*****
***** WHERE 'FILENAME' DEPENDS ON WHETHER YOU WISH TO USE THE
***** STANDARD EXCLUSION RULES AND/OR THE 10 STANDARD ARCHETYPES
*****
***** FILENAME  STANDARD  STANDARD
*****          ARCHETYPE  EXRULES
*****
***** DATA1    NO        NO
***** DATA2    NO        YES
***** DATA3    YES       NO
***** DATA4    YES       YES
*****
***** SOURCE DATA?
*****
***** SORT-CH56.578 (DATA) IN OUTPUT - SORTED
***** Statistics: 12147 1
*****
***** THE OUTPUT OF THE LINEAR PROGRAMMING PACKAGE MPS IS NOW IN FULL FLOW
***** THE MPS EDIT WILL NOW SCAN THIS FILE FOR TREE-STAR CORRELATIONS
*****
***** THE RESULTING OUTPUT WILL BE EITHER:
***** SEARCH FAILED.....)
*****
***** OR
*****
***** SOLUTION (INFEASIBLE).....)
*****
***** IF NO, ENTER:
***** SOURCE SCAR2
*****
***** IF NO, ENTER:
***** SOURCE UTILS
*****
***** 102 SOLUTION (INFEASIBLE)

```


APPENDIX A4

TRANSLATION OF QUESTIONNAIRE RESPONSES
INTO PROGRAM INPUT DATA

This appendix demonstrates the translation of questionnaire responses into coded form suitable for input into the preprocessor computer program.

The procedure is straightforward:

- a. Convert relative likelihoods into probabilities, by dividing each likelihood by the sum over all levels;
- b. Identify the appropriate code for the marginal or conditional probability involved.

For example, consider expert A's responses to Question 3.1 (see Figure 7.2).

<u>Motivation</u>	<u>Relative Likelihood</u>
1. Symbolic	1
2. Money	10
3. Extortion	5
4. Weapon	3

Since the sum of the relative likelihoods is 19, we have

prob (Symbolic) = 1/19 = .0526
 prob (Money) = 10/19 = .5263
 prob (Extortion) = 5/19 = .2633
 prob (Weapon) = 3/19 = .1579

Using the notation of Figure 4.1, this set of judgments becomes:

$P(1,0,0,0,0,0,0) = .0526$
 $P(2,0,0,0,0,0,0) = .5263$
 $P(3,0,0,0,0,0,0) = .2633$
 $P(4,0,0,0,0,0,0) = .1579$

Note that it is only necessary to enter three of the four probabilities, since the fourth is always constrained so that they all sum to 1. For the preprocessing program, the "=" signs are entered as "P".

Similarly, expert A's response to the first part of Question 4.0 would be coded:

$P \{ (1,0,0,0,0,0,0) \text{ given High NMSS information} \} = 1/18 = .0556$
 $P \{ (2,0,0,0,0,0,0) \text{ given High NMSS information} \} = 10/18 = .5556$
 $P \{ (3,0,0,0,0,0,0) \text{ given High NMSS information} \} = 5/18 = .2778$

In terms of the format required by the preprocessing program, this becomes:

$P1=1G2=1E .0556$
 $P1=2G2=1E .5556$
 $P1=3G2=1E .2778$

Finally, for the qualitative conditional judgments of expert C we write, for example, for the first part of Question 4:

$P1=1G2=1G \ .1667$

Figure A4.1 shows the coded translation of the judgments of Figures 7.1 and 7.2.

Question	Code	Judgment of Expert		
		A	B	C
3.1	(1,0,0,0,0,0,0,0)	-.0526	-.5882	-.1667
	(2,0,0,0,0,0,0,0)	-.5263	-.0588	-.1667
	(3,0,0,0,0,0,0,0)	-.2632	-.2941	-.5
3.2	(0,1,0,0,0,0,0,0)	-.5	-.6667	-.9091
3.3	(0,0,1,0,0,0,0,0)	-.7	-.6667	-.75
3.4	(0,0,0,0,0,0,0,0)	-.7	-.5	-.9091
4.0	P1=1G2=1	-.0588	-.25	G .1667
	P1=2G2=1	-.5882	-.25	L .1667
	P1=3G2=1	-.2941	-.25	L .5
	P1=1G3=1	-.0588	-.25	G .1667
	P1=2G3=1	-.5882	-.25	L .1667
	P1=3G3=1	-.2941	-.25	L .5
	P1=1G6=1	-.0588	-.25	L .1667
	P1=2G6=1	-.5882	-.25	G .1667
	P1=3G6=1	-.2941	-.25	G .5
	P2=1G1=2	-.6250	-.9091	L .9091
	P2=1G1=4	-.4	-.0095	G .9091
	P2=1G3=1	-.1667	-.5	G .9091
	P2=1G6=1	-.5	-.5	G .9091
6.0	P3=1G1=2	-.6250	-.625	L .75
	P3=1G1=4	-.4	-.6667	G .75
	P3=1G2=1	1.0	-.5	G .75
	P3=1G6=1	-.5	-.5	G .75
7.0	P5=1G1=2	-.667	-.9091	-.9091
	P6=1G1=4	1.0	-.9524	G .9091
	P6=1G2=1	1.0	-.5	G .9091
	P6=1G3=1	-.5714	-.5	G .9091

Figure A4.1 CODED TRANSLATION OF JUDGMENTS OF FIGURES 7.1, 7.2

APPENDIX A5
PROGRAM DOCUMENTATION

Understanding the operations of the programs that calculate bounds on archetype probabilities requires understanding the IBM Mathematical Programming System program MPS. This is documented in detail in Appendix A6. With an understanding of MPS, the annotated listing of S.SETUP, the preprocessor source program, which is given in Appendix A7, should be relatively easy to follow. The remaining files listed in Appendix A7 are (1) command (SOURCE) files which contain instructions to the Michigan Terminal System to carry out various file manipulations necessary to prepare data for MPS or interpret the output of MPS; (2) permanent data files which contain either instructions for MPS or data on the archetypes or exclusion rules; or (3) temporary data files prepared by the object program O.SETUP for MPS or containing output from MPS. The function of each file is briefly explained below.

A5.1 Command Files

DATA1: Sets up files for MPS if nonstandard archetypes and standard exclusion rules are to be used.

DATA2: Sets up files for MPS if nonstandard archetypes and standard exclusion rules are to be used.

DATA3: Sets up files for MPS if standard archetypes and non-standard exclusion rules are to be used.

DATA4: Sets up files for MPS if standard archetypes and exclusion rules are to be used.

START: Prints message explaining how to use programs.

SETUP: Contains the commands necessary to run the preprocessor program.

RUNLP: Runs MPS and checks output for infeasibility.

SCAN2: Scans output file from MPS to find bounds on archetype probabilities.

INFEAS: Scans output file from MPS to determine cause of infeasibility if input data was inconsistent.

MESSAGE: Contains explanatory messages printed out by several different command files when they are executed.

A5.2 Permanent Files

COMMANDS: Remainder of instruction file and top of input data file for MPS if standard archetypes are to be used.

MAX: Top of instruction file for MPS if upper bounds on archetype probabilities are desired.

MIN: Top of instruction file for MPS if lower bounds on archetype probabilities are desired.

END: End-of-data marker for MPS.

RULEROWS: Names of constraint rows to implement standard exclusion rules.

RULESRHS: Probabilities to implement exclusion rules named in RULEROWS.

EXRULES: Definitions of constraints to implement standard exclusion rules.

TYPEFILE: Definitions of standard archetypes.

TYPROWS: Names of objective function rows to implement archetypes.

S.SETUP: Source program for O.SETUP.

O.SETUP: Object code for preprocessor that sets up data for input to MPS. It creates files -F2, -F3, -F7, -F8, and -F9.

ROWSFILE: Names of a previously stored set of assessed probabilities to be used as input data for MPS.

RHS: Previously stored set of values for the probabilities named in ROWSFILE.

A5.3 Temporary Files

-F2: Corresponds to COMMANDS when nonstandard archetypes are to be used.

-F3: Corresponds to ROWSFILE if a new set of assessed probability data is to be used.

-F8: Corresponds to RHS if a new set of assessed probability data is to be used.

-F9: Corresponds to TYPFILE if nonstandard archetypes are to be used.

-F7: Standard row coefficients for MPS.

-LPOUT: File containing output data from MPS.

-LP: Final input file for MPS.

APPENDIX A6
DOCUMENTATION OF IBM MATHEMATICAL PROGRAMMING SYSTEM

Reprinted from:

W. K. Hall, A. McWhorter, and W. A. Spivey, "Optimization Programs at the University of Michigan," Second Edition, Graduate School of Business Administration, The University of Michigan, Ann Arbor, Michigan.

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III. MATHEMATICAL PROGRAMMING SYSTEM/360

A. DESCRIPTION OF PROGRAM

The IBM Mathematical Programming System/360 consists of three major programs. Although this write-up will provide an introduction to only the first of these programs, a brief description of all three is provided below:*

1. MPS/360. This program contains a set of linear and separable programming algorithms, a control language compiler, and a FORTRAN interface called READCOMM.

The linear programming algorithm and the associated control language compiler are documented in this manual.** This algorithm uses the revised simplex method with the product form of the inverse. (See References 1 and 11 for a discussion of the algorithm.) Additional algorithm features include scaling, multiple pricing, restricted basis entry, and upper bounding. The maximum problem size is 4095 rows with a virtually unlimited number of columns.

The separable programming algorithm allows the user to analyze certain classes of non-linear programming problems where the objective function and constraints can be written as linear combinations of functions of a single variable. This algorithm utilizes piece-wise linear approximation of the non-linear functions to reduce the problem to a linear programming problem with restricted basis entry. Documentation of these features is currently in progress.

READCOMM is a subroutine designed to transfer MPS/360 data, MARVEL/360 data (see Part 3 in this section), and control language parameters to FORTRAN procedures which have been written by the user and incorporated under the control of MPS/360. Reference 6 provides complete documentation on this routine.

2. MPS/360 Report Generator (MPSRG). This program consists of a report language and three procedures that compile and execute the main program; Reference 7 documents these procedures.
3. MARVEL. This program is a language processor for matrix generation, file maintenance, output analysis, and management report writing. MARVEL can access (from an MPS/360 program) the original input data, results, or any auxiliary data required to produce management reports or new input data for a subsequent mathematical programming run. References 8 and 9 document the MARVEL processor.

*The reader is referred to Reference 3, which provides a more detailed overview of the concepts and features of this software system.

**References 4 and 5 provide the IBM documentation on the LP algorithm and control language compiler. The user should consult these to utilize advanced features of these programs.

All of the programs in this software package are written in OS/360 assembly language, and double precision is used in most of the linear programming procedures.

The size of MPS/360 is approximately 32K bytes (K=1024). A minimum system configuration for running MPS/360 is a 64K-byte 360 with standard and decimal instruction sets, floating point, and a 132-position print line (if the system output is a printer). MPS/360 supports the 24000 series magnetic tape units and the 2311, 2314, 2301, 2302, 2303 direct access devices.

Effective March, 1973, MPS/360 will be available in MTS. Users who are familiar with earlier versions of this monograph should realize that it is no longer necessary to run MPS/360 under IBM's operating system (OS/360).

B. GENERAL FORM OF THE INPUT STREAM

The job control cards, source program (written in MPS), and data cards for a problem run in MPS will take the general form outlined below:

```
$$SIGNON  usid
password
$RUN *MPSCG
.
.
MPS Source Program
.
.
One blank card
.
.
Data
.
.
SENDFILE
$$SIGNOFF
```

where "usid" is the user's 4-character computing center ID number and "password" is the user's password. As a note to the experienced MTS user, *MPSCG uses logical units SCARDS and SPRINT for input and output, respectively.

C. INSTRUCTIONS IN MPS

1. Format--The compiler recognizes MPS programs written in either free or fixed format. The rules for fixed format are:

Columns	Contents
1-8	Label (optional)--contains 1-8 alphabetic (A-Z) or numeric (0-9) characters; first character must be alphabetic, but cannot be an X. Embedded blanks are not allowed.
9	Blank
10-71	Operation Name and (optional) Arguments <u>or</u> arithmetic expression. Either statement must begin in column 10.
72	Continuation--a nonblank character in column 72 indicates that this statement continues in column 1 of the following record. This character is not considered part of the statement.

(Comments may be included anywhere in the source program or the data deck by entering an asterisk in column 1).

2. Required Statements--For our purposes, the following 8 statements will be required in any MPS program.

- (1) PROGRAM--first statement in the source program.
- (2) INITIALZ--second statement in the source program.
- (3) EXIT--next-to-last statement in the source program.
- (4) PEND--last statement in the source program.
- (5) MOVE--This statement moves data from one location to another. We will assume that a minimum of the following 4 MOVE statements will be required in any MPS program:

```

      :
      :
MOVE(XDATA,'probname')
MOVE(XPBNNAME,'PBFILE')
      :
      :
MOVE(XRHS,'rthname')
MOVE(XOBJ,'objname')

```

where probname = name of the problem as defined on the NAME card of the input data.

rthname = name assigned to the right-hand-side vector as defined on the COLUMNS cards following the RHS card in the input data.

objname = name assigned to the objective function on one of the unconstrained ROWS cards in the input data.

(All other characters in the 4 MOVE statements listed above are required as specified).

3. Commonly Used MPS Statements

- (1) CONVERT--This statement causes the input file to be read into an area called PRODFILE. Heading information and an error summary by input section is printed. If the optional parameter 'SUMMARY' is included (i.e., CONVERT ('SUMMARY')), MPS produces a 2-page summary listing concerning the columns and rows of the original matrix. (See section H for discussion of output.) This statement must be preceded by the first two MOVE statements referenced in C.2. above.
- (2) BCDOUT--This statement produces a listing of the input data.
- (3) SETUP--This statement must be preceded (although not immediately) by the CONVERT statement. SETUP allocates storage, initializes input/output, creates a work matrix, and determines an initial solution. It is essential to note that MPS assumes all problems to be minimization problems. The program user can override this convention by writing SETUP ('MAX') instead of SETUP.

The SETUP statement must also be modified when there are finite upper bounds or non-zero lower bounds on the decision variables. In these situations the statement should read SETUP('BOUND','XXXX'), where XXXX is the user-supplied name of the row vector in the BOUNDS section of the data set containing the upper and lower bounds.

In certain situations various problem constraints will be required to lie within a certain range of values. Here the SETUP statement should read SETUP('RANGE','YYYY'), where YYYY is the user-supplied name of the column vector in the RANGES section of the data set containing the valid constraint ranges.

When a problem requires maximization and when bounds and ranges are present, the SETUP statement would read SETUP('BOUND','XXXX','RANGE','YYYY','MAX').

- (4) PICTURE--This statement will cause a condensed, "coded" representation of the current matrix to be printed. The format of this output is discussed in Section H.
- (5) PRIMAL--This is the main optimization procedure in MPS. It is based on the revised simplex algorithm and terminates with (1) an optimal solution, (2) an infeasible solution, or (3) an unbounded solution. This statement must be preceded by the second 2 MOVE statements discussed in C.2. above. The output produced by PRIMAL is discussed in Section H.
- (6) DUAL--This statement offers an alternate method of solving an LP problem and is particularly useful if there are more rows than columns in the original matrix. However, since DUAL can only guarantee a feasible solution, PRIMAL must be called after DUAL to ensure optimality.

- (7) SOLUTION--This statement causes the current solution of the LP problem to be printed. The content of this output is discussed in Section H.

D. THE INPUT DATA

There are two types of input cards--indicator cards and data cards. Data is entered in the order NAME, ROWS, COLUMNS, RHS, RANGES, BOUNDS, as specified by the corresponding indicator cards. A description of these sections of the input data deck follows:

1. NAME--Always the first card of the data deck; included to uniquely identify the data.

(1) Indicator Card Format

Col 1-4	NAME
Col 15-22	A name assigned to the data (generally the same name moved into XDATA in the MPS control program)

(2) Data Card Format

The NAME section requires no data.

2. ROWS--This section describes the rows of a linear programming tableau by assigning names to the rows and by indicating the type of constraint represented by the row.

(1) Indicator Card Format

Col 1-4	ROWS
---------	------

(2) Data Card Format

Col 2	Type of constraint coded as follows:
-------	--------------------------------------

N No constraint (the objective function or a change row to be used in parameterization)

G Greater than or equal to

L Less than or equal to

E Equality

Col 5-12	The user-assigned name of the row (left-justified)
----------	--

3. COLUMNS--This section describes the columns of the linear programming tableau by assigning names to the columns and also contains the non-zero cost and coefficient input data for the problem.

(1) Indicator Card Format

Col 1-7 COLUMNS

(2) Data Card Format

Col 5-12 The user-supplied name of the columns (left-justified).

Col 15-22 The name of the row in which a data element is being entered (left-justified).

Col 25-36 The value of the data element (Fortran E notation is permissible).

Col 40-47 Optional. The name of a second row in which a data element is being entered.

Col 50-61 Optional. The value of the second data element.

Note: Matrix elements must be entered by column. That is, all non-zero elements in each column must be specified before a second column is named. Zero elements need not be specified.

4. RHS--This section describes the requirement vector and any column parameterization vectors of the linear programming tableau by assigning names to non-zero data entries of these vectors.

(1) Indicator Card Format

Col 1-3 RHS

(2) Data Card Format

The data card format is identical to that of the COLUMNS section.

5. RANGES--This section describes the ranges within which problem constraints are required to lie. It is not included in the input data stream when the problem requires no ranges.

(1) Indicator Card Format

Col 1-6 RANGES

(2) Data Card Format

Col 5-12 The user-supplied name of a column vector designated to contain the ranges (left-justified).

Col 15-22 The name of the row to which a range is to be applied (left-justified).

Col 25-36 The value of the range (r_i in the table below).

Col 40-47 Optional. The name of a second row to which a range is to be applied.

Col 50-61 Optional. The value of the second range.

Ranges are applied to constraints as shown in the following table, where b_i is the value specified on the RHS data card for row i and r_i is the corresponding range.

Type of Row	Sign of r_i	Upper Limit on RHS	Lower Limit on RHS
G	+	$b_i + r_i$	b_i
L	+	b_i	$b_i - r_i$
E	+	$b_i + r_i$	b_i
E	-	b_i	$b_i - r_i$

6. BOUNDS--This section describes finite upper bounds or non-zero lower bounds on the problem decision variables. It is not included in the input data stream when the decision variables are only restricted to be non-negative.

(1) Indicator Card Format

Col 1-6 BOUNDS

(2) Data Card Format

Col 2-3 Type of bound as indicated by the following symbolism

LO Lower bound
 UP Upper bound
 FX Fixed Variable
 FR Free Variable ($-\infty < x_i < \infty$)
 MI Lower bound of $-\infty$
 PL Upper bound of $+\infty$

Col 5-12 The user-supplied name of a row vector designated to contain the bounds (left-justified).

Col 15-22 The name of the column corresponding to the variable which is to be bounded.

Col 25-36

If Col 2-3 contains LO, UP, or FX, this field contains the value of the associated bound. Otherwise it is left blank.

Note: It is possible to specify both upper and lower bounds or only one bound for a decision variable. In the later case, the unspecified bound remains at its original value of 0 or $+\infty$.

7. ENDATA---Always the last card of the data deck. Used to indicate the end of the current data set.

(1) Indicator Card Format

Col 1-6

ENDATA

(2) Data Card Format

The ENDATA section requires no data.

E. SAMPLE PROGRAM 1

Assume that you have been asked to solve the following problem using MPS/360:

$$\text{Maximize } f = x_1 + 3x_2 + 5x_3 + 4x_4 + 9x_5$$

$$\text{Subject to: } 3x_1 + 2x_2 + 4x_3 + x_4 + 5x_5 = 15$$

$$x_1 + 2x_2 + x_3 + 5x_4 + 5x_5 = 13$$

$$2x_3 + 3x_4 + 3x_5 \leq 6$$

$$x_j \geq 0, \quad (j = 1, \dots, 5).$$

Assume further that your user number is X527, your password is KINGKONG, and you have decided to name your problem and the data TRIALRUN. You have also decided to give the objective function (row) the name OBJ and the three constraint rows the names R1, R2, and R3 respectively. Further, you have given the columns corresponding to the decision variables the names C1, ..., C5 respectively, and the column vector of constants (the requirement vector) the name BVEC.

The form that the complete program should take, including job control cards, source program, and data, is given on the computer listing that follows.

\$SIGNON X527

KINGKONG

\$RUN *MPS

PROGRAM

INITIALZ

MOVE(XDATA,'TRIALRUN')

MOVE(XPBNAM, 'PBFILE')

CONVERT('SUMMARY')

BCDOUT

SETUP('MAX')

MOVE (XRHS,'BVEC')

MOVE(XOBJ,'OBJ')

PICTURE

PRIMAL

SOLUTION

EXIT

PEND

(blank card)

NAME TRIALRUN

ROWS

N OBJ

E R1

E R2

L R3

COLUMNS

C1	OBJ	1.0	R1	3.0
----	-----	-----	----	-----

C1	R2	1.0		
----	----	-----	--	--

C2	OBJ	3.0	R1	2.0
----	-----	-----	----	-----

C2	R2	2.0		
----	----	-----	--	--

C3	OBJ	5.0	R1	4.0
----	-----	-----	----	-----

C3	R2	1.0	R3	2.0
----	----	-----	----	-----

C4	OBJ	4.0	R1	1.0
----	-----	-----	----	-----

C4	R2	5.0	R3	3.0
----	----	-----	----	-----

C5	OBJ	9.0	R1	5.0
----	-----	-----	----	-----

C5	R2	5.0	R3	3.0
----	----	-----	----	-----

RHS

BVEC	R1	15.0	R2	13.0
------	----	------	----	------

BVEC	R3	6.0		
------	----	-----	--	--

ENDATA

\$ENDFILE

\$SIGNOFF

F. POSTOPTIMALITY STATEMENTS (OPTIONAL)

1. RANGE--This statement outputs a sensitivity analysis of the current solution, including:

- (1) The effects of cost changes on optimum activity levels.

- (2) The cost of changing an activity from the optimum level and the activity range for which this cost is valid.
- (3) The value of changing a row activity level and the interval for which the value is valid.

The mathematics underlying these procedures is documented in reference (11; pp. 180-196), and more complete discussion of the output from RANGE is given in Section H.

2. PARARHS--This statement enables the programmer to parameterize the RHS. From the original LP problem, a series of related problems is defined by replacing the current RHS with a new RHS obtained by incrementing each element of the original RHS by some multiple of a corresponding term of a user-specified change column. The multiple, and its maximum value are supplied as described below. Four statements must precede the PARARHS statement:

- (1) MOVE(XCHCOL, 'xxxxxxx') where xxxxxxxx is the name of a change column which the user has defined in the RHS section of the matrix.
- (2) XPARAM = 0
- (3) XPARAMAX = m where m is the required maximum value of the parameter (must be > 0, must contain decimal point).
- (4) XPARDELT = p where p is the parameter interval at which a solution will be printed (must be > 0, must contain decimal point).

The solution is kept optimal and feasible by changing the basis when necessary. The output from this option is discussed in Section H. The mathematics underlying PARARHS is documented in Appendix A. Similar mathematical procedures apply to the parameterization options discussed in 3-6 below.

3. PARARIM--This statement enables the programmer to simultaneously parameterize the RHS and the objective function. This procedure is essentially identical to PARARHS with the additional stipulation that a user-specified change row (to be used for parameterization of the objective function) is required. The following 5 statements must precede PARARIM:

```
MOVE(XCHROW, 'yyyyyyy')
MOVE(XCHCOL, 'xxxxxxx')
XPARAM = 0
XPARAMAX = m
XPARDELT = p
```

where yyyyyyy is the name of a change row and all other names, etc., are identical to the explanation of PARARHS. The solution is kept optimal and feasible by changing the basis when necessary. The output of PARARIM is discussed in Section H.

4. PARACOL--This statement enables the programmer to parameterize a structural column using a user-specified change column which is defined in the RHS section of the data input. This procedure is essentially identical to XPARARHS. The following 5 statements must precede the PARACOL statement:

```
MOVE(XCOLUMN,'zzzzzzzz')
MOVE(XCHCOL,'xxxxxxxx')
XPARAM = 0
XPARAMAX = m
XPARDELT = p
```

where zzzzzzzz is the name of the column that is to be parameterized. The solution is kept optimal and feasible by changing the basis when necessary. The output of PARACOL is discussed in Section H.

5. PARAROW--This statement enables the programmer to parameterize a constraint row. The procedure is similar to XPARARHS. The following five statements must precede the PARAROW statement:

```
MOVE(XROW,'rrrrrrrr')
MOVE(XCHROW,'xxxxxxxx')
XPARAM = 0
XPARAMAX = m
XPARDELT = p
```

where rrrrrrrr is the name of the row to be parameterized, and must be a constraint row, and xxxxxxxx is the name of the user-specified change row. The solution is kept optimal and feasible by changing the basis when necessary. The output of PARAROW is discussed in Section H.

6. PARAOBJ--This statement enables the programmer to parameterize the objective row. The procedure is similar to PARAROW. The following 4 statements must precede PARAOBJ.

```
MOVE(XCHROW,'xxxxxxxx')
XPARAM = 0
XPARAMAX = m
XPARDELT = p
```

where xxxxxxxx is the name of the change row. The solution is kept optimal and feasible by changing the basis when necessary. The output from PARAOBJ is discussed in Section H.

G. SAMPLE PROGRAM 2

Assume that you have been asked to conduct a RANGE analysis and then parameterize the RHS in the sample program from section E. In particular, you are asked to determine the effect of decreasing the L_j in constraint equation 1 from 15 down to 0 in decrements of 1 (i.e., 15, 14, 13, ..., 0), while holding all the other equations constant. A vector of the form $\begin{pmatrix} -1 \\ 0 \\ 0 \end{pmatrix}$ must be set up in the RHS

section to accomplish this parameterization. The computer listing which follows indicates how this post-optimality option might be handled when this change vector has been given the name BSTAR.

SSIGNON X527

KINGKONG

\$RUN *MPSCG

PROGRAM

INITIALZ

MOVE(XDATA,'TRIALRUN')

MOVE(XPBNAM,'PBFILE')

CONVERT('SUMMARY')

BCDOUT

SETUP('MAX')

MOVE(XRHS,'BVEC')

MOVE(XOBJ,'OBJ')

PICTURE

PRIMAL

SOLUTION

RANGE

MOVE(XCHCOL,'BSTAR')

XPARAM=0.

XPARMAX=15.

XPARDELT=1.

PARARHS

SOLUTION

EXIT

PEND

(blank card)

NAME TRIALRUN

ROWS

N OBJ

E R1

E R2

L R3

COLUMNS

C1	OBJ	1.0	R1	3.0
----	-----	-----	----	-----

C1	R2	1.0		
----	----	-----	--	--

C2	OBJ	3.0	R1	2.0
----	-----	-----	----	-----

C2	R2	2.0		
----	----	-----	--	--

C3	OBJ	5.0	R1	4.0
----	-----	-----	----	-----

C3	R2	1.0	R3	2.0
----	----	-----	----	-----

C4	OBJ	4.0	R1	1.0
----	-----	-----	----	-----

C4	R2	5.0	R3	3.0
----	----	-----	----	-----

C5	OBJ	9.0	R1	5.0
----	-----	-----	----	-----

C5	R2	5.0	R3	3.0
----	----	-----	----	-----

RHS

BVEC	R1	15.0	R2	13.0
------	----	------	----	------

BVEC	R3	6.0		
------	----	-----	--	--

BSTAR	R1	-1.	R2	0.
-------	----	-----	----	----

BSTAR	R3	0.		
-------	----	----	--	--

ENDATA

SENDFILE

SSIGNOFF

H. INTERPRETATION OF OUTPUT FROM MPS

1. Commonly Used Statements

(1) CONVERT--Execution of this statement yields the following output:

- (a) Heading information--the procedure name, elapsed time, etc.
- (b) A count of minor and major errors by section of the input data.
- (c) A summary of statistics for the model--number of rows, number of variables (including slack variables), the number of nonzero elements in the matrix, and the percentage of elements that are nonzero ("density").

If the 'SUMMARY' option is used, a page listing the name of each column and the number of nonzero elements in the columns, followed by a page listing the name of each row and the number of nonzero elements in that row will be printed. (These two pages precede the summary listing). The column listing includes, at the far left of each line, the internal vector number of the first vector on the line. Similarly, the row listing includes, at the far left of each line, the internal number of the slack variable in the first row on the line.

(2) SETUP--Execution of this statement yields the following output:

- (a) Heading information.
- (b) A listing of the internal files to be used in the solution.
- (c) A map of the data-storage area of memory.
- (d) A summary of problem statistics.

(3) PICTURE--Execution of this statement produces a condensed, coded "picture" of the current matrix. Each entry is given an alphabetic code depending on its magnitude, all columns and rows are labeled, and the type of constraint associated with each row is printed. A "key" to the alphabetic code follows this printout.

(4) PRIMAL--Execution of this statement produces the following output:

- (a) The heading section, which specifies the name of the procedure, the name of the objective function and the right-hand side, and the elapsed time in the solution.
- (b) An iteration log of the steps in the solution during the stage from infeasibility to feasibility. The iteration number, the number of infeasibilities, the internal number of the outgoing vector, the internal number of the incoming vector, the reduced cost of the incoming vector, and the sum of the infeasibilities are specified.
- (c) Notification when the feasible solution is determined.
- (d) An iteration log of the steps in the solution, progressing from the feasible solution to an optimal (or unbounded) solution. The iteration number, the number of nonoptimal variables, the internal number of the outgoing vector, the internal number of the incoming vector, the reduced cost of the incoming vector and the value of the functional are specified.
- (e) Notification when an optimal (or unbounded) solution is reached.

(5) SOLUTION--Execution of this statement outputs the current solution of the problem including the following three sections:

(a) The identification section provides the following output.

- i. The status of the solution.
 - (1) INFEASIBLE
 - (2) NON-OPTIMAL
 - (3) OPTIMAL
- ii. The time required by the LP program from the start of its execution to the start of the current procedure.
- iii. The number of iterations (basis changes) performed so far.
- iv. The name, activity level, and definition of each of the special rows and columns of the problem definition.
- v. The names of the BOUNDS and RANGES vectors utilized (if any).

(b) The row section.

(c) The column section.

Each of these sections is printed as a table of eight columns, with one row of the table corresponding to each row or column of the problem. A description of these columns follows:

NUMBER. The number of an internal logical variable associated with the row-or column. If a work matrix contains m rows and n columns, the rows are numbered from 1 through m and the columns are numbered from $(m + 1)$ through $(m + n)$. These numbers are useful principally for analysis of the iteration log output which identifies vectors by their serial number.

ROW/COLUMN. The eight-character name given to the row or column by the user.

AT. A two-character code indicating the status of the row or column (designated as an activity) in the solution:

BS - in the basis and feasible
** - in the basis and infeasible
FR - nonbasis free
EQ - nonbasis artificial or fixed
UL - nonbasis at upper limit
LL - nonbasis at lower limit

ACTIVITY. The value of the row or column in the current solution.

For columns, this value is simply the value of the associated decision variable. For rows, this value is given by

$$\sum_j a_{ij}x_j = b_i - l_i$$

where b_i = the right-hand side and l_i is the slack variable for the i^{th} constraint.

SLACK ACTIVITY/INPUT COST. The slack activity is provided in the Row Section. The input cost is provided in the Column Section.

LOWER LIMIT. The algebraically lowest value that the activity can assume and still remain feasible.

UPPER LIMIT. The algebraically highest value that the activity can assume and still remain feasible.

DUAL ACTIVITY/REDUCED COST. The dual activity is provided in the Row Section and is generally known as the simplex multiplier.

[The dual activity of a row is the reduced cost of the corresponding slack variable.] The reduced cost is provided in the Column Section. The reduced cost of a variable is the rate of increase in the objective function per unit increase in the variable.

If the optimal solution contains nonbasic variables with zero reduced cost, then alternate optima exist. Such variables are flagged in the printed tabulation.

The row and column sections of the SOLUTION output for the sample problem given in section E are reproduced below to illustrate the interpretations of these sections.

ROWS

Number	Row	At	Activity	Slack Activity	Lower Limit	Upper Limit	Dual Activity
1	OBJ	BS	24.16667	24.16667-	None	None	1.00000
2	R1	EQ	15.00000	...	15.00000	15.00000	.83333-
3	R2	EQ	13.00000	...	13.00000	13.00000	.66667-
4	R3	UL	6.00000	...	None	6.00000	.50000-

The optimal value of the objective function is 24.16667. The constraints corresponding to R1 and R2 are equalities (EQ), and hence the upper and lower limits for these rows are fixed. The inequality constraint corresponding to R3 is at its upper limit (UL), and this activity could vary from 0 to 6 while still maintaining feasibility. The dual prices corresponding to the three constraints are -.83333, -.66667, and -.50000 respectively, and these indicate the rate of increase of the objective function value per unit decrease in the values of the requirement vector (BVEC).

COLUMNS

Number	Column	At	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
5	C1	LL	...	1.00000	...	None	2.16667-
6	C2	BS	2.27778	3.00000	...	None	...
7	C3	BS	.66667	5.00000	...	None	...
8	C4	LL	...	4.00000	...	None	1.66667-
9	C5	BS	1.55556	9.00000	...	None	...

Columns C2, C3, and C5 are basic (BS), while columns C1 and C4 are non-basic at their lower limit (LL) of zero. Hence the optimal program is $x_1 = 0$, $x_2 = 2.27778$, $x_3 = .66667$, $x_4 = 0$, and $x_5 = 1.55556$. No upper or lower feasibility limits are given for the columns, since the decision variables were only constrained to be non-negative. The reduced costs of variables x_1 and x_3 are

-2.16667 and -1.66667 respectively, and these indicate the rate of increase in the objective function value per unit increase in these variables.

2. Postoptimality Statements

(1) RANGE--This statement produces 5 sections of output:

- (a) Identification--elapsed time of the run, number of iterations, etc.
- (b) Activity--value relationships for constraint rows at limit level. (constraints which are "tight")
- (c) Activity--value relationships for constraint rows at intermediate level. (constraints which are not binding at optimality)
- (d) Price--activity cost relationships for structural variables (columns) at limit level. (at their upper or lower bounds)
- (e) Price--activity--cost relationship for structural variables (columns) at intermediate level.

Selected portions of Sections (b) through (d) of the RANGE output for the sample problem given in Section C are reproduced below to illustrate the interpretations of these sections.

Row	Activity	Lower Limit Upper Limit	Lower Activity Upper Activity	Unit Cost	Upper Cost Lower Cost	Limiting Process	At
R1	15.00	15.00	13.00	.83-		C3	LL
		15.00	22.00	.83	..	C5	LL
		13.00	6.00	.67-		C5	LL
R2	13.00	13.00	15.00	.67	..	C3	LL
		None	1.33	.50-		C5	LL
R3	6.00	6.00	8.73	.50	..	C2	LL

For instance, the right hand side of the first constraint can range from 13.00 to 22.00 while the current optimal basis is still maintained. For this range of values the rate of increase in the value of the objective function per unit increase in the RHS is .83. For values of the right hand side below 13.00 column C3 leaves the basis, and for values of the right hand side above 22.00 column C5 leaves the basis.

COLUMNS AT LIMIT LEVEL

Column	Activity	Lower Limit Upper Limit	Lower Activity Upper Activity	Unit Cost	Upper Cost Lower Cost	Limiting Process	At
C1	...	...	3.50-	2.17	Infinity-	C5	LL
		None	1.00	2.17-	3.17	C3	LL
		...	.50-	1.67	Infinity-	C3	LL
C4	...	None	.82	1.67-	5.67	C5	LL

For instance, if the unit input cost of C4 is reduced from 4 to $-\infty$, C4 will enter the optimal solution at a level of $-.50$ (ignoring the non-negativity restriction). If the unit input cost of C4 is increased from 4 to 5.67, C4 will enter the optimal solution at a level of $.82$, replacing C5 in the basis. For the original problem, the rate of decrease in the objective per unit increase in the level of C4 is -1.67 (the reduced cost of the non-basic column C4).

ROWS AT INTERMEDIATE LEVEL

(For the sample problem, no rows are at an intermediate level.)

COLUMNS AT INTERMEDIATE LEVEL

Column	Activity	Lower Limit	Upper Limit	Lower Activity	Upper Activity	Unit Cost	Upper Cost	Lower Cost	Limiting Process	At
		...		1.00		1.70-	1.30		C1	LL
C2	2.28	None		6.17		.60-	3.60		R3	UL
		...		.52-		3.25-	1.75		C1	LL
C3	.67	None		1.76		1.25-	6.25		C4	LL
		...		Infinity-		.88-	8.12		C4	LL
C5	1.56	None		2.00		4.88-	13.88		C1	LL

For instance, if the unit input cost of C2 is reduced from 3 to 1.30, C2 will be reduced to a level of 1.00. The rate of decrease of the objective function per unit decrease in C2 will be 1.70. Further decreases in the input cost of C2 will result in non-basic column C1 entering the optimal basis.

If the unit input cost of C2 is increased to 3.60, C2 will be increased to a level of 6.17 in an optimal solution. The rate of increase in the objective function per unit increase of C2 will be $.60$. Further increases in the unit cost of C2 will not result in a change of the level of C2, since constraint R3 is binding for the resulting optimal solution when C2 is at a level of 6.17.

- (2) PARARHS--This statement function produces an iteration log giving the value of the objective and the parameter at basis changes, and prints one of the following three messages upon completion:

- (a) "Maximum of Parameter"--The parameter is at its maximum value (XPARMAX).
- (b) "Premature Maximum"--The problem becomes infeasible at the current value of the parameter. No further basis change can occur.
- (c) "No Maximum for Parameter"--The parameter has reached a value beyond which it can be increased indefinitely without requiring a basis change to maintain feasibility.

- (3) PARARIN--This statement produces an output with format almost identical to PARARHS. If the problem becomes infeasible or unbounded, the solution is kept at the optimal and feasible value attained immediately before termination of PARARIN. If there is "no maximum for the parameter," the parameter is set equal to XPARMAX, and the solution is brought up to this value.

- (4) PARACOL--This statement produces an output with format identical to that produced by PARARIN.

- (5) PARAROW--This statement produces an output with format identical to that produced by PARARIM.
- (6) PARAOBJ--This statement produces an output with format identical to that produced by PARARHS.

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APPENDIX A7
PROGRAM LISTINGS

COMMAND FILES

FILE NAME: DATA1, DATA2, DATA3, DATA4
START, SETUP, RUNLP, SCAN2, INFEAS
MESSAGE

PERMANENT FILES

FILE NAME: COMMANDS
MAX, MIN, END
RULEROWS, RULESRHS
EXRULES
TYPEFILE
TYPROWS
S.SETUP

TEMPORARY FILES

FILE NAME: -F2, -F3, -F8, -F9
-F7

COMMAND FILES

FILE NAME: DATA1

```
1 $EMPTY -SORTED
2 $EMPTY -LP
2.2 $EMPTY -IN
2.4 $COPY -F7+-F9 TO -IN
3 $RUN *SORT PAR=SORT=CH,A,5,8 INPUT=-IN OUTPUT=-SORTED
4 $COPY -F4+-F3+-SORTED+-F8+END TO -LP
5 $SOURCE RUNLP
END OF FILE
```

FILE NAME: DATA2

```
1 $EMPTY -SORTED
2 $EMPTY -LP
2.2 $EMPTY -IN
2.4 $COPY -F7+-F9+EARULES TO -IN
3 $RUN *SORT PAR=SORT=CH,A,5,8 INPUT=-IN OUTPUT=-SORTED
4 $COPY -F2+RULERONS+-F3+-SORTED+-F8+RULESRHS+END TO -LP
5 $SOURCE RUNLP
END OF FILE
```

FILE NAME: DATA3

```
1 $EMPTY -SORTED
2 $EMPTY -LP
2.2 $EMPTY -IN
2.4 $COPY -F7+TYPEFILE TO -IN
3 $RUN *SORT PAR=SORT=CH,A,5,8 INPUT=-IN OUTPUT=-SORTED
4 $COPY COMMANDS+-F3+-SORTED+-F8+END TO -LP
5 $SOURCE RUNLP
END OF FILE
```

FILE NAME: DATA4

```
1 $EMPTY -SORTED
2 $EMPTY -LP
2.2 $EMPTY -IN
2.4 $COPY -F7+EARULES+TYPEFILE TO -IN
3 $RUN *SORT PAR=SORT=CH,A,5,8 INPUT=-IN OUTPUT=-SORTED
4 $COPY COMMANDS+RULERONS+-F3+-SORTED+-F8+RULESRHS+END TO -LP
5 $SOURCE RUNLP
```

COMMAND FILES

FILE NAME: START

```
1 $SET ECHO=OFF
2 $COPY MESSAGE(1,3)
END OF FILE
```

FILE NAME: SETUP

```
1 $EMPTY -F2
2 $EMPTY -F3
3 $EMPTY -F7
4 $EMPTY -F8
5 $EMPTY -F9
6 $RUN J.SETUP 2=-F2 3=-F3 5=MSOURCE= 7=-F7 8=-F8 9=-F9
7 $COPY MESSAGE(3,5,17)
END OF FILE
```

FILE NAME: RUNLP

```
2 $EMPTY -LPJUT
3 $RUN *MPS SCARUS=MAX*-LP SPRINT=-LPJUT
3.5 $COPY MESSAGE(17,5,32)
4 $EDIT -LPJUT
5 SCAN 1 1000 *((INFEASIBLE)*
6 MTS
END OF FILE
```

FILE NAME: SCAN2

```
1 $COPY MESSAGE(43,40)
2 $EDIT -LPJUT
3 COL 11 20
4 SCALGA /F 'FUNCTIONAL'
5 MTS
6 $EMPTY -LPJUT
7 $RUN *MPS SCARUS=MIN*-LP SPRINT=-LPJUT
8 $COPY MESSAGE(40,40)
9 $EDIT -LPJUT
10 SCALGA /FILE 'FUNCTIONAL'
11 COL
12 MTS
13 $COPY MESSAGE(32,5,36)
14 $COPY MESSAGE1
END OF FILE
```

FILE NAME: INFEAS

```
1 $COPY MESSAGE(36,5,42)
2 $EDIT -LPJUT
3 SCAN /FILE '(INFEASIBLE)*
3.5 6
4 PRINT * C=00
5 MTS
END OF FILE
```

COMMAND FILES

FILE NAME: MESSAGE

1 ***** TO RUN THE MCC ADVERSARIES PROGRAM, ENTER:
2 ***** SOURCE SETUP
3 *****NOTE TO MTS USER: ECHO IS NOW SET OFF. REMEMBER TO SET ECHO=ON
3.5 *****
4 ***** NOW ENTER:
5 *****
6 ***** SOURCE FILENAME
7 *****
8 ***** WHERE 'FILENAME' DEPENDS ON WHETHER YOU WISH TO USE THE
9 ***** STANDARD EXCLUSION RULES AND/OR THE 19 STANDARD ARCHETYPES--
10 *****
11 ***** FILENAME STANDARD STANDARD
12 ***** ARCHETYPE EARLIES
13 *****
14 ***** DATA1 NU NU
15 ***** DATA2 NU YES
16 ***** DATA3 YES NU
17 ***** DATA4 YES YES
17.5 *****
18 ***** THE OUTPUT OF THE LINEAR PROGRAMMING PACKAGE MPS IS NOW IN FILE -LPQUT
19 ***** THE MTS EDIT WILL NOW SCAN THIS FILE FOR INFEASIBLE CONDITIONS
20 *****
21 ***** THE RESULTING OUTPUT WILL BE EITHER:
22 ***** SEARCH FAILED.....A)
23 *****
24 ***** JK
25 *****

FILE NAME: MESSAGE (continued)

```

26 ***** SOLUTION (INFEASIBLE).....0)
27 *****
28 ***** IF A), ENTER:
29 ***** SOURCE SCANZ
30 *****
31 ***** IF B), ENTER:
32 ***** SOURCE INFEAS
32.5 *****
33 ***** IF 'SEARCH FAILED, COLUMN RANGE IN EFFECT' THEN THERE IS PROBABLY A DATA ENTRY ERROR.
34 ***** ENTER:
35 ***** LIST -LP0UT(50,100)
36 ***** TO TRY TO DIAGNOSE THE PROBLEM
36.5 *****
37 ***** THE STANDARD EXCLUSION RULES AND/OR THE ENTERED ASSESSED PROBABILITIES
38 ***** HAVE COMBINED TO PRODUCE AN INFEASIBLE SOLUTION.
39 ***** THE FOLLOWING PORTION OF THE FILE '-LP0UT' MAY HELP IN DETERMINING
40 ***** THE OVERCONSTRAINTS. IN PARTICULAR, THE ROW WITH THE ** IN THE 'AT' COLUMN
41 ***** IS ONE OF THE CONTRIBUTING FACTORS TO THE INFEASIBILITY.
42 *****
43
44 MAX PROB. ARCHETYPE
45
46
47 MIN PROB. ARCHETYPE
48

```

END OF FILE

PERMANENT FILES

FILE NAME: COMMANDS

1	MOVE(XRHS,'PROBS')
2	MOVE(XOBJ,'ARTYPE1')
3	PRIMAL
3.5	SOLUTION
4	MOVE(XOBJ,'ARTYPE2')
5	PRIMAL
5.5	SOLUTION
6	MOVE(XOBJ,'ARTYPE3A')
7	PRIMAL
7.5	SOLUTION
8	MOVE(XOBJ,'ARTYPE3B')
9	PRIMAL
9.5	SOLUTION
10	MOVE(XOBJ,'ARTYPE4')
11	PRIMAL
11.5	SOLUTION
12	MOVE(XOBJ,'ARTYPE5A')
13	PRIMAL
13.5	SOLUTION
14	MOVE(XOBJ,'ARTYPE5B')
15	PRIMAL
15.5	SOLUTION
16	MOVE(XOBJ,'ARTYPE6A')
17	PRIMAL
17.5	SOLUTION
18	MOVE(XOBJ,'ARTYPE6B')
19	PRIMAL
19.5	SOLUTION
20	MOVE(XOBJ,'ARTYPE7')
21	PRIMAL
21.5	SOLUTION
22	MOVE(XOBJ,'ARTYPE8')
23	PRIMAL
23.5	SOLUTION
24	MOVE(XOBJ,'ARTYPE9')
25	PRIMAL
25.5	SOLUTION

FILE NAME: COMMANDS (continued)

```

26          MOVE(XOBJ,'ARTYPE10')
27          PRIMAL
27.5        SOLUTION
28          MOVE(XOBJ,'ARTYPE11')
29          PRIMAL
29.5        SOLUTION
30          MOVE(XOBJ,'ARTYPE12')
31          PRIMAL
31.5        SOLUTION
32          MOVE(XOBJ,'ARTYPE13')
33          PRIMAL
33.5        SOLUTION
34          MOVE(XOBJ,'ARTYPE14')
35          PRIMAL
35.5        SOLUTION
36          MOVE(XOBJ,'ARTYPE15')
37          PRIMAL
37.5        SOLUTION
38          MOVE(XOBJ,'ARTYPE16')
39          PRIMAL
40          SOLUTION
41          EXIT
42          PEND
43
44          NAME          TERGROUP
45          ROWS
46          N ARTYPE1
47          N ARTYPE2
48          N ARTYPE3A
49          N ARTYPE3B
50          N ARTYPE4
51          N ARTYPE5A
52          N ARTYPE5B
53          N ARTYPE6A
54          N ARTYPE6B
55          N ARTYPE7
56          N ARTYPE8
57          N ARTYPE9
58          N ARTYPE10
59          N ARTYPE11
60          N ARTYPE12
61          N ARTYPE13
62          N ARTYPE14
63          N ARTYPE15
64          N ARTYPE16
END OF FILE

```


PERMANENT FILES

FILE NAME: MAX

```
1      PROGRAM
2      INITIALZ
3      XFREE=25000
4      MOVE(AJDATA,'TERGROUP')
5      MOVE(APNAME,'P8FILE')
6      CONVERT
7      SETUP('MAX')
END OF FILE
```

FILE NAME: MIN

```
1      PROGRAM
2      INITIALZ
3      XFREE=25000
4      MOVE(AJDATA,'TERGROUP')
5      MOVE(APNAME,'P8FILE')
6      CONVERT
7      SETUP
END OF FILE
```

FILE NAME: END

```
END OF FILE
1      ENDATA
END OF FILE
```

PERMANENT FILES

FILE NAME: RULEROWS

1	E	00201000
2	E	22200000
3	E	32200000
4	E	42200000
5	E	40000002
6	E	40002000
7	E	01121100
8	E	30020000

END OF FILE

FILE NAME: RULESRHS

1	PROBS	00201000	0.0
2	PROBS	22200000	0.0
3	PROBS	32200000	0.0
4	PROBS	42200000	0.0
5	PROBS	40000002	0.0
6	PROBS	40002000	0.0
7	PROBS	01121100	0.0
8	PROBS	30020000	0.0

END OF FILE

PERMANENT FILES

FILE NAME: EXRULES

1	11211111	00201000	1.000000
2	11211112	00201000	1.000000
3	11211121	00201000	1.000000
4	11211122	00201000	1.000000
5	11211211	00201000	1.000000
6	11211212	00201000	1.000000
7	11211221	00201000	1.000000
8	11211222	00201000	1.000000
9	11221111	00201000	1.000000
10	11221112	00201000	1.000000
11	11221121	00201000	1.000000
12	11221122	00201000	1.000000
13	11221211	00201000	1.000000
14	11221212	00201000	1.000000
15	11221221	00201000	1.000000
16	11221222	00201000	1.000000
17	12211111	00201000	1.000000
18	12211112	00201000	1.000000
19	12211121	00201000	1.000000
20	12211122	00201000	1.000000
21	12211211	00201000	1.000000
22	12211212	00201000	1.000000
23	12211221	00201000	1.000000
24	12211222	00201000	1.000000
25	12221111	00201000	1.000000
26	12221112	00201000	1.000000
27	12221121	00201000	1.000000
28	12221122	00201000	1.000000
29	12221211	00201000	1.000000
30	12221212	00201000	1.000000
31	12221221	00201000	1.000000
32	12221222	00201000	1.000000
33	21211111	00201000	1.000000
34	21211112	00201000	1.000000
35	21211121	00201000	1.000000
36	21211122	00201000	1.000000
37	21211211	00201000	1.000000
38	21211212	00201000	1.000000
39	21211221	00201000	1.000000
40	21211222	00201000	1.000000

FILE NAME: EXRULES (continued)

41	21221111	00201000	1.000000
42	21221112	00201000	1.000000
43	21221121	00201000	1.000000
44	21221122	00201000	1.000000
45	21221211	00201000	1.000000
46	21221212	00201000	1.000000
47	21221221	00201000	1.000000
48	21221222	00201000	1.000000
49	22211111	00201000	1.000000
50	22211112	00201000	1.000000
51	22211121	00201000	1.000000
52	22211122	00201000	1.000000
53	22211211	00201000	1.000000
54	22211212	00201000	1.000000
55	22211221	00201000	1.000000
56	22211222	00201000	1.000000
57	22221111	00201000	1.000000
58	22221112	00201000	1.000000
59	22221121	00201000	1.000000
60	22221122	00201000	1.000000
61	22221211	00201000	1.000000
62	22221212	00201000	1.000000
63	22221221	00201000	1.000000
64	22221222	00201000	1.000000
65	31211111	00201000	1.000000
66	31211112	00201000	1.000000
67	31211121	00201000	1.000000
68	31211122	00201000	1.000000
69	31211211	00201000	1.000000
70	31211212	00201000	1.000000
71	31211221	00201000	1.000000
72	31211222	00201000	1.000000
73	31221111	00201000	1.000000
74	31221112	00201000	1.000000
75	31221121	00201000	1.000000
76	31221122	00201000	1.000000
77	31221211	00201000	1.000000
78	31221212	00201000	1.000000
79	31221221	00201000	1.000000
80	31221222	00201000	1.000000
81	32211111	00201000	1.000000
82	32211112	00201000	1.000000
83	32211121	00201000	1.000000
84	32211122	00201000	1.000000
85	32211211	00201000	1.000000
86	32211212	00201000	1.000000
87	32211221	00201000	1.000000
88	32211222	00201000	1.000000
89	32221111	00201000	1.000000
90	32221112	00201000	1.000000
91	32221121	00201000	1.000000
92	32221122	00201000	1.000000
93	32221211	00201000	1.000000
94	32221212	00201000	1.000000
95	32221221	00201000	1.000000
96	32221222	00201000	1.000000
97	41211111	00201000	1.000000
98	41211112	00201000	1.000000
99	41211121	00201000	1.000000
100	41211122	00201000	1.000000

FILE NAME: EXRULES (continued)

101	41211211	00201000	1.000000
102	41211212	00201000	1.000000
103	41211221	00201000	1.000000
104	41211222	00201000	1.000000
105	41221111	00201000	1.000000
106	41221112	00201000	1.000000
107	41221121	00201000	1.000000
108	41221122	00201000	1.000000
109	41221211	00201000	1.000000
110	41221212	00201000	1.000000
111	41221221	00201000	1.000000
112	41221222	00201000	1.000000
113	42211111	00201000	1.000000
114	42211112	00201000	1.000000
115	42211121	00201000	1.000000
116	42211122	00201000	1.000000
117	42211211	00201000	1.000000
118	42211212	00201000	1.000000
119	42211221	00201000	1.000000
120	42211222	00201000	1.000000
121	42221111	00201000	1.000000
122	42221112	00201000	1.000000
123	42221121	00201000	1.000000
124	42221122	00201000	1.000000
125	42221211	00201000	1.000000
126	42221212	00201000	1.000000
127	42221221	00201000	1.000000
128	42221222	00201000	1.000000
129	22211111	22200000	1.00000000
130	22211112	22200000	1.00000000
131	22211121	22200000	1.00000000
132	22211122	22200000	1.00000000
133	22211211	22200000	1.00000000
134	22211212	22200000	1.00000000
135	22211221	22200000	1.00000000
136	22211222	22200000	1.00000000
137	22212111	22200000	1.00000000
138	22212112	22200000	1.00000000
139	22212121	22200000	1.00000000
140	22212122	22200000	1.00000000
141	22212211	22200000	1.00000000
142	22212212	22200000	1.00000000
143	22212221	22200000	1.00000000
144	22212222	22200000	1.00000000
145	22221111	22200000	1.00000000
146	22221112	22200000	1.00000000
147	22221121	22200000	1.00000000
148	22221122	22200000	1.00000000
149	22221211	22200000	1.00000000
150	22221212	22200000	1.00000000
151	22221221	22200000	1.00000000
152	22221222	22200000	1.00000000
153	22222111	22200000	1.00000000
154	22222112	22200000	1.00000000
155	22222121	22200000	1.00000000
156	22222122	22200000	1.00000000
157	22222211	22200000	1.00000000
158	22222212	22200000	1.00000000
159	22222221	22200000	1.00000000
160	22222222	22200000	1.00000000

FILE NAME: EXRULES (continued)

161	32211111	32200000	1.000000
162	32211112	32200000	1.000000
163	32211121	32200000	1.000000
164	32211122	32200000	1.000000
165	32211211	32200000	1.000000
166	32211212	32200000	1.000000
167	32211221	32200000	1.000000
168	32211222	32200000	1.000000
169	32212111	32200000	1.000000
170	32212112	32200000	1.000000
171	32212121	32200000	1.000000
172	32212122	32200000	1.000000
173	32212211	32200000	1.000000
174	32212212	32200000	1.000000
175	32212221	32200000	1.000000
176	32212222	32200000	1.000000
177	32221111	32200000	1.000000
178	32221112	32200000	1.000000
179	32221121	32200000	1.000000
180	32221122	32200000	1.000000
181	32221211	32200000	1.000000
182	32221212	32200000	1.000000
183	32221221	32200000	1.000000
184	32221222	32200000	1.000000
185	32222111	32200000	1.000000
186	32222112	32200000	1.000000
187	32222121	32200000	1.000000
188	32222122	32200000	1.000000
189	32222211	32200000	1.000000
190	32222212	32200000	1.000000
191	32222221	32200000	1.000000
192	32222222	32200000	1.000000
193	42211111	42200000	1.000000
194	42211112	42200000	1.000000
195	42211121	42200000	1.000000
196	42211122	42200000	1.000000
197	42211211	42200000	1.000000
198	42211212	42200000	1.000000
199	42211221	42200000	1.000000
200	42211222	42200000	1.000000
201	42212111	42200000	1.000000
202	42212112	42200000	1.000000
203	42212121	42200000	1.000000
204	42212122	42200000	1.000000
205	42212211	42200000	1.000000
206	42212212	42200000	1.000000
207	42212221	42200000	1.000000
208	42212222	42200000	1.000000
209	42221111	42200000	1.000000
210	42221112	42200000	1.000000
211	42221121	42200000	1.000000
212	42221122	42200000	1.000000
213	42221211	42200000	1.000000
214	42221212	42200000	1.000000
215	42221221	42200000	1.000000
216	42221222	42200000	1.000000
217	42222111	42200000	1.000000
218	42222112	42200000	1.000000
219	42222121	42200000	1.000000
220	42222122	42200000	1.000000

FILE NAME: EXRULES (continued)

221	+2222211	+2200000	1.0000000
222	42222212	42200000	1.0000000
223	42222221	42200000	1.0000000
224	+2222222	+2200000	1.0000000
225	+1111112	+0000002	1.00000000
226	+1111122	+0000002	1.00000000
227	+1111212	+0000002	1.00000000
228	+1111222	+0000002	1.00000000
229	+1112112	+0000002	1.00000000
230	+1112122	+0000002	1.00000000
231	+1112212	+0000002	1.00000000
232	+1112222	+0000002	1.00000000
233	+1121112	+0000002	1.00000000
234	+1121122	+0000002	1.00000000
235	+1121212	+0000002	1.00000000
236	+1121222	+0000002	1.00000000
237	+1122112	+0000002	1.00000000
238	+1122122	+0000002	1.00000000
239	+1122212	+0000002	1.00000000
240	+1122222	+0000002	1.00000000
241	+1211112	+0000002	1.00000000
242	+1211122	+0000002	1.00000000
243	+1211212	+0000002	1.00000000
244	+1211222	+0000002	1.00000000
245	+1212112	+0000002	1.00000000
246	+1212122	+0000002	1.00000000
247	+1212212	+0000002	1.00000000
248	+1212222	+0000002	1.00000000
249	+1221112	+0000002	1.00000000
250	+1221122	+0000002	1.00000000
251	+1221212	+0000002	1.00000000
252	+1221222	+0000002	1.00000000
253	+1222112	+0000002	1.00000000
254	+1222122	+0000002	1.00000000
255	+1222212	+0000002	1.00000000
256	+1222222	+0000002	1.00000000
257	+2111112	+0000002	1.00000000
258	+2111122	+0000002	1.00000000
259	+2111212	+0000002	1.00000000
260	+2111222	+0000002	1.00000000
261	+2112112	+0000002	1.00000000
262	+2112122	+0000002	1.00000000
263	+2112212	+0000002	1.00000000
264	+2112222	+0000002	1.00000000
265	+2121112	+0000002	1.00000000
266	+2121122	+0000002	1.00000000
267	+2121212	+0000002	1.00000000
268	+2121222	+0000002	1.00000000
269	+2122112	+0000002	1.00000000
270	+2122122	+0000002	1.00000000
271	+2122212	+0000002	1.00000000
272	+2122222	+0000002	1.00000000
273	+2211112	+0000002	1.00000000
274	+2211122	+0000002	1.00000000
275	+2211212	+0000002	1.00000000
276	+2211222	+0000002	1.00000000
277	+2212112	+0000002	1.00000000
278	+2212122	+0000002	1.00000000
279	+2212212	+0000002	1.00000000
280	+2212222	+0000002	1.00000000

FILE NAME: EXRULES (continued)

281	42221112	40000002	1.00000000
282	42221122	40000002	1.00000000
283	42221212	40000002	1.00000000
284	42221222	40000002	1.00000000
285	42222112	40000002	1.00000000
286	42222122	40000002	1.00000000
287	42222212	40000002	1.00000000
288	42222222	40000002	1.00000000
289	41112111	40002000	1.00000000
290	41112112	40002000	1.00000000
291	41112121	40002000	1.00000000
292	41112122	40002000	1.00000000
293	41112211	40002000	1.00000000
294	41112212	40002000	1.00000000
295	41112221	40002000	1.00000000
296	41112222	40002000	1.00000000
297	41122111	40002000	1.00000000
298	41122112	40002000	1.00000000
299	41122121	40002000	1.00000000
300	41122122	40002000	1.00000000
301	41122211	40002000	1.00000000
302	41122212	40002000	1.00000000
303	41122221	40002000	1.00000000
304	41122222	40002000	1.00000000
305	41212111	40002000	1.00000000
306	41212112	40002000	1.00000000
307	41212121	40002000	1.00000000
308	41212122	40002000	1.00000000
309	41212211	40002000	1.00000000
310	41212212	40002000	1.00000000
311	41212221	40002000	1.00000000
312	41212222	40002000	1.00000000
313	41222111	40002000	1.00000000
314	41222112	40002000	1.00000000
315	41222121	40002000	1.00000000
316	41222122	40002000	1.00000000
317	41222211	40002000	1.00000000
318	41222212	40002000	1.00000000
319	41222221	40002000	1.00000000
320	41222222	40002000	1.00000000
321	42112111	40002000	1.00000000
322	42112112	40002000	1.00000000
323	42112121	40002000	1.00000000
324	42112122	40002000	1.00000000
325	42112211	40002000	1.00000000
326	42112212	40002000	1.00000000
327	42112221	40002000	1.00000000
328	42112222	40002000	1.00000000
329	42122111	40002000	1.00000000
330	42122112	40002000	1.00000000
331	42122121	40002000	1.00000000
332	42122122	40002000	1.00000000
333	42122211	40002000	1.00000000
334	42122212	40002000	1.00000000
335	42122221	40002000	1.00000000
336	42122222	40002000	1.00000000
337	42212111	40002000	1.00000000
338	42212112	40002000	1.00000000
339	42212121	40002000	1.00000000
340	42212122	40002000	1.00000000

FILE NAME: EXRULES (continued)

341	42212211	40002000	1.000000000
342	42212212	40002000	1.000000000
343	42212221	40002000	1.000000000
344	42212222	40002000	1.000000000
345	42222111	40002000	1.000000000
346	42222112	40002000	1.000000000
347	42222121	40002000	1.000000000
348	42222122	40002000	1.000000000
349	42222211	40002000	1.000000000
350	42222212	40002000	1.000000000
351	42222221	40002000	1.000000000
352	42222222	40002000	1.000000000
353	11121111	01121100	1.000000000
354	11121112	01121100	1.000000000
355	11121121	01121100	1.000000000
356	11121122	01121100	1.000000000
357	21121111	01121100	1.000000000
358	21121112	01121100	1.000000000
359	21121121	01121100	1.000000000
360	21121122	01121100	1.000000000
361	31121111	01121100	1.000000000
362	31121112	01121100	1.000000000
363	31121121	01121100	1.000000000
364	31121122	01121100	1.000000000
365	41121111	01121100	1.000000000
366	41121112	01121100	1.000000000
367	41121121	01121100	1.000000000
368	41121122	01121100	1.000000000
369	31121111	30020000	1.000000000
370	31121112	30020000	1.000000000
371	31121121	30020000	1.000000000
372	31121122	30020000	1.000000000
373	31121211	30020000	1.000000000
374	31121212	30020000	1.000000000
375	31121221	30020000	1.000000000
376	31121222	30020000	1.000000000
377	31122111	30020000	1.000000000
378	31122112	30020000	1.000000000
379	31122121	30020000	1.000000000
380	31122122	30020000	1.000000000
381	31122211	30020000	1.000000000
382	31122212	30020000	1.000000000
383	31122221	30020000	1.000000000
384	31122222	30020000	1.000000000
385	31221111	30020000	1.000000000
386	31221112	30020000	1.000000000
387	31221121	30020000	1.000000000
388	31221122	30020000	1.000000000
389	31221211	30020000	1.000000000
390	31221212	30020000	1.000000000
391	31221221	30020000	1.000000000
392	31221222	30020000	1.000000000
393	31222111	30020000	1.000000000
394	31222112	30020000	1.000000000
395	31222121	30020000	1.000000000
396	31222122	30020000	1.000000000
397	31222211	30020000	1.000000000
398	31222212	30020000	1.000000000
399	31222221	30020000	1.000000000
400	31222222	30020000	1.000000000

FILE NAME: EXRULES (continued)

401	32121111	30020000	1.00000000
402	32121112	30020000	1.00000000
403	32121121	30020000	1.00000000
404	32121122	30020000	1.00000000
405	32121211	30020000	1.00000000
406	32121212	30020000	1.00000000
407	32121221	30020000	1.00000000
408	32121222	30020000	1.00000000
409	32122111	30020000	1.00000000
410	32122112	30020000	1.00000000
411	32122121	30020000	1.00000000
412	32122122	30020000	1.00000000
413	32122211	30020000	1.00000000
414	32122212	30020000	1.00000000
415	32122221	30020000	1.00000000
416	32122222	30020000	1.00000000
417	32221111	30020000	1.00000000
418	32221112	30020000	1.00000000
419	32221121	30020000	1.00000000
420	32221122	30020000	1.00000000
421	32221211	30020000	1.00000000
422	32221212	30020000	1.00000000
423	32221221	30020000	1.00000000
424	32221222	30020000	1.00000000
425	32222111	30020000	1.00000000
426	32222112	30020000	1.00000000
427	32222121	30020000	1.00000000
428	32222122	30020000	1.00000000
429	32222211	30020000	1.00000000
430	32222212	30020000	1.00000000
431	32222221	30020000	1.00000000
432	32222222	30020000	1.00000000

END OF FILE

PERMANENT FILES

FILE NAME: TYPFILE

1	11111111	ARTYPE4	1.0
2	11111112	ARTYPE4	1.0
3	11111121	ARTYPE4	1.0
4	11111122	ARTYPE4	1.0
5	11111211	ARTYPE4	1.0
6	11111212	ARTYPE4	1.0
7	11111221	ARTYPE4	1.0
8	11111222	ARTYPE4	1.0
9	11112111	ARTYPE4	1.0
10	11112112	ARTYPE4	1.0
11	11112121	ARTYPE4	1.0
12	11112122	ARTYPE4	1.0
13	11112211	ARTYPE4	1.0
14	11112212	ARTYPE4	1.0
15	11112221	ARTYPE4	1.0
16	11112222	ARTYPE4	1.0
17	11121111	ARTYPE4	1.0
18	11121112	ARTYPE4	1.0
19	11121121	ARTYPE4	1.0
20	11121122	ARTYPE4	1.0

FILE NAME: TYPFILE (continued)

21	11121211	ARTYPE4	1.0
22	11121212	ARTYPE4	1.0
23	11121221	ARTYPE4	1.0
24	11121222	ARTYPE4	1.0
25	11122111	ARTYPE4	1.0
26	11122112	ARTYPE4	1.0
27	11122121	ARTYPE4	1.0
28	11122122	ARTYPE4	1.0
29	11122211	ARTYPE4	1.0
30	11122212	ARTYPE4	1.0
31	11122221	ARTYPE4	1.0
32	11122222	ARTYPE4	1.0
33	11211111	ARTYPE3d	1.0
34	11211112	ARTYPE3d	1.0
35	11211121	ARTYPE3d	1.0
36	11211122	ARTYPE3d	1.0
37	11212111	ARTYPE3d	1.0
38	11212112	ARTYPE3d	1.0
39	11212121	ARTYPE3d	1.0
40	11212122	ARTYPE3d	1.0
41	11221111	ARTYPE3d	1.0
42	11221112	ARTYPE3d	1.0
43	11221121	ARTYPE3d	1.0
44	11221122	ARTYPE3d	1.0
45	11222111	ARTYPE3d	1.0
46	11222112	ARTYPE3d	1.0
47	11222121	ARTYPE3d	1.0
48	11222122	ARTYPE3d	1.0
49	11211211	ARTYPE3A	1.0
50	11211212	ARTYPE3A	1.0
51	11211221	ARTYPE3A	1.0
52	11211222	ARTYPE3A	1.0
53	11212211	ARTYPE3A	1.0
54	11212212	ARTYPE3A	1.0
55	11212221	ARTYPE3A	1.0
56	11212222	ARTYPE3A	1.0
57	11221211	ARTYPE3A	1.0
58	11221212	ARTYPE3A	1.0
59	11221221	ARTYPE3A	1.0
60	11221222	ARTYPE3A	1.0
61	11222211	ARTYPE3A	1.0
62	11222212	ARTYPE3A	1.0
63	11222221	ARTYPE3A	1.0
64	11222222	ARTYPE3A	1.0
65	12111111	ARTYPE2	1.0
66	12111112	ARTYPE2	1.0
67	12111121	ARTYPE2	1.0
68	12111122	ARTYPE2	1.0
69	12111211	ARTYPE2	1.0
70	12111212	ARTYPE2	1.0
71	12111221	ARTYPE2	1.0
72	12111222	ARTYPE2	1.0
73	12112111	ARTYPE2	1.0
74	12112112	ARTYPE2	1.0
75	12112121	ARTYPE2	1.0
76	12112122	ARTYPE2	1.0
77	12112211	ARTYPE2	1.0
78	12112212	ARTYPE2	1.0
79	12112221	ARTYPE2	1.0
80	12112222	ARTYPE2	1.0

FILE NAME: TYPFILE (continued)

81	12121111	ARTYPE2	1.0
82	12121112	ARTYPE2	1.0
83	12121121	ARTYPE2	1.0
84	12121122	ARTYPE2	1.0
85	12121211	ARTYPE2	1.0
86	12121212	ARTYPE2	1.0
87	12121221	ARTYPE2	1.0
88	12121222	ARTYPE2	1.0
89	12122111	ARTYPE2	1.0
90	12122112	ARTYPE2	1.0
91	12122121	ARTYPE2	1.0
92	12122122	ARTYPE2	1.0
93	12122211	ARTYPE2	1.0
94	12122212	ARTYPE2	1.0
95	12122221	ARTYPE2	1.0
96	12122222	ARTYPE2	1.0
97	12211111	ARTYPE1	1.0
98	12211112	ARTYPE1	1.0
99	12211121	ARTYPE1	1.0
100	12211122	ARTYPE1	1.0
101	12211211	ARTYPE1	1.0
102	12211212	ARTYPE1	1.0
103	12211221	ARTYPE1	1.0
104	12211222	ARTYPE1	1.0
105	12212111	ARTYPE1	1.0
106	12212112	ARTYPE1	1.0
107	12212121	ARTYPE1	1.0
108	12212122	ARTYPE1	1.0
109	12212211	ARTYPE1	1.0
110	12212212	ARTYPE1	1.0
111	12212221	ARTYPE1	1.0
112	12212222	ARTYPE1	1.0
113	12221111	ARTYPE1	1.0
114	12221112	ARTYPE1	1.0
115	12221121	ARTYPE1	1.0
117	12221122	ARTYPE1	1.0
118	12221211	ARTYPE1	1.0
119	12221212	ARTYPE1	1.0
120	12221221	ARTYPE1	1.0
121	12221222	ARTYPE1	1.0
122	12222111	ARTYPE1	1.0
123	12222112	ARTYPE1	1.0
124	12222121	ARTYPE1	1.0
125	12222122	ARTYPE1	1.0
126	12222211	ARTYPE1	1.0
127	12222212	ARTYPE1	1.0
128	12222221	ARTYPE1	1.0
129	12222222	ARTYPE1	1.0
130	21111111	ARTYPE7	1.0
131	21111112	ARTYPE7	1.0
132	21111121	ARTYPE7	1.0
133	21111122	ARTYPE7	1.0
134	21112111	ARTYPE7	1.0
135	21112112	ARTYPE7	1.0
136	21112121	ARTYPE7	1.0
137	21112122	ARTYPE7	1.0
138	21112111	ARTYPE7	1.0
139	21121111	ARTYPE7	1.0
140	21121121	ARTYPE7	1.0
141	21121122	ARTYPE7	1.0

FILE NAME: TYPFILE (continued)

142	21122111	ARTYPE7	1.0
143	21122112	ARTYPE7	1.0
144	21122121	ARTYPE7	1.0
145	21122122	ARTYPE7	1.0
146	21111211	ARTYPE8	1.0
147	21111212	ARTYPE8	1.0
148	21111221	ARTYPE8	1.0
149	21111222	ARTYPE8	1.0
150	21112211	ARTYPE8	1.0
151	21112212	ARTYPE8	1.0
152	21112221	ARTYPE8	1.0
153	21112222	ARTYPE8	1.0
154	21121211	ARTYPE8	1.0
155	21121212	ARTYPE8	1.0
156	21121221	ARTYPE8	1.0
157	21121222	ARTYPE8	1.0
158	21122211	ARTYPE8	1.0
159	21122212	ARTYPE8	1.0
160	21122221	ARTYPE8	1.0
161	21122222	ARTYPE8	1.0
162	21211111	ARTYPE68	1.0
163	21211112	ARTYPE68	1.0
164	21211121	ARTYPE68	1.0
165	21211122	ARTYPE68	1.0
166	21212111	ARTYPE68	1.0
167	21212112	ARTYPE68	1.0
168	21212121	ARTYPE68	1.0
169	21212122	ARTYPE68	1.0
170	21221111	ARTYPE68	1.0
171	21221112	ARTYPE68	1.0
172	21221121	ARTYPE68	1.0
173	21221122	ARTYPE68	1.0
174	21222111	ARTYPE68	1.0
175	21222112	ARTYPE68	1.0
176	21222121	ARTYPE68	1.0
177	21222122	ARTYPE68	1.0
178	21211211	ARTYPE6A	1.0
179	21211212	ARTYPE6A	1.0
180	21211221	ARTYPE6A	1.0
181	21211222	ARTYPE6A	1.0
182	21212211	ARTYPE6A	1.0
183	21212212	ARTYPE6A	1.0
184	21212221	ARTYPE6A	1.0
185	21212222	ARTYPE6A	1.0
186	21221211	ARTYPE6A	1.0
187	21221212	ARTYPE6A	1.0
188	21221221	ARTYPE6A	1.0
189	21221222	ARTYPE6A	1.0
190	21222211	ARTYPE6A	1.0
191	21222212	ARTYPE6A	1.0
192	21222221	ARTYPE6A	1.0
193	21222222	ARTYPE6A	1.0
194	22111111	ARTYPE58	1.0
195	22111112	ARTYPE58	1.0
196	22111121	ARTYPE58	1.0
197	22111122	ARTYPE58	1.0
198	22112111	ARTYPE58	1.0
199	22112112	ARTYPE58	1.0
200	22112121	ARTYPE58	1.0
201	22112122	ARTYPE58	1.0

FILE NAME: TYPFIL (continued)

202	22121111	ARTYPE50	1.0
203	22121112	ARTYPE50	1.0
204	22121121	ARTYPE50	1.0
205	22121122	ARTYPE50	1.0
206	22122111	ARTYPE50	1.0
207	22122112	ARTYPE50	1.0
208	22122121	ARTYPE50	1.0
209	22122122	ARTYPE50	1.0
210	31111111	ARTYPE10	1.0
211	31111112	ARTYPE10	1.0
212	31111121	ARTYPE10	1.0
213	31111122	ARTYPE10	1.0
214	31111211	ARTYPE10	1.0
215	31111212	ARTYPE10	1.0
216	31111221	ARTYPE10	1.0
217	31111222	ARTYPE10	1.0
218	31112111	ARTYPE10	1.0
219	31112112	ARTYPE10	1.0
220	31112121	ARTYPE10	1.0
221	31112122	ARTYPE10	1.0
222	31112211	ARTYPE10	1.0
223	31112212	ARTYPE10	1.0
224	31112221	ARTYPE10	1.0
225	31112222	ARTYPE10	1.0
226	31121111	ARTYPE10	1.0
227	31121112	ARTYPE10	1.0
228	31121121	ARTYPE10	1.0
229	31121122	ARTYPE10	1.0
230	31121211	ARTYPE10	1.0
231	31121212	ARTYPE10	1.0
232	31121221	ARTYPE10	1.0
233	31121222	ARTYPE10	1.0
234	31122111	ARTYPE10	1.0
235	31122112	ARTYPE10	1.0
236	31122121	ARTYPE10	1.0
237	31122122	ARTYPE10	1.0
238	31122211	ARTYPE10	1.0
239	31122212	ARTYPE10	1.0
240	31122221	ARTYPE10	1.0
241	31122222	ARTYPE10	1.0
242	22111211	ARTYPE50	1.0
243	22111212	ARTYPE50	1.0
244	22111221	ARTYPE50	1.0
245	22111222	ARTYPE50	1.0
246	22112211	ARTYPE50	1.0
247	22112212	ARTYPE50	1.0
248	22112221	ARTYPE50	1.0
249	22112222	ARTYPE50	1.0
250	22121211	ARTYPE50	1.0
251	22121212	ARTYPE50	1.0
252	22121221	ARTYPE50	1.0
253	22121222	ARTYPE50	1.0
254	22122211	ARTYPE50	1.0
255	22122212	ARTYPE50	1.0
256	22122221	ARTYPE50	1.0
257	22122222	ARTYPE50	1.0
258	31211111	ARTYPE10	1.0
259	31211112	ARTYPE10	1.0
260	31211121	ARTYPE10	1.0
261	31211122	ARTYPE10	1.0

FILE NAME: TYPFILE (continued)

262	31211211	ARTYPE15	1.0
263	31211212	ARTYPE15	1.0
264	31211221	ARTYPE15	1.0
265	31211222	ARTYPE15	1.0
266	31212111	ARTYPE15	1.0
267	31212112	ARTYPE15	1.0
268	31212121	ARTYPE15	1.0
269	31212122	ARTYPE15	1.0
270	31212211	ARTYPE15	1.0
271	31212212	ARTYPE15	1.0
272	31212221	ARTYPE15	1.0
273	31212222	ARTYPE15	1.0
274	31221111	ARTYPE15	1.0
275	31221112	ARTYPE15	1.0
276	31221121	ARTYPE15	1.0
277	31221122	ARTYPE15	1.0
278	31221211	ARTYPE15	1.0
279	31221212	ARTYPE15	1.0
280	31221221	ARTYPE15	1.0
281	31221222	ARTYPE15	1.0
282	31222111	ARTYPE15	1.0
283	31222112	ARTYPE15	1.0
284	31222121	ARTYPE15	1.0
285	31222122	ARTYPE15	1.0
286	31222211	ARTYPE15	1.0
287	31222212	ARTYPE15	1.0
288	31222221	ARTYPE15	1.0
289	31222222	ARTYPE15	1.0
290	32111111	ARTYPE13	1.0
291	32111112	ARTYPE13	1.0
292	32111121	ARTYPE13	1.0
293	32111122	ARTYPE13	1.0
294	32112111	ARTYPE13	1.0
295	32112112	ARTYPE13	1.0
296	32112121	ARTYPE13	1.0
297	32112122	ARTYPE13	1.0
298	32121111	ARTYPE13	1.0
299	32121112	ARTYPE13	1.0
300	32121121	ARTYPE13	1.0
301	32121122	ARTYPE13	1.0
302	32122111	ARTYPE13	1.0
303	32122112	ARTYPE13	1.0
304	32122121	ARTYPE13	1.0
305	32122122	ARTYPE13	1.0
306	32111211	ARTYPE14	1.0
307	32111212	ARTYPE14	1.0
308	32111221	ARTYPE14	1.0
309	32111222	ARTYPE14	1.0
310	32112211	ARTYPE14	1.0
311	32112212	ARTYPE14	1.0
312	32112221	ARTYPE14	1.0
313	32112222	ARTYPE14	1.0
314	32121211	ARTYPE14	1.0
315	32121212	ARTYPE14	1.0
316	32121221	ARTYPE14	1.0
317	32121222	ARTYPE14	1.0
318	32122211	ARTYPE14	1.0
319	32122212	ARTYPE14	1.0
320	32122221	ARTYPE14	1.0
321	32122222	ARTYPE14	1.0

FILE NAME: TYPFILE (continued)

322	41111111	ARTYPE11	1.0
323	41111121	ARTYPE11	1.0
324	41121111	ARTYPE11	1.0
325	41121121	ARTYPE11	1.0
326	41111112	ARTYPE11	1.0
327	41111122	ARTYPE11	1.0
328	41121112	ARTYPE11	1.0
329	41121122	ARTYPE11	1.0
330	41111211	ARTYPE12	1.0
331	41111221	ARTYPE12	1.0
332	41121211	ARTYPE12	1.0
333	41121221	ARTYPE12	1.0
334	41111212	ARTYPE12	1.0
335	41111222	ARTYPE12	1.0
336	41121212	ARTYPE12	1.0
337	41121222	ARTYPE12	1.0
338	42111111	ARTYPE9	1.0
339	42111121	ARTYPE9	1.0
340	42121111	ARTYPE9	1.0
341	42121121	ARTYPE9	1.0
342	42111112	ARTYPE9	1.0
343	42111122	ARTYPE9	1.0
344	42121112	ARTYPE9	1.0
345	42121122	ARTYPE9	1.0
346	42111211	ARTYPE10	1.0
347	42111221	ARTYPE10	1.0
348	42121211	ARTYPE10	1.0
349	42121221	ARTYPE10	1.0
350	42111212	ARTYPE10	1.0
351	42111222	ARTYPE10	1.0
352	42121212	ARTYPE10	1.0
353	42121222	ARTYPE10	1.0

END OF FILE

PERMANENT FILES

FILE NAME: TYPROWS

1	N	ARTYPE1
2	N	ARTYPE2
3	N	ARTYPE3A
4	N	ARTYPE3b
5	N	ARTYPE4
6	N	ARTYPE5A
7	N	ARTYPE5b
8	N	ARTYPE6A
9	N	ARTYPE6b
10	N	ARTYPE7
11	N	ARTYPE8
12	N	ARTYPE9
13	N	ARTYPE10
14	N	ARTYPE11
15	N	ARTYPE12
16	N	ARTYPE13
17	N	ARTYPE14
18	N	ARTYPE15
19	N	ARTYPE16

END OF FILE

PERMANENT FILES

FILE NAME: S.SETUP

```

1  C  SOURCE PROGRAM TO REQUEST MARGINAL PROBABILITIES AND SETUP
2  C  CONSTRAINTS SUITABLE FOR THE MPS LINEAR PROGRAMMING PACKAGE
3  C  OUTPUT: 6=TERMINAL 7=CONSTRAINT EQN FILE 8=RHS FILE
4  C  9=OBJECTIVE FN FILE
5  C  2=MPS PROGRAM 3=CONSTRAINT TYPE FILE
6  C
7  C  INITIALIZE
8  C
9  C  DIMENSION LAGN(8), LO(8), LIM(8), A(9),LOUT(8),
10     ILAB(8),LAB2(8),NLAB(8),JJ(8)
11     DATA A/ '1','2','3','4','5','6','7','8','0'/
12     WRITE(8,4)
13     4 FORMAT('RHS')
14     ONE=1.0
15     ZERO=0.
16     NPROBS=0
17     LOOP=1
18  C
19  C  MAKE COLUMNS FOR THE CONSTRAINT SUM=1, WRITE ON -F7
20  C
21     DO 35 I=1,4
22     DO 35 I2=1,2
23     DO 35 I3=1,2
24     DO 35 I4=1,2
25     DO 35 I5=1,2
26     DO 35 I6=1,2
27     DO 35 I7=1,2
28     DO 35 I8=1,2
29     WRITE(7,17) A(I1),A(I2),A(I3),A(I4),A(I5),A(I6),A(I7),A(I8),ONE
30     17 FORMAT(4A,8A1,2A,'SUM',7A,F12.6)
31     35 CONTINUE
32  C
33  C  QUERY FOR MARGINALS
34  C
35     WRITE(6,5)
36     5 FORMAT('1 ENTER MARGINAL AND JOINT PROBABILITIES:EVENT(811),',
37     '1'E OR L OR G, BLANK,F12.6',/' EXAMPLE:30200000E .3 MEANS',
38     '2' PROBI(VA1=3,VAR3=2) = .3',/' ENTER 9 IF NO MORE')
39     60 WRITE(6,19)
40     19 FORMAT(' ?')
41     READ(5,3) (LABIN(J),J=1,8),TYPCON,PROB
42     IF(LABIN(1).EQ.9) GO TO 240
43     3 FORMAT(8I1,A1,F12.6)
44  C
45  C  INITIALIZE LIMITS
46  C
47     260 LO(1)=1
48     LIM(1)=4
49     DO 10 I=2,8
50     LO(I)=1
51     10 LIM(I)=2
52  C
53  C  SET LABEL FOR GIVEN MARGINAL VALUES
54  C
55     DO 20 K=1,3

```

FILE NAME: S.SETUP (continued)

```

56      IF(LA0IN(K).EQ.0) GO TO 25
57      LO(K)=LA0IN(K)
58      LIM(K)=LA0IN(K)
59      LOOT(K)=LA0IN(K)
60      20 CONTINUE
61      C
62      C GENERATE LABELS FOR EVENTS INCLUDED IN MARGINALS
63      C THEN WRITE ONE LINE OF LP DATA INPUT FOR EACH ON -F7
64      C
65      LO1=LO(1)
66      LIM1=LIM(1)
67      LP1=LOOT(1)
68      LP2=LOOT(2)
69      LP3=LOOT(3)
70      LP4=LOOT(4)
71      LP5=LOOT(5)
72      LP6=LOOT(6)
73      LP7=LOOT(7)
74      LP8=LOOT(8)
75      LO4=LO(4)
76      LO5=LO(5)
77      LO6=LO(6)
78      LO7=LO(7)
79      LO8=LO(8)
80      LIM4=LIM(4)
81      LIM5=LIM(5)
82      LIM6=LIM(6)
83      LIM7=LIM(7)
84      LIM8=LIM(8)
85      LO2=LO(2)
86      LIM2=LIM(2)
87      LO3=LO(3)
88      LIM3=LIM(3)
89      DO 30 I1=LO1,LIM1
90      DO 30 I2=LO2,LIM2
91      DO 30 I3=LO3,LIM3
92      DO 30 I4=LO4,LIM4
93      DO 30 I5=LO5,LIM5
94      DO 30 I6=LO6,LIM6
95      DO 30 I7=LO7,LIM7
96      DO 30 I8=LO8,LIM8
97      GO TO (300,272,273,370,372), LOOP
97.2    272 IF(LAB2(I1).NE.11.AND.LAB2(I1).NE.0) GO TO 270
97.6    IF(LAB2(I2).NE.12.AND.LAB2(I2).NE.0) GO TO 270
97.8    IF(LAB2(I3).NE.13.AND.LAB2(I3).NE.0) GO TO 270
97.86   IF(LAB2(I4).NE.14.AND.LAB2(I4).NE.0) GO TO 270
97.92   IF(LAB2(I5).NE.15.AND.LAB2(I5).NE.0) GO TO 270
97.93   IF(LAB2(I6).NE.16.AND.LAB2(I6).NE.0) GO TO 270
97.94   IF(LAB2(I7).NE.17.AND.LAB2(I7).NE.0) GO TO 270
97.95   IF(LAB2(I8).NE.18.AND.LAB2(I8).NE.0) GO TO 270
97.96   GO TO 30
97.964  273 IF(LAB1(I1).NE.11.AND.LAB1(I1).NE.0) GO TO 270
97.968  IF(LAB1(I2).NE.12.AND.LAB1(I2).NE.0) GO TO 270
97.972  IF(LAB1(I3).NE.13.AND.LAB1(I3).NE.0) GO TO 270
97.976  IF(LAB1(I4).NE.14.AND.LAB1(I4).NE.0) GO TO 270
97.98   IF(LAB1(I5).NE.15.AND.LAB1(I5).NE.0) GO TO 270

```

FILE NAME: S.SETUP (continued)

```

97.984 IF(LAB1(1),NE,16,AND,LAB1(1),NE,0) GO TO 270
97.985 IF(LAB1(7),NE,17,AND,LAB1(7),NE,0) GO TO 270
97.992 IF(LAB1(8),NE,18,AND,LAB1(8),NE,0) GO TO 270
97.996 GO TO 30
98 300 WRITE(7,1) A(11),A(12),A(13),A(14),A(15),A(16),A(17),A(18),
99 1A(1P1),A(1P2),A(1P3),A(1P4),A(1P5),A(1P6),A(1P7),A(1P8),ONE
100 1 FORMAT(4A,6A1,2A,6A1,2A,F12.6)
101 30 CONTINUE
102 GO TO 1301,271,271,371,371,LOOP
103 C
104 C WRITE LINE FOR RHS FILE ON -F8
105 C
106 301 WRITE(8,2)A(1P1),A(1P2),A(1P3),
107 1A(1P4),A(1P5),A(1P6),A(1P7),A(1P8),PROD
108 2 FORMAT(4A,'PROBS',2A,6A1,2A,F12.6)
109 C
110 C WRITE LINE FOR 'TYPE OF CONSTRAINT' FILE ON -F3
111 C
112 WRITE(13,16) TYPCON, A(1P1),A(1P2),A(1P3),
113 1A(1P4),A(1P5),A(1P6),A(1P7),A(1P8)
114 16 FORMAT(1X,A1,2A,6A1)
115 NPROBS=NPROBS+1
116 GO TO 00
117 25 LOU(1,1)=9
118 GO TO 20
119 C
120 C FINISH RHS FILE -F8
121 C
122 40 ONE=1.
123 WRITE(8,6) ONE
124 6 FORMAT(4A,'PROBS',5A,'SUM',7A,F12.6)
125 C
126 C ASK FOR NEW ARCHETYPE
127 C FOR WHICH UPPER AND LOWER BOUNDS ARE DESIRED
128 C
129 WRITE(6,23)
130 23 FORMAT(' TO ADD A NEW ARCHETYPE, ENTER 1, ELSE ENTER 0')
131 READ(5,24) NTYPES
132 24 FORMAT(I1)
133 IF(NTYPES.EQ.1) GO TO 200
133.5 220 INDEX=INDEX+1
134 WRITE(6,26) NPROBS,NCONU,INDEX,NTYPES
135 26 FORMAT('TEMPORARY FILES HAVE BEEN CREATED WITH INFORMATION ON ',
136 112,' NEW PROBABILITY CONSTRAINTS',55A,12,
137 2' CONJUNCTIONAL PROBABILITIES',55A,12,' COMPARED EVENTS',
137.5 3/55A,12,' NEW ARCHETYPES')
138 GO TO 210
139 200 WRITE(6,30)
140 30 FORMAT('ENTER ARCHETYPE NAME (FORMAT 8A--8 CHARACTERS)',
141 1'FOR WHICH YOU WISH PROBABILITY BOUNDS',
142 2' NUMBER OF TYPES(12) AND -- ONE TO A LINE --THE TYPES',
143 3/113)',/' EXAMPLE:/' NEWARTYP 03',
144 4/ 11221112/' 12211222/' 22211121')
145 WRITE(6,19)
146 READ(5,9) TYPE1,TYPE2,NCOMP
147 9 FORMAT(2A4,1A,12)
148 DO 70 N=1,NCOMP
149 WRITE(6,19)
150 READ(5,11)COMP1,COMP2

```

FILE NAME: S.SETUP (continued)

```

151      11 FORMAT(2A4)
152      C
153      C WRITE OBJECTIVE FUNCTION COLUMNS FOR LP DATA INPUT ON -F9
154      C
155          WRITE(9,12) COMP1,COMP2,TYPE1,TYPE2,ONE
156      12 FORMAT(4A,2A4,2A,2A4,2A,F12.6)
157      70 CONTINUE
158      GO TO 220
159      C
160      C FINISH 'TYPE OF CONSTRAINT' FILE -F3
161      C
162      210 WRITE(3,18)
163      18 FORMAT(' E SUM',/'COLUMNS')
164      C
165      C WRITE COMMAND FILE -F2
166      C
167          WRITE(2,22) TYPE1,TYPE2
168      22 FORMAT(9A,'MOVE(ARMS','dH'PRUBS'),
169      1/9A,'MOVE(AGGJ','LH',2A4,2H')',/9A,'PRIMAL',/9A,
170      2'SOLUTION',/9A,
171      3'EXIT',/9A,'PEND',/9A)
172      C
173      C WRITE 3 LINES FOR LPDATA FILE -F2
174      C
175          WRITE(2,21) TYPE1,TYPE2
176      21 FORMAT('NAME',1JA,'TERGROUP',/'ROWS',/' N ',2A4)
177      CALL EXIT
178      C
179      C QUERY FOR INEQUALITIES BETWEEN MARGINALS
180      C
181      240 LOOP=2
182      INDEX=1
183      WRITE(6,27)
184      27 FORMAT(' ENTER COMPARED MARGINAL OR JOINT EVENTS',/ ' EXAMPLE:',
185      1'1JJ12JJJG2JJ12JJJJ MEANS PROB(VAR1=1,VAR4=1,VAR5=2)',
186      2'IS GR. THAN PROB(VAR1=2,VAR4=1,VAR5=2)',
187      3' ENTER 9 FOR NO MORE')
188      245 WRITE(6,19)
189      READ(5,26) (LAB1(J),J=1,d),TYPLDn,(LAB2(J),J=1,d)
190      26 FORMAT(8I1,A1,8I1)
191      IF(LAB1(1).EQ.9) GO TO 340
192      DO 250 I=1,d
193      250 LABIN(I)=LAB1(I)
194      ONE=1.
195      GO TO 260
196      270 WRITE(7,29) A(11),A(12),A(13),A(14),A(15),A(16),A(17),A(18),
197      1A(INDEX),ONE
198      29 FORMAT(4A,3A1,2A,7HINEQUAL,A1,2A,F12.6)
199      GO TO 30
200      271 IF(LOOP.EQ.3) GO TO 290
201      LOOP=3
202      DO 280 I=1,d
203      280 LABIN(I)=LAB2(I)
204      ONE=-1.
205      GO TO 260
206      290 WRITE(8,31) A(INDEX),ZERO
207      31 FORMAT(4A,'PRUBS',5A,7HINEQUAL,A1,2A,F12.6)

```

FILE NAME: S.SETUP (continued)

```

206      WRITE(3,32) TYPCON,A1(INDEX)
207      32 FORMAT(1A,A1,2A,7MINEQUAL,A1)
208      INDEX=INDEX+1
209      LOUP=2
210      GO TO 245
211      C
212      C   QUERY FOR CONDITIONAL PROBABILITIES
213      C
214.5    340 NCOUNU=0
215          WRITE(6,33)
216      33 FORMAT(' ENTER CONDITIONAL PROBABILITIES',/' EXAMPLE: ',
217      1*'P1=30.4=2E .37 MEANS PROB(YAK1=3 GIVEN VAR4=2)=.37',/
218      2*' ENTER 99 FOR NO MORE')
219      345 WRITE(6,19)
219.2    LOOP=4
220          READ(5,34) (NLAB(I),I=1,d), TYPCON,PROB
221      34 FORMAT(1A,11),A1,F12.6)
222      IF(NLAB(2).EQ.9) GO TO 40
222.5    NCOUNU=NCOUNU+1
223          K2=NLAB(2)
224          K4=NLAB(4)
225          K6=NLAB(6)
226          Kd=NLAB(d)
227          PHI:=PROB
228          DO 355 K=1,d
229      355  LABIN(K)=0
230          LABI(Kd)=Kd
231          GO TJ 260
231.05   370 JJ(1)=11
231.1    JJ(2)=12
231.15   JJ(3)=13
231.2    JJ(4)=14
231.25   JJ(5)=15
231.3    JJ(6)=16
231.35   JJ(7)=17
231.4    JJ(8)=18
231.45   IF(JJ(K2).EQ.NLAB(4)) GO TO 30
232      372 WRITE(7,39) A(11),A(12),A(13),A(14),A(15),A(16),A(17),A(18),
233      INLAB(1),A(K2),NLAB(3),A(K4),NLAB(5),A(K6),NLAB(7),A(Kd),PHIN
234      39 FORMAT(4A,dA1,2A,dA1,2A,F12.6)
235      GO TO 30
236      371 IF(LOUP.EQ.5) GO TO 390
237          LOUP=5
238          LABIN(K2)=K4
239          PHI:=1.-PROB
240          GO TJ 260
241      390 WRITE(6,2) NLAB(1),A(K2),NLAB(3),A(K4),NLAB(5),A(K6),NLAB(7),A(Kd),
242      1ZER)
243          WRITE(3,16) TYPCON,NLAB(1),A(K2),NLAB(3),A(K4),NLAB(5),A(K6),
244      INLAB(7),A(Kd)
245          GO TJ 345
246      END
END OF FILE

```

TEMPORARY FILES

FILE NAME: -F2

```

1      MOVE(RHS,'PROBS')
2      MOVE(ADBJ,'TESTTYPE')
3      PRIMAL
4      SOLUTION
5      EXIT
6      PEND
7
8      NAME          TERGROUP
9      ROWS
10     N TESTTYPE

```

FILE NAME: -F3

```

1      E 1000000
2      G 4000000
3      L 01000000
4      G 00010000
5      L 00000011
6      G INEQUAL1
7      G P5=101=3
8      E SUM
9      COLUMNS

```

FILE NAME: -F8

```

1      RHS
2      PROBS 1000000 0.700000
3      PROBS 4000000 0.100000
4      PROBS 01000000 0.000000
5      PROBS 00010000 0.000000
6      PROBS 00000011 0.200000
7      PROBS INEQUAL1 0.0
8      PROBS P5=101=3 0.0
9      PROBS SUM 1.000000

```

FILE NAME: -F9

```

1      11111111 TESTTYPE 1.000000
2      22222222 TESTTYPE 1.000000
END OF FILE

```


TEMPORARY FILES

FILE NAME: -F7

1	11111111	SUM	1.000000
2	11111112	SUM	1.000000
3	11111121	SUM	1.000000
4	11111122	SUM	1.000000
5	11111211	SUM	1.000000
6	11111212	SUM	1.000000
7	11111221	SUM	1.000000
8	11111222	SUM	1.000000
9	11112111	SUM	1.000000
10	11112112	SUM	1.000000
11	11112121	SUM	1.000000
12	11112122	SUM	1.000000
13	11112211	SUM	1.000000
14	11112212	SUM	1.000000
15	11112221	SUM	1.000000
16	11112222	SUM	1.000000
17	11121111	SUM	1.000000
18	11121112	SUM	1.000000
19	11121121	SUM	1.000000
20	11121122	SUM	1.000000
21	11121211	SUM	1.000000
22	11121212	SUM	1.000000
23	11121221	SUM	1.000000
24	11121222	SUM	1.000000
25	11122111	SUM	1.000000
26	11122112	SUM	1.000000
27	11122121	SUM	1.000000
28	11122122	SUM	1.000000
29	11122211	SUM	1.000000
30	11122212	SUM	1.000000
31	11122221	SUM	1.000000
32	11122222	SUM	1.000000
33	11211111	SUM	1.000000
34	11211112	SUM	1.000000
35	11211121	SUM	1.000000
36	11211122	SUM	1.000000
37	11211211	SUM	1.000000
38	11211212	SUM	1.000000
39	11211221	SUM	1.000000
40	11211222	SUM	1.000000
41	11212111	SUM	1.000000

FILE NAME: F7 (continued)

42	11212112	SUM	1.000000
43	11212121	SUM	1.000000
44	11212122	SUM	1.000000
45	11212211	SUM	1.000000
46	11212212	SUM	1.000000
47	11212221	SUM	1.000000
48	11212222	SUM	1.000000
49	11221111	SUM	1.000000
50	11221112	SUM	1.000000
51	11221121	SUM	1.000000
52	11221122	SUM	1.000000
53	11221211	SUM	1.000000
54	11221212	SUM	1.000000
55	11221221	SUM	1.000000
56	11221222	SUM	1.000000
57	11222111	SUM	1.000000
58	11222112	SUM	1.000000
59	11222121	SUM	1.000000
60	11222122	SUM	1.000000
61	11222211	SUM	1.000000
62	11222212	SUM	1.000000
63	11222221	SUM	1.000000
64	11222222	SUM	1.000000
65	12111111	SUM	1.000000
66	12111112	SUM	1.000000
67	12111121	SUM	1.000000
68	12111122	SUM	1.000000
69	12111211	SUM	1.000000
70	12111212	SUM	1.000000
71	12111221	SUM	1.000000
72	12111222	SUM	1.000000
73	12112111	SUM	1.000000
74	12112112	SUM	1.000000
75	12112121	SUM	1.000000
76	12112122	SUM	1.000000
77	12112211	SUM	1.000000
78	12112212	SUM	1.000000
79	12112221	SUM	1.000000
80	12112222	SUM	1.000000
81	12121111	SUM	1.000000
82	12121112	SUM	1.000000
83	12121121	SUM	1.000000
84	12121122	SUM	1.000000
85	12121211	SUM	1.000000
86	12121212	SUM	1.000000
87	12121221	SUM	1.000000
88	12121222	SUM	1.000000
89	12122111	SUM	1.000000
90	12122112	SUM	1.000000
91	12122121	SUM	1.000000
92	12122122	SUM	1.000000
93	12122211	SUM	1.000000
94	12122212	SUM	1.000000
95	12122221	SUM	1.000000
96	12122222	SUM	1.000000
97	12211111	SUM	1.000000
98	12211112	SUM	1.000000
99	12211121	SUM	1.000000
100	12211122	SUM	1.000000
101	12211211	SUM	1.000000

FILE NAME:-F7 (continued)

102	12211212	SUM	1.000000
103	12211221	SUM	1.000000
104	12211222	SUM	1.000000
105	12212111	SUM	1.000000
106	12212112	SUM	1.000000
107	12212121	SUM	1.000000
108	12212122	SUM	1.000000
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114	12221112	SUM	1.000000
115	12221121	SUM	1.000000
116	12221122	SUM	1.000000
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119	12221221	SUM	1.000000
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121	12222111	SUM	1.000000
122	12222112	SUM	1.000000
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126	12222212	SUM	1.000000
127	12222221	SUM	1.000000
128	12222222	SUM	1.000000
129	21111111	SUM	1.000000
130	21111112	SUM	1.000000
131	21111121	SUM	1.000000
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133	21111211	SUM	1.000000
134	21111212	SUM	1.000000
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138	21112112	SUM	1.000000
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140	21112122	SUM	1.000000
141	21112211	SUM	1.000000
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143	21112221	SUM	1.000000
144	21112222	SUM	1.000000
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146	21121112	SUM	1.000000
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152	21121222	SUM	1.000000
153	21122111	SUM	1.000000
154	21122112	SUM	1.000000
155	21122121	SUM	1.000000
156	21122122	SUM	1.000000
157	21122211	SUM	1.000000
158	21122212	SUM	1.000000
159	21122221	SUM	1.000000
160	21122222	SUM	1.000000
161	21211111	SUM	1.000000

FILE NAME: -F7 (continued)

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163	21211121	SUM	1.000000
164	21211122	SUM	1.000000
165	21211211	SUM	1.000000
166	21211212	SUM	1.000000
167	21211221	SUM	1.000000
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174	21212212	SUM	1.000000
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177	21221111	SUM	1.000000
178	21221112	SUM	1.000000
179	21221121	SUM	1.000000
180	21221122	SUM	1.000000
181	21221211	SUM	1.000000
182	21221212	SUM	1.000000
183	21221221	SUM	1.000000
184	21221222	SUM	1.000000
185	21222111	SUM	1.000000
186	21222112	SUM	1.000000
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189	21222211	SUM	1.000000
190	21222212	SUM	1.000000
191	21222221	SUM	1.000000
192	21222222	SUM	1.000000
193	22111111	SUM	1.000000
194	22111112	SUM	1.000000
195	22111121	SUM	1.000000
196	22111122	SUM	1.000000
197	22111211	SUM	1.000000
198	22111212	SUM	1.000000
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209	22121111	SUM	1.000000
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211	22121121	SUM	1.000000
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213	22121211	SUM	1.000000
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216	22121222	SUM	1.000000
217	22122111	SUM	1.000000
218	22122112	SUM	1.000000
219	22122121	SUM	1.000000
220	22122122	SUM	1.000000
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FILE NAME: -F7 (continued)

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224	22122222	SUM	1.000000
225	22211111	SUM	1.000000
226	22211112	SUM	1.000000
227	22211121	SUM	1.000000
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229	22211211	SUM	1.000000
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231	22211221	SUM	1.000000
232	22211222	SUM	1.000000
233	22212111	SUM	1.000000
234	22212112	SUM	1.000000
235	22212121	SUM	1.000000
236	22212122	SUM	1.000000
237	22212211	SUM	1.000000
238	22212212	SUM	1.000000
239	22212221	SUM	1.000000
240	22212222	SUM	1.000000
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254	22222212	SUM	1.000000
255	22222221	SUM	1.000000
256	22222222	SUM	1.000000
257	31111111	SUM	1.000000
258	31111112	SUM	1.000000
259	31111121	SUM	1.000000
260	31111122	SUM	1.000000
261	31111211	SUM	1.000000
262	31111212	SUM	1.000000
263	31111221	SUM	1.000000
264	31111222	SUM	1.000000
265	31112111	SUM	1.000000
266	31112112	SUM	1.000000
267	31112121	SUM	1.000000
268	31112122	SUM	1.000000
269	31112211	SUM	1.000000
270	31112212	SUM	1.000000
271	31112221	SUM	1.000000
272	31112222	SUM	1.000000
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277	31121211	SUM	1.000000
278	31121212	SUM	1.000000
279	31121221	SUM	1.000000
280	31121222	SUM	1.000000
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FILE NAME: -F7 (continued)

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284	31122122	SUM	1.000000
285	31122211	SUM	1.000000
286	31122212	SUM	1.000000
287	31122221	SUM	1.000000
288	31122222	SUM	1.000000
289	31211111	SUM	1.000000
290	31211112	SUM	1.000000
291	31211121	SUM	1.000000
292	31211122	SUM	1.000000
293	31211211	SUM	1.000000
294	31211212	SUM	1.000000
295	31211221	SUM	1.000000
296	31211222	SUM	1.000000
297	31212111	SUM	1.000000
298	31212112	SUM	1.000000
299	31212121	SUM	1.000000
300	31212122	SUM	1.000000
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305	31221111	SUM	1.000000
306	31221112	SUM	1.000000
307	31221121	SUM	1.000000
308	31221122	SUM	1.000000
309	31221211	SUM	1.000000
310	31221212	SUM	1.000000
311	31221221	SUM	1.000000
312	31221222	SUM	1.000000
313	31222111	SUM	1.000000
314	31222112	SUM	1.000000
315	31222121	SUM	1.000000
316	31222122	SUM	1.000000
317	31222211	SUM	1.000000
318	31222212	SUM	1.000000
319	31222221	SUM	1.000000
320	31222222	SUM	1.000000
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322	32111112	SUM	1.000000
323	32111121	SUM	1.000000
324	32111122	SUM	1.000000
325	32111211	SUM	1.000000
326	32111212	SUM	1.000000
327	32111221	SUM	1.000000
328	32111222	SUM	1.000000
329	32112111	SUM	1.000000
330	32112112	SUM	1.000000
331	32112121	SUM	1.000000
332	32112122	SUM	1.000000
333	32112211	SUM	1.000000
334	32112212	SUM	1.000000
335	32112221	SUM	1.000000
336	32112222	SUM	1.000000
337	32121111	SUM	1.000000
338	32121112	SUM	1.000000
339	32121121	SUM	1.000000
340	32121122	SUM	1.000000
341	32121211	SUM	1.000000

FILE NAME: -F7 (continued)

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344	32121222	SUM	1.000000
345	32122111	SUM	1.000000
346	32122112	SUM	1.000000
347	32122121	SUM	1.000000
348	32122122	SUM	1.000000
349	32122211	SUM	1.000000
350	32122212	SUM	1.000000
351	32122221	SUM	1.000000
352	32122222	SUM	1.000000
353	32211111	SUM	1.000000
354	32211112	SUM	1.000000
355	32211121	SUM	1.000000
356	32211122	SUM	1.000000
357	32211211	SUM	1.000000
358	32211212	SUM	1.000000
359	32211221	SUM	1.000000
360	32211222	SUM	1.000000
361	32212111	SUM	1.000000
362	32212112	SUM	1.000000
363	32212121	SUM	1.000000
364	32212122	SUM	1.000000
365	32212211	SUM	1.000000
366	32212212	SUM	1.000000
367	32212221	SUM	1.000000
368	32212222	SUM	1.000000
369	32221111	SUM	1.000000
370	32221112	SUM	1.000000
371	32221121	SUM	1.000000
372	32221122	SUM	1.000000
373	32221211	SUM	1.000000
374	32221212	SUM	1.000000
375	32221221	SUM	1.000000
376	32221222	SUM	1.000000
377	32222111	SUM	1.000000
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381	32222211	SUM	1.000000
382	32222212	SUM	1.000000
383	32222221	SUM	1.000000
384	32222222	SUM	1.000000
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386	41111112	SUM	1.000000
387	41111121	SUM	1.000000
388	41111122	SUM	1.000000
389	41111211	SUM	1.000000
390	41111212	SUM	1.000000
391	41111221	SUM	1.000000
392	41111222	SUM	1.000000
393	41112111	SUM	1.000000
394	41112112	SUM	1.000000
395	41112121	SUM	1.000000
396	41112122	SUM	1.000000
397	41112211	SUM	1.000000
398	41112212	SUM	1.000000
399	41112221	SUM	1.000000
400	41112222	SUM	1.000000
401	41121111	SUM	1.000000

FILE NAME: -F7 (continued)

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403	41121121	SUM	1.000000
404	41121122	SUM	1.000000
405	41121211	SUM	1.000000
406	41121212	SUM	1.000000
407	41121221	SUM	1.000000
408	41121222	SUM	1.000000
409	41122111	SUM	1.000000
410	41122112	SUM	1.000000
411	41122121	SUM	1.000000
412	41122122	SUM	1.000000
413	41122211	SUM	1.000000
414	41122212	SUM	1.000000
415	41122221	SUM	1.000000
416	41122222	SUM	1.000000
417	41211111	SUM	1.000000
418	41211112	SUM	1.000000
419	41211121	SUM	1.000000
420	41211122	SUM	1.000000
421	41211211	SUM	1.000000
422	41211212	SUM	1.000000
423	41211221	SUM	1.000000
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427	41212121	SUM	1.000000
428	41212122	SUM	1.000000
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433	41221111	SUM	1.000000
434	41221112	SUM	1.000000
435	41221121	SUM	1.000000
436	41221122	SUM	1.000000
437	41221211	SUM	1.000000
438	41221212	SUM	1.000000
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440	41221222	SUM	1.000000
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442	41222112	SUM	1.000000
443	41222121	SUM	1.000000
444	41222122	SUM	1.000000
445	41222211	SUM	1.000000
446	41222212	SUM	1.000000
447	41222221	SUM	1.000000
448	41222222	SUM	1.000000
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450	42111112	SUM	1.000000
451	42111121	SUM	1.000000
452	42111122	SUM	1.000000
453	42111211	SUM	1.000000
454	42111212	SUM	1.000000
455	42111221	SUM	1.000000
456	42111222	SUM	1.000000
457	42112111	SUM	1.000000
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459	42112121	SUM	1.000000
460	42112122	SUM	1.000000
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FILE NAME: -F7 (continued)

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464	42112222	SUM	1.000000
465	42121111	SUM	1.000000
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467	42121121	SUM	1.000000
468	42121122	SUM	1.000000
469	42121211	SUM	1.000000
470	42121212	SUM	1.000000
471	42121221	SUM	1.000000
472	42121222	SUM	1.000000
473	42122111	SUM	1.000000
474	42122112	SUM	1.000000
475	42122121	SUM	1.000000
476	42122122	SUM	1.000000
477	42122211	SUM	1.000000
478	42122212	SUM	1.000000
479	42122221	SUM	1.000000
480	42122222	SUM	1.000000
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482	42211112	SUM	1.000000
483	42211121	SUM	1.000000
484	42211122	SUM	1.000000
485	42211211	SUM	1.000000
486	42211212	SUM	1.000000
487	42211221	SUM	1.000000
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490	42212112	SUM	1.000000
491	42212121	SUM	1.000000
492	42212122	SUM	1.000000
493	42212211	SUM	1.000000
494	42212212	SUM	1.000000
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497	42221111	SUM	1.000000
498	42221112	SUM	1.000000
499	42221121	SUM	1.000000
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504	42221222	SUM	1.000000
505	42222111	SUM	1.000000
506	42222112	SUM	1.000000
507	42222121	SUM	1.000000
508	42222122	SUM	1.000000
509	42222211	SUM	1.000000
510	42222212	SUM	1.000000
511	42222221	SUM	1.000000
512	42222222	SUM	1.000000
513	11111111	1.000000	1.000000
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516	11111122	1.000000	1.000000
517	11111211	1.000000	1.000000
518	11111212	1.000000	1.000000
519	11111221	1.000000	1.000000
520	11111222	1.000000	1.000000
521	11112111	1.000000	1.000000

FILE NAME: -F7 (continued)

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526	11112212	1.000000	1.000000
527	11112221	1.000000	1.000000
528	11112222	1.000000	1.000000
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530	11121112	1.000000	1.000000
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532	11121122	1.000000	1.000000
533	11121211	1.000000	1.000000
534	11121212	1.000000	1.000000
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536	11121222	1.000000	1.000000
537	11122111	1.000000	1.000000
538	11122112	1.000000	1.000000
539	11122121	1.000000	1.000000
540	11122122	1.000000	1.000000
541	11122211	1.000000	1.000000
542	11122212	1.000000	1.000000
543	11122221	1.000000	1.000000
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546	11211112	1.000000	1.000000
547	11211121	1.000000	1.000000
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556	11212122	1.000000	1.000000
557	11212211	1.000000	1.000000
558	11212212	1.000000	1.000000
559	11212221	1.000000	1.000000
560	11212222	1.000000	1.000000
561	11221111	1.000000	1.000000
562	11221112	1.000000	1.000000
563	11221121	1.000000	1.000000
564	11221122	1.000000	1.000000
565	11221211	1.000000	1.000000
566	11221212	1.000000	1.000000
567	11221221	1.000000	1.000000
568	11221222	1.000000	1.000000
569	11222111	1.000000	1.000000
570	11222112	1.000000	1.000000
571	11222121	1.000000	1.000000
572	11222122	1.000000	1.000000
573	11222211	1.000000	1.000000
574	11222212	1.000000	1.000000
575	11222221	1.000000	1.000000
576	11222222	1.000000	1.000000
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578	12111112	1.000000	1.000000
579	12111121	1.000000	1.000000
580	12111122	1.000000	1.000000
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FILE NAME: -F7 (continued)

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583	12111221	1.000000	1.000000
584	12111222	1.000000	1.000000
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587	12112121	1.000000	1.000000
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592	12112222	1.000000	1.000000
593	12121111	1.000000	1.000000
594	12121112	1.000000	1.000000
595	12121121	1.000000	1.000000
596	12121122	1.000000	1.000000
597	12121211	1.000000	1.000000
598	12121212	1.000000	1.000000
599	12121221	1.000000	1.000000
600	12121222	1.000000	1.000000
601	12122111	1.000000	1.000000
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610	12211112	1.000000	1.000000
611	12211121	1.000000	1.000000
612	12211122	1.000000	1.000000
613	12211211	1.000000	1.000000
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621	12212211	1.000000	1.000000
622	12212212	1.000000	1.000000
623	12212221	1.000000	1.000000
624	12212222	1.000000	1.000000
625	12221111	1.000000	1.000000
626	12221112	1.000000	1.000000
627	12221121	1.000000	1.000000
628	12221122	1.000000	1.000000
629	12221211	1.000000	1.000000
630	12221212	1.000000	1.000000
631	12221221	1.000000	1.000000
632	12221222	1.000000	1.000000
633	12222111	1.000000	1.000000
634	12222112	1.000000	1.000000
635	12222121	1.000000	1.000000
636	12222122	1.000000	1.000000
637	12222211	1.000000	1.000000
638	12222212	1.000000	1.000000
639	12222221	1.000000	1.000000
640	12222222	1.000000	1.000000
641	41111111	4.000000	1.000000

FILE NAME: -F7 (continued)

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644	41111122	40000000	1.000000
645	41111211	40000000	1.000000
646	41111212	40000000	1.000000
647	41111221	40000000	1.000000
648	41111222	40000000	1.000000
649	41112111	40000000	1.000000
650	41112112	40000000	1.000000
651	41112121	40000000	1.000000
652	41112122	40000000	1.000000
653	41112211	40000000	1.000000
654	41112212	40000000	1.000000
655	41112221	40000000	1.000000
656	41112222	40000000	1.000000
657	41121111	40000000	1.000000
658	41121112	40000000	1.000000
659	41121121	40000000	1.000000
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661	41121211	40000000	1.000000
662	41121212	40000000	1.000000
663	41121221	40000000	1.000000
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665	41122111	40000000	1.000000
666	41122112	40000000	1.000000
667	41122121	40000000	1.000000
668	41122122	40000000	1.000000
669	41122211	40000000	1.000000
670	41122212	40000000	1.000000
671	41122221	40000000	1.000000
672	41122222	40000000	1.000000
673	41211111	40000000	1.000000
674	41211112	40000000	1.000000
675	41211121	40000000	1.000000
676	41211122	40000000	1.000000
677	41211211	40000000	1.000000
678	41211212	40000000	1.000000
679	41211221	40000000	1.000000
680	41211222	40000000	1.000000
681	41212111	40000000	1.000000
682	41212112	40000000	1.000000
683	41212121	40000000	1.000000
684	41212122	40000000	1.000000
685	41212211	40000000	1.000000
686	41212212	40000000	1.000000
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688	41212222	40000000	1.000000
689	41221111	40000000	1.000000
690	41221112	40000000	1.000000
691	41221121	40000000	1.000000
692	41221122	40000000	1.000000
693	41221211	40000000	1.000000
694	41221212	40000000	1.000000
695	41221221	40000000	1.000000
696	41221222	40000000	1.000000
697	41222111	40000000	1.000000
698	41222112	40000000	1.000000
699	41222121	40000000	1.000000
700	41222122	40000000	1.000000
701	41222211	40000000	1.000000

FILE NAME: -F7 (continued)

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703	41222221	40000000	1.000000
704	41222222	40000000	1.000000
705	42111111	40000000	1.000000
706	42111112	40000000	1.000000
707	42111121	40000000	1.000000
708	42111122	40000000	1.000000
709	42111211	40000000	1.000000
710	42111212	40000000	1.000000
711	42111221	40000000	1.000000
712	42111222	40000000	1.000000
713	42112111	40000000	1.000000
714	42112112	40000000	1.000000
715	42112121	40000000	1.000000
716	42112122	40000000	1.000000
717	42112211	40000000	1.000000
718	42112212	40000000	1.000000
719	42112221	40000000	1.000000
720	42112222	40000000	1.000000
721	42121111	40000000	1.000000
722	42121112	40000000	1.000000
723	42121121	40000000	1.000000
724	42121122	40000000	1.000000
725	42121211	40000000	1.000000
726	42121212	40000000	1.000000
727	42121221	40000000	1.000000
728	42121222	40000000	1.000000
729	42122111	40000000	1.000000
730	42122112	40000000	1.000000
731	42122121	40000000	1.000000
732	42122122	40000000	1.000000
733	42122211	40000000	1.000000
734	42122212	40000000	1.000000
735	42122221	40000000	1.000000
736	42122222	40000000	1.000000
737	42211111	40000000	1.000000
738	42211112	40000000	1.000000
739	42211121	40000000	1.000000
740	42211122	40000000	1.000000
741	42211211	40000000	1.000000
742	42211212	40000000	1.000000
743	42211221	40000000	1.000000
744	42211222	40000000	1.000000
745	42212111	40000000	1.000000
746	42212112	40000000	1.000000
747	42212121	40000000	1.000000
748	42212122	40000000	1.000000
749	42212211	40000000	1.000000
750	42212212	40000000	1.000000
751	42212221	40000000	1.000000
752	42212222	40000000	1.000000
753	42221111	40000000	1.000000
754	42221112	40000000	1.000000
755	42221121	40000000	1.000000
756	42221122	40000000	1.000000
757	42221211	40000000	1.000000
758	42221212	40000000	1.000000
759	42221221	40000000	1.000000
760	42221222	40000000	1.000000
761	42222111	40000000	1.000000

FILE NAME: -F7 (continued)

762	42222112	40000000	1.000000
763	42222121	40000000	1.000000
764	42222122	40000000	1.000000
765	42222211	40000000	1.000000
766	42222212	40000000	1.000000
767	42222221	40000000	1.000000
768	42222222	40000000	1.000000
769	11111111	01000000	1.000000
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771	11111121	01000000	1.000000
772	11111122	01000000	1.000000
773	11111211	01000000	1.000000
774	11111212	01000000	1.000000
775	11111221	01000000	1.000000
776	11111222	01000000	1.000000
777	11112111	01000000	1.000000
778	11112112	01000000	1.000000
779	11112121	01000000	1.000000
780	11112122	01000000	1.000000
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782	11112212	01000000	1.000000
783	11112221	01000000	1.000000
784	11112222	01000000	1.000000
785	11121111	01000000	1.000000
786	11121112	01000000	1.000000
787	11121121	01000000	1.000000
788	11121122	01000000	1.000000
789	11121211	01000000	1.000000
790	11121212	01000000	1.000000
791	11121221	01000000	1.000000
792	11121222	01000000	1.000000
793	11122111	01000000	1.000000
794	11122112	01000000	1.000000
795	11122121	01000000	1.000000
796	11122122	01000000	1.000000
797	11122211	01000000	1.000000
798	11122212	01000000	1.000000
799	11122221	01000000	1.000000
800	11122222	01000000	1.000000
801	11211111	01000000	1.000000
802	11211112	01000000	1.000000
803	11211121	01000000	1.000000
804	11211122	01000000	1.000000
805	11211211	01000000	1.000000
806	11211212	01000000	1.000000
807	11211221	01000000	1.000000
808	11211222	01000000	1.000000
809	11212111	01000000	1.000000
810	11212112	01000000	1.000000
811	11212121	01000000	1.000000
812	11212122	01000000	1.000000
813	11212211	01000000	1.000000
814	11212212	01000000	1.000000
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816	11212222	01000000	1.000000
817	11221111	01000000	1.000000
818	11221112	01000000	1.000000
819	11221121	01000000	1.000000
820	11221122	01000000	1.000000
821	11221211	01000000	1.000000

FILE NAME: -F7 (continued)

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823	11221221	01000000	1.000000
824	11221222	01000000	1.000000
825	11222111	01000000	1.000000
826	11222112	01000000	1.000000
827	11222121	01000000	1.000000
828	11222122	01000000	1.000000
829	11222211	01000000	1.000000
830	11222212	01000000	1.000000
831	11222221	01000000	1.000000
832	11222222	01000000	1.000000
833	21111111	01000000	1.000000
834	21111112	01000000	1.000000
835	21111121	01000000	1.000000
836	21111122	01000000	1.000000
837	21111211	01000000	1.000000
838	21111212	01000000	1.000000
839	21111221	01000000	1.000000
840	21111222	01000000	1.000000
841	21112111	01000000	1.000000
842	21112112	01000000	1.000000
843	21112121	01000000	1.000000
844	21112122	01000000	1.000000
845	21112211	01000000	1.000000
846	21112212	01000000	1.000000
847	21112221	01000000	1.000000
848	21112222	01000000	1.000000
849	21121111	01000000	1.000000
850	21121112	01000000	1.000000
851	21121121	01000000	1.000000
852	21121122	01000000	1.000000
853	21121211	01000000	1.000000
854	21121212	01000000	1.000000
855	21121221	01000000	1.000000
856	21121222	01000000	1.000000
857	21122111	01000000	1.000000
858	21122112	01000000	1.000000
859	21122121	01000000	1.000000
860	21122122	01000000	1.000000
861	21122211	01000000	1.000000
862	21122212	01000000	1.000000
863	21122221	01000000	1.000000
864	21122222	01000000	1.000000
865	21211111	01000000	1.000000
866	21211112	01000000	1.000000
867	21211121	01000000	1.000000
868	21211122	01000000	1.000000
869	21211211	01000000	1.000000
870	21211212	01000000	1.000000
871	21211221	01000000	1.000000
872	21211222	01000000	1.000000
873	21212111	01000000	1.000000
874	21212112	01000000	1.000000
875	21212121	01000000	1.000000
876	21212122	01000000	1.000000
877	21212211	01000000	1.000000
878	21212212	01000000	1.000000
879	21212221	01000000	1.000000
880	21212222	01000000	1.000000
881	21221111	01000000	1.000000

FILE NAME: -F7 (continued)

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883	21221121	01000000	1.000000
884	21221142	01000000	1.000000
885	21221211	01000000	1.000000
886	21221212	01000000	1.000000
887	21221221	01000000	1.000000
888	21221222	01000000	1.000000
889	21222111	01000000	1.000000
890	21222112	01000000	1.000000
891	21222141	01000000	1.000000
892	21222122	01000000	1.000000
893	21222211	01000000	1.000000
894	21222212	01000000	1.000000
895	21222241	01000000	1.000000
896	21222222	01000000	1.000000
897	31111111	01000000	1.000000
898	31111112	01000000	1.000000
899	31111141	01000000	1.000000
900	31111122	01000000	1.000000
901	31111211	01000000	1.000000
902	31111212	01000000	1.000000
903	31111241	01000000	1.000000
904	31111222	01000000	1.000000
905	31112111	01000000	1.000000
906	31112112	01000000	1.000000
907	31112141	01000000	1.000000
908	31112122	01000000	1.000000
909	31112211	01000000	1.000000
910	31112212	01000000	1.000000
911	31112241	01000000	1.000000
912	31112222	01000000	1.000000
913	31121111	01000000	1.000000
914	31121112	01000000	1.000000
915	31121141	01000000	1.000000
916	31121122	01000000	1.000000
917	31121241	01000000	1.000000
918	31121212	01000000	1.000000
919	31121221	01000000	1.000000
920	31121222	01000000	1.000000
921	31122111	01000000	1.000000
922	31122112	01000000	1.000000
923	31122121	01000000	1.000000
924	31122122	01000000	1.000000
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926	31122212	01000000	1.000000
927	31122221	01000000	1.000000
928	31122222	01000000	1.000000
929	31211111	01000000	1.000000
930	31211112	01000000	1.000000
931	31211141	01000000	1.000000
932	31211142	01000000	1.000000
933	31211121	01000000	1.000000
934	31211122	01000000	1.000000
935	31211221	01000000	1.000000
936	31211142	01000000	1.000000
937	31212111	01000000	1.000000
938	31212112	01000000	1.000000
939	31212141	01000000	1.000000
940	31212122	01000000	1.000000
941	31212211	01000000	1.000000

FILE NAME: F7 (continued)

942	31212212	01000000	1.000000
943	31212221	01000000	1.000000
944	31212222	01000000	1.000000
945	31221111	01000000	1.000000
946	31221112	01000000	1.000000
947	31221121	01000000	1.000000
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950	31221212	01000000	1.000000
951	31221221	01000000	1.000000
952	31221222	01000000	1.000000
953	31222111	01000000	1.000000
954	31222112	01000000	1.000000
955	31222121	01000000	1.000000
956	31222122	01000000	1.000000
957	31222211	01000000	1.000000
958	31222212	01000000	1.000000
959	31222221	01000000	1.000000
960	31222222	01000000	1.000000
961	41111111	01000000	1.000000
962	41111112	01000000	1.000000
963	41111121	01000000	1.000000
964	41111122	01000000	1.000000
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966	41111212	01000000	1.000000
967	41111221	01000000	1.000000
968	41111222	01000000	1.000000
969	41112111	01000000	1.000000
970	41112112	01000000	1.000000
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972	41112122	01000000	1.000000
973	41112211	01000000	1.000000
974	41112212	01000000	1.000000
975	41112221	01000000	1.000000
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977	41121111	01000000	1.000000
978	41121112	01000000	1.000000
979	41121121	01000000	1.000000
980	41121122	01000000	1.000000
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986	41122112	01000000	1.000000
987	41122121	01000000	1.000000
988	41122122	01000000	1.000000
989	41122211	01000000	1.000000
990	41122212	01000000	1.000000
991	41122221	01000000	1.000000
992	41122222	01000000	1.000000
993	41211111	01000000	1.000000
994	41211112	01000000	1.000000
995	41211121	01000000	1.000000
996	41211122	01000000	1.000000
997	41211211	01000000	1.000000
998	41211212	01000000	1.000000
999	41211221	01000000	1.000000
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1001	41212111	01000000	1.000000

FILE NAME: F7 (continued)

1002	41212112	01000000	1.000000
1003	41212121	01000000	1.000000
1004	41212122	01000000	1.000000
1005	41212211	01000000	1.000000
1006	41212212	01000000	1.000000
1007	41212221	01000000	1.000000
1008	41212222	01000000	1.000000
1009	41221111	01000000	1.000000
1010	41221112	01000000	1.000000
1011	41221121	01000000	1.000000
1012	41221122	01000000	1.000000
1013	41221211	01000000	1.000000
1014	41221212	01000000	1.000000
1015	41221221	01000000	1.000000
1016	41221222	01000000	1.000000
1017	41222111	01000000	1.000000
1018	41222112	01000000	1.000000
1019	41222121	01000000	1.000000
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1021	41222211	01000000	1.000000
1022	41222212	01000000	1.000000
1023	41222221	01000000	1.000000
1024	41222222	01000000	1.000000
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1026	11111112	00010000	1.000000
1027	11111121	00010000	1.000000
1028	11111122	00010000	1.000000
1029	11111211	00010000	1.000000
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1039	11112221	00010000	1.000000
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1043	11211121	00010000	1.000000
1044	11211122	00010000	1.000000
1045	11211211	00010000	1.000000
1046	11211212	00010000	1.000000
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1056	11212222	00010000	1.000000
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1059	12111121	00010000	1.000000
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1061	12111211	00010000	1.000000

FILE NAME: -F7(continued)

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1064	12111222	00010000	1.000000
1065	12112111	00010000	1.000000
1066	12112112	00010000	1.000000
1067	12112121	00010000	1.000000
1068	12112122	00010000	1.000000
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1075	12211121	00010000	1.000000
1076	12211222	00010000	1.000000
1077	12211211	00010000	1.000000
1078	12211212	00010000	1.000000
1079	12211221	00010000	1.000000
1080	12211222	00010000	1.000000
1081	12212111	00010000	1.000000
1082	12212112	00010000	1.000000
1083	12212121	00010000	1.000000
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1086	12212212	00010000	1.000000
1087	12212221	00010000	1.000000
1088	12212222	00010000	1.000000
1089	21111111	00010000	1.000000
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1098	21112112	00010000	1.000000
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1100	21112122	00010000	1.000000
1101	21112211	00010000	1.000000
1102	21112212	00010000	1.000000
1103	21112221	00010000	1.000000
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1109	21211211	00010000	1.000000
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1116	21212122	00010000	1.000000
1117	21212211	00010000	1.000000
1118	21212212	00010000	1.000000
1119	21212221	00010000	1.000000
1120	21212222	00010000	1.000000
1121	22111111	00010000	1.000000

FILE NAME: F7 (continued)

1122	22111112	00010000	1.000000
1123	22111121	00010000	1.000000
1124	22111122	00010000	1.000000
1125	22111211	00010000	1.000000
1126	22111212	00010000	1.000000
1127	22111221	00010000	1.000000
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1132	22112122	00010000	1.000000
1133	22112211	00010000	1.000000
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1135	22112221	00010000	1.000000
1136	22112222	00010000	1.000000
1137	22211111	00010000	1.000000
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1176	31211222	00010000	1.000000
1177	31212111	00010000	1.000000
1178	31212112	00010000	1.000000
1179	31212121	00010000	1.000000
1180	31212122	00010000	1.000000
1181	31212211	00010000	1.000000

FILE NAME: F7 (continued)

1182	31212212	00010000	1.000000
1183	31212221	00010000	1.000000
1184	31212222	00010000	1.000000
1185	32111111	00010000	1.000000
1186	32111112	00010000	1.000000
1187	32111121	00010000	1.000000
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1194	32112112	00010000	1.000000
1195	32112121	00010000	1.000000
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1197	32112211	00010000	1.000000
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1199	32112221	00010000	1.000000
1200	32112222	00010000	1.000000
1201	32211111	00010000	1.000000
1202	32211112	00010000	1.000000
1203	32211121	00010000	1.000000
1204	32211122	00010000	1.000000
1205	32211211	00010000	1.000000
1206	32211212	00010000	1.000000
1207	32211221	00010000	1.000000
1208	32211222	00010000	1.000000
1209	32212111	00010000	1.000000
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1211	32212121	00010000	1.000000
1212	32212122	00010000	1.000000
1213	32212211	00010000	1.000000
1214	32212212	00010000	1.000000
1215	32212221	00010000	1.000000
1216	32212222	00010000	1.000000
1217	41111111	00010000	1.000000
1218	41111112	00010000	1.000000
1219	41111121	00010000	1.000000
1220	41111122	00010000	1.000000
1221	41111211	00010000	1.000000
1222	41111212	00010000	1.000000
1223	41111221	00010000	1.000000
1224	41111222	00010000	1.000000
1225	41112111	00010000	1.000000
1226	41112112	00010000	1.000000
1227	41112121	00010000	1.000000
1228	41112122	00010000	1.000000
1229	41112211	00010000	1.000000
1230	41112212	00010000	1.000000
1231	41112221	00010000	1.000000
1232	41112222	00010000	1.000000
1233	41211111	00010000	1.000000
1234	41211112	00010000	1.000000
1235	41211121	00010000	1.000000
1236	41211122	00010000	1.000000
1237	41211211	00010000	1.000000
1238	41211212	00010000	1.000000
1239	41211221	00010000	1.000000
1240	41211222	00010000	1.000000
1241	41212111	00010000	1.000000

FILE NAME: -F7 (continued)

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1244	41212122	00010000	1.000000
1245	41212211	00010000	1.000000
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1247	41212221	00010000	1.000000
1248	41212222	00010000	1.000000
1249	42111111	00010000	1.000000
1250	42111112	00010000	1.000000
1251	42111121	00010000	1.000000
1252	42111122	00010000	1.000000
1253	42111211	00010000	1.000000
1254	42111212	00010000	1.000000
1255	42111221	00010000	1.000000
1256	42111222	00010000	1.000000
1257	42112111	00010000	1.000000
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1259	42112121	00010000	1.000000
1260	42112122	00010000	1.000000
1261	42112211	00010000	1.000000
1262	42112212	00010000	1.000000
1263	42112221	00010000	1.000000
1264	42112222	00010000	1.000000
1265	42211111	00010000	1.000000
1266	42211112	00010000	1.000000
1267	42211121	00010000	1.000000
1268	42211122	00010000	1.000000
1269	42211211	00010000	1.000000
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1271	42211221	00010000	1.000000
1272	42211222	00010000	1.000000
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1275	42212121	00010000	1.000000
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1277	42212211	00010000	1.000000
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1281	11111111	00000011	1.000000
1282	11111211	00000011	1.000000
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1285	11121111	00000011	1.000000
1286	11121211	00000011	1.000000
1287	11122111	00000011	1.000000
1288	11122211	00000011	1.000000
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1296	11222211	00000011	1.000000
1297	12111111	00000011	1.000000
1298	12111211	00000011	1.000000
1299	12112111	00000011	1.000000
1300	12112211	00000011	1.000000
1301	12121111	00000011	1.000000

FILE NAME: -F7 (continued)

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1306	12211211	00000011	1.000000
1307	12212111	00000011	1.000000
1308	12212211	00000011	1.000000
1309	12221111	00000011	1.000000
1310	12221211	00000011	1.000000
1311	12222111	00000011	1.000000
1312	12222211	00000011	1.000000
1313	21111111	00000011	1.000000
1314	21111211	00000011	1.000000
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1316	21112211	00000011	1.000000
1317	21121111	00000011	1.000000
1318	21121211	00000011	1.000000
1319	21122111	00000011	1.000000
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1321	21211111	00000011	1.000000
1322	21211211	00000011	1.000000
1323	21212111	00000011	1.000000
1324	21212211	00000011	1.000000
1325	21221111	00000011	1.000000
1326	21221211	00000011	1.000000
1327	21222111	00000011	1.000000
1328	21222211	00000011	1.000000
1329	22111111	00000011	1.000000
1330	22111211	00000011	1.000000
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1335	22122111	00000011	1.000000
1336	22122211	00000011	1.000000
1337	22211111	00000011	1.000000
1338	22211211	00000011	1.000000
1339	22212111	00000011	1.000000
1340	22212211	00000011	1.000000
1341	22221111	00000011	1.000000
1342	22221211	00000011	1.000000
1343	22222111	00000011	1.000000
1344	22222211	00000011	1.000000
1345	31111111	00000011	1.000000
1346	31111211	00000011	1.000000
1347	31112111	00000011	1.000000
1348	31112211	00000011	1.000000
1349	31121111	00000011	1.000000
1350	31121211	00000011	1.000000
1351	31122111	00000011	1.000000
1352	31122211	00000011	1.000000
1353	31211111	00000011	1.000000
1354	31211211	00000011	1.000000
1355	31212111	00000011	1.000000
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1357	31221111	00000011	1.000000
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1359	31222111	00000011	1.000000
1360	31222211	00000011	1.000000
1361	32111111	00000011	1.000000

FILE NAME: -F7 (continued)

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1364	32112211	00000011	1.000000
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1366	32121211	00000011	1.000000
1367	32122111	00000011	1.000000
1368	32122211	00000011	1.000000
1369	32211111	00000011	1.000000
1370	32211211	00000011	1.000000
1371	32212111	00000011	1.000000
1372	32212211	00000011	1.000000
1373	32221111	00000011	1.000000
1374	32221211	00000011	1.000000
1375	32222111	00000011	1.000000
1376	32222211	00000011	1.000000
1377	41111111	00000011	1.000000
1378	41111211	00000011	1.000000
1379	41112111	00000011	1.000000
1380	41112211	00000011	1.000000
1381	41121111	00000011	1.000000
1382	41121211	00000011	1.000000
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1384	41122211	00000011	1.000000
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1386	41211211	00000011	1.000000
1387	41212111	00000011	1.000000
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1390	41221211	00000011	1.000000
1391	41222111	00000011	1.000000
1392	41222211	00000011	1.000000
1393	42111111	00000011	1.000000
1394	42111211	00000011	1.000000
1395	42112111	00000011	1.000000
1396	42112211	00000011	1.000000
1397	42121111	00000011	1.000000
1398	42121211	00000011	1.000000
1399	42122111	00000011	1.000000
1400	42122211	00000011	1.000000
1401	42211111	00000011	1.000000
1402	42211211	00000011	1.000000
1403	42212111	00000011	1.000000
1404	42212211	00000011	1.000000
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1406	42221211	00000011	1.000000
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1408	42222211	00000011	1.000000
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FILE NAME: F7 (continued)

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1427	21121121	INewJAL1	1.000000
1428	21121122	INewJAL1	1.000000
1429	21121211	INewJAL1	1.000000
1430	21121212	INewJAL1	1.000000
1431	21121221	INewJAL1	1.000000
1432	21121222	INewJAL1	1.000000
1433	21122111	INewJAL1	1.000000
1434	21122112	INewJAL1	1.000000
1435	21122121	INewJAL1	1.000000
1436	21122122	INewJAL1	1.000000
1437	21122211	INewJAL1	1.000000
1438	21122212	INewJAL1	1.000000
1439	21122221	INewJAL1	1.000000
1440	21122222	INewJAL1	1.000000
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1445	21211211	INewJAL1	1.000000
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1458	21221112	INewJAL1	1.000000
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1461	21221211	INewJAL1	1.000000
1462	21221212	INewJAL1	1.000000
1463	21221221	INewJAL1	1.000000
1464	21221222	INewJAL1	1.000000
1465	21222111	INewJAL1	1.000000
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1467	21222121	INewJAL1	1.000000
1468	21222122	INewJAL1	1.000000
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1470	21222212	INewJAL1	1.000000
1471	21222221	INewJAL1	1.000000
1472	21222222	INewJAL1	1.000000
1473	22111111	INewJAL1	1.000000
1474	22111112	INewJAL1	1.000000
1475	22111121	INewJAL1	1.000000
1476	22111122	INewJAL1	1.000000
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FILE NAME: -F7 (continued)

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1483	22112121	INEWJAL1	1.000000
1484	22112122	INEWJAL1	1.000000
1485	22112211	INEWJAL1	1.000000
1486	22112212	INEWJAL1	1.000000
1487	22112221	INEWJAL1	1.000000
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1489	22121111	INEWJAL1	1.000000
1490	22121112	INEWJAL1	1.000000
1491	22121121	INEWJAL1	1.000000
1492	22121122	INEWJAL1	1.000000
1493	22121211	INEWJAL1	1.000000
1494	22121212	INEWJAL1	1.000000
1495	22121221	INEWJAL1	1.000000
1496	22121222	INEWJAL1	1.000000
1497	22122111	INEWJAL1	1.000000
1498	22122112	INEWJAL1	1.000000
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1500	22122122	INEWJAL1	1.000000
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1509	22211211	INEWJAL1	1.000000
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1511	22211221	INEWJAL1	1.000000
1512	22211222	INEWJAL1	1.000000
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1514	22212112	INEWJAL1	1.000000
1515	22212121	INEWJAL1	1.000000
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1522	22221112	INEWJAL1	1.000000
1523	22221121	INEWJAL1	1.000000
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1529	22222111	INEWJAL1	1.000000
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1535	22222221	INEWJAL1	1.000000
1536	22222222	INEWJAL1	1.000000
1537	31111111	INEWJAL1	-1.000000
1538	31111112	INEWJAL1	-1.000000
1539	31111121	INEWJAL1	-1.000000
1540	31111122	INEWJAL1	-1.000000
1541	31111211	INEWJAL1	-1.000000

FILE NAME: -F7 (continued)

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1594	31222112	INEJAL1	-1.000000
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1599	31222221	INEJAL1	-1.000000
1600	31222222	INEJAL1	-1.000000
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FILE NAME: -F7 (continued)

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1625	32122111	INewJAL1	-1.000000
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1650	32221112	INewJAL1	-1.000000
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1656	32221222	INewJAL1	-1.000000
1657	32222111	INewJAL1	-1.000000
1658	32222112	INewJAL1	-1.000000
1659	32222121	INewJAL1	-1.000000
1660	32222122	INewJAL1	-1.000000
1661	32222211	INewJAL1	-1.000000

FILE NAME: -F7 (continued)

1662	32222212	IN64JAL1	-1.000000
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1664	32222222	IN64JAL1	-1.000000
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1666	31112112	P5=1.01=3	-0.500000
1667	31112121	P5=1.01=3	-0.500000
1668	31112122	P5=1.01=3	-0.500000
1669	31112211	P5=1.01=3	-0.500000
1670	31112212	P5=1.01=3	-0.500000
1671	31112221	P5=1.01=3	-0.500000
1672	31112222	P5=1.01=3	-0.500000
1673	31122111	P5=1.01=3	-0.500000
1674	31122112	P5=1.01=3	-0.500000
1675	31122121	P5=1.01=3	-0.500000
1676	31122122	P5=1.01=3	-0.500000
1677	31122211	P5=1.01=3	-0.500000
1678	31122212	P5=1.01=3	-0.500000
1679	31122221	P5=1.01=3	-0.500000
1680	31122222	P5=1.01=3	-0.500000
1681	31212111	P5=1.01=3	-0.500000
1682	31212112	P5=1.01=3	-0.500000
1683	31212121	P5=1.01=3	-0.500000
1684	31212122	P5=1.01=3	-0.500000
1685	31212211	P5=1.01=3	-0.500000
1686	31212212	P5=1.01=3	-0.500000
1687	31212221	P5=1.01=3	-0.500000
1688	31212222	P5=1.01=3	-0.500000
1689	31222111	P5=1.01=3	-0.500000
1690	31222112	P5=1.01=3	-0.500000
1691	31222121	P5=1.01=3	-0.500000
1692	31222122	P5=1.01=3	-0.500000
1693	31222211	P5=1.01=3	-0.500000
1694	31222212	P5=1.01=3	-0.500000
1695	31222221	P5=1.01=3	-0.500000
1696	31222222	P5=1.01=3	-0.500000
1697	32112111	P5=1.01=3	-0.500000
1698	32112112	P5=1.01=3	-0.500000
1699	32112121	P5=1.01=3	-0.500000
1700	32112122	P5=1.01=3	-0.500000
1701	32112211	P5=1.01=3	-0.500000
1702	32112212	P5=1.01=3	-0.500000
1703	32112221	P5=1.01=3	-0.500000
1704	32112222	P5=1.01=3	-0.500000
1705	32122111	P5=1.01=3	-0.500000
1706	32122112	P5=1.01=3	-0.500000
1707	32122121	P5=1.01=3	-0.500000
1708	32122122	P5=1.01=3	-0.500000
1709	32122211	P5=1.01=3	-0.500000
1710	32122212	P5=1.01=3	-0.500000
1711	32122221	P5=1.01=3	-0.500000
1712	32122222	P5=1.01=3	-0.500000
1713	32212111	P5=1.01=3	-0.500000
1714	32212112	P5=1.01=3	-0.500000
1715	32212121	P5=1.01=3	-0.500000
1716	32212122	P5=1.01=3	-0.500000
1717	32212211	P5=1.01=3	-0.500000
1718	32212212	P5=1.01=3	-0.500000
1719	32212221	P5=1.01=3	-0.500000
1720	32212222	P5=1.01=3	-0.500000
1721	32222111	P5=1.01=3	-0.500000

FILE NAME: -F7 (continued)

1722	32222112	P5=101=3	-0.500000
1723	32222121	P5=101=3	-0.500000
1724	32222122	P5=101=3	-0.500000
1725	32222211	P5=101=3	-0.500000
1726	32222212	P5=101=3	-0.500000
1727	32222221	P5=101=3	-0.500000
1728	32222222	P5=101=3	-0.500000
1729	31111111	P5=101=3	0.500000
1730	31111112	P5=101=3	0.500000
1731	31111121	P5=101=3	0.500000
1732	31111122	P5=101=3	0.500000
1733	31111211	P5=101=3	0.500000
1734	31111212	P5=101=3	0.500000
1735	31111221	P5=101=3	0.500000
1736	31111222	P5=101=3	0.500000
1737	31121111	P5=101=3	0.500000
1738	31121112	P5=101=3	0.500000
1739	31121121	P5=101=3	0.500000
1740	31121122	P5=101=3	0.500000
1741	31121211	P5=101=3	0.500000
1742	31121212	P5=101=3	0.500000
1743	31121221	P5=101=3	0.500000
1744	31121222	P5=101=3	0.500000
1745	31211111	P5=101=3	0.500000
1746	31211112	P5=101=3	0.500000
1747	31211121	P5=101=3	0.500000
1748	31211122	P5=101=3	0.500000
1749	31211211	P5=101=3	0.500000
1750	31211212	P5=101=3	0.500000
1751	31211221	P5=101=3	0.500000
1752	31211222	P5=101=3	0.500000
1753	31221111	P5=101=3	0.500000
1754	31221112	P5=101=3	0.500000
1755	31221121	P5=101=3	0.500000
1756	31221122	P5=101=3	0.500000
1757	31221211	P5=101=3	0.500000
1758	31221212	P5=101=3	0.500000
1759	31221221	P5=101=3	0.500000
1760	31221222	P5=101=3	0.500000
1761	32111111	P5=101=3	0.500000
1762	32111112	P5=101=3	0.500000
1763	32111121	P5=101=3	0.500000
1764	32111122	P5=101=3	0.500000
1765	32111211	P5=101=3	0.500000
1766	32111212	P5=101=3	0.500000
1767	32111221	P5=101=3	0.500000
1768	32111222	P5=101=3	0.500000
1769	32121111	P5=101=3	0.500000
1770	32121112	P5=101=3	0.500000
1771	32121121	P5=101=3	0.500000
1772	32121122	P5=101=3	0.500000
1773	32121211	P5=101=3	0.500000
1774	32121212	P5=101=3	0.500000
1775	32121221	P5=101=3	0.500000
1776	32121222	P5=101=3	0.500000
1777	32211111	P5=101=3	0.500000
1778	32211112	P5=101=3	0.500000
1779	32211121	P5=101=3	0.500000
1780	32211122	P5=101=3	0.500000
1781	32211211	P5=101=3	0.500000

FILE NAME: F7 (continued)

17a2	32211212	P3=1.1=3	0.500000
17a3	32211221	P3=1.1=3	0.500000
17a4	32211222	P3=1.1=3	0.500000
17a5	32221111	P3=1.1=3	0.500000
17a6	32221112	P3=1.1=3	0.500000
17a7	32221121	P3=1.1=3	0.500000
17a8	32221122	P3=1.1=3	0.500000
17a9	32221211	P3=1.1=3	0.500000
17a0	32221212	P3=1.1=3	0.500000
17a1	32221221	P3=1.1=3	0.500000
17a2	32221222	P3=1.1=3	0.500000