



INSTITUTE FOR DEFENSE ANALYSES

**The RAMF-SM Stockpile Sizing  
Module: Updated Documentation and  
User's Guide**

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April 2022

Approved for public release;  
distribution unlimited.

IDA Paper P-22696

Log: H 21-000208



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**About this Publication**

This work was conducted by the Institute for Defense Analyses (IDA) under contract HQ0034-14-D-0001, Task DE-6-4333, “Comprehensive Assistance to DLA Strategic Materials in Preparing Reports of the DOD to the Congress and other stakeholders on National Defense Stockpile Requirements and related Assessments,” for the Strategic Materials Office of the Defense Logistics Agency (DLA-Strategic Materials). The views, opinions, and findings should not be construed as representing the official position of either the Department of Defense or the sponsoring organization.

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**Acknowledgments:**

The author wishes to thank the staff of DLA Strategic Materials for their input and guidance. She is also grateful to IDA staff members Dr. David Graham, Dr. Peter Picucci, Ms. Mary Catherine Flythe, and Dr. Michael Rigdon for reviewing this paper.

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## Executive Summary

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The Stockpile Sizing Module (SSM) is a mathematical model, with associated computer program, that constitutes a key portion of the Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM). RAMF-SM is a set of models, procedures, and databases that can be used to assess the risks associated with shortfalls of strategic and critical materials (S&CMs) and to develop and assess methods for mitigating those risks. Developed by the Institute for Defense Analyses (IDA), RAMF-SM has played a key role in the analyses that have supported the Reports to the Congress from the Department of Defense (DOD) concerning requirements for the National Defense Stockpile (NDS) of strategic and critical non-fuel materials (S&CMs). The SSM computes shortfalls of S&CMs that might occur in a national emergency scenario. It has two major parts:

1. The computation of the amounts of supply (of the various materials) available to the United States in the scenario; and
2. Comparison of the available supplies with the demands for the materials to determine material shortfalls. (The demands are determined in an earlier part of RAMF-SM.)

The original version of the SSM was developed in the late 1980s. Over the ensuing decades it has undergone many changes, both in methodology and in computer program structure. However, documentation of the model has not kept pace with these changes. A thorough documentation, IDA Paper P-2867,<sup>\*</sup> was written in 1997, but is now largely out of date. Portions of the updates to the methodology have been described in assorted papers and memos, some of which were officially published while others were not. A “training manual” for the SSM, IDA document D-5270, was written in 2014.<sup>\*\*</sup> That publication is oriented around familiarizing a new user with the SSM and showing the user how to run the model. It includes descriptions of the SSM input files and major output files and provides a sample database. Much of it is still current, but it left out descriptions of some of the lesser-used but still important SSM features. Also, a number of new options and output files have been added to the SSM since then.

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<sup>\*</sup> Tara E. Santmire, *Stockpile Sizing Module Documentation for Version 4.4*. Vol. I: *Theoretical Foundations and User’s Guide*, Vol. II: *SSM Inputs*, and Vol. III: *SSM Outputs*, IDA Paper P-2867 (Alexandria, VA: Institute for Defense Analyses, March 1997).

<sup>\*\*</sup> Robert J. Atwell et al., *Generic Unclassified Stockpile Sizing Module (SSM) Training and Testing for the National Defense Stockpile (NDS) 2015*, IDA Document D-5270 (Alexandria, VA: Institute for Defense Analyses, November 2014).

The purpose of this paper is twofold: first, to familiarize a new user with the SSM enough to be able to set up runs and interpret their output; and second, to consolidate documentation of the methodological changes into one paper. The focus is on the SSM's methodology and file structure rather than the computer program's routines and variables. Some topics are discussed in several places from slightly different viewpoints. This is so the redundancy will enhance the reader's understanding of the SSM.

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# 1. Introduction and Background

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## A. A Note to the Reader: How to Use This Document

This paper provides documentation of the Stockpile Sizing Module (SSM) model and computer program. It is intended to be read in conjunction with an earlier volume of SSM documentation, Institute for Defense Analyses (IDA) Document D-5270.<sup>1</sup> There is much in D-5270 that is valuable, especially the sample input files. However, some names and terminology have changed and some new features have been added to the SSM. Also, the current document includes details about the program inputs, outputs, and methodology that D-5270 was not intended to cover. Overall, someone with intent to learn more about the SSM should read both documents.

Below are some possible tasks a user of the SSM might wish to do with the sections of D-5270 and the current paper that provide information on how to perform them.

### 1. Learning the Context of the SSM and How it is Used in Analyses

Read the Executive Summary of D-5270, Appendix A of the current paper, and the remainder of Chapter 1.

### 2. Run the SSM, Given the Input Data Files

Set up the appropriate directory structure and be sure that the appropriate files are in the appropriate directories (Chapter 4, Section A.1).

Construct a case file following the guidance in Chapter 4, Section A.3, document D-5270, the annotations to D-5270 in Chapter 2, and the discussion of options in Chapter 5, Section A. (It is best to start with a sample case file and edit it.)

Construct a batch file following the guidance in Chapter 4, Section A.2, document D-5270, and the annotations to D-5270 in Chapter 2.

Run the executable program following the guidance in Chapter 4, Section B.1

### 3. Construct Input Data Files

- Read Chapter 4.

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<sup>1</sup> Robert J. Atwell et al., *Generic Unclassified Stockpile Sizing Module (SSM) Training and Testing for the National Defense Stockpile (NDS) 2015*.

- Read the appropriate places in D-5270 that Chapter 4 refers to.
- Read the annotations to D-5270 in Chapter 2.
- Read the places in Chapter 6 that Chapter 4 refers to.

Note: this paper explains the structure and format of the data files, but not the process of developing the actual data values, which come from a variety of government agencies and subject matter experts.

#### **4. Interpret the SSM Output**

Examination of the SSM output is necessary to ascertain the reasons for certain results, the reasons for differences in certain results, and so forth. To learn about the output:

- Read the second part of Chapter 5.
- Read the portions of Chapters 3 and 6 that Chapter 5 refers to.

#### **5. Understand the SSM Methodology**

Interpretation of the SSM results is enhanced by knowledge of the methodology. This whole document deals with methodology in some sense, but Chapters 3 and 6 are especially relevant.

### **B. RAMF-SM and the SSM**

The Stockpile Sizing Module is a mathematical model, with associated computer program and methodology, that implements Substeps 2c and 2d of the Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM). RAMF-SM is a set of models, procedures, and databases that can be used to assess the risks associated with shortfalls of strategic and critical materials (S&CMs) and to develop and assess methods for mitigating those risks. Appendix A contains a precis of RAMF-SM. Substep 2c of RAMF-SM is concerned with determining the shortfalls of S&CMs that might occur in a national emergency scenario. It has two parts:

1. The computation of the amounts of supply (of the various materials) available to the United States in the scenario;
2. Comparison of the available supplies with the demands for the materials to determine material shortfalls. (The demands for materials are determined by RAMF-SM Substep 2b and then input to the SSM.)

The Strategic and Critical Materials Stock Piling Act (50 U.S.C. § 98 et seq.) provides for the establishment and maintenance of a National Defense Stockpile of Strategic and Critical Materials. The NDS is administered by the Defense Logistics Agency Office of Strategic Materials (DLA-SM), which is the sponsor of the work underlying the

development of RAMF-SM. The Act mandates that the Department of Defense submit periodic Requirements Reports to Congress on the status of S&CMs. In various versions, the SSM has been used in studies supporting the Requirements Reports since the late 1980s. The model's name, Stockpile Sizing Module, is a legacy from the early days of these studies when the material shortfalls computed by the model were to be considered as goals for the amounts of material to hold in the National Defense Stockpile. The interpretation now is that the shortfalls represent potential risks to national security; they become candidates for a number of risk mitigation options, of which stockpiling is one possibility.

### **C. Previous SSM Documentation**

The original version of the SSM was developed in the late 1980s. Over the ensuing decades it has undergone many changes, both in methodology and in computer program structure. However, documentation of the model has not kept pace with these changes. A thorough documentation, IDA Paper P-2867,<sup>2</sup> was written in 1997, but is now largely out of date. Portions of the updates to the methodology have been described in assorted papers and memos, some of which were officially published while others were not. A “training manual” for the SSM, IDA document D-5270, was written in 2014.<sup>3</sup> That publication is oriented around familiarizing a new user with the SSM and showing the user how to run the model. It includes descriptions of the SSM input files and major output files, and provides a sample database. Much of that document is still current, but it left out descriptions of some of the lesser-used but still important SSM features. Also, a number of new options and output files have been added to the SSM since then. Nonetheless, as explained in Section A, the current paper should be read in conjunction with it.

### **D. Structure of this Paper**

The purpose of the current paper is twofold: first, to provide enough information to enable a new user to run the current version of the SSM; and second, to consolidate documentation of the methodological changes into one paper.

Chapter 2 consists of one table: a listing of annotations to D-5270 that provides updates and additional details. This chapter should be read side-by-side with D-5270. When additional detail would be helpful, Chapter 2 provides references to discussion in subsequent chapters.

Chapter 3 is an integrated description of the methodology that is used to compute the supplies of materials that are available to the United States in a national emergency. This

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<sup>2</sup> Tara E. Santmire, *Stockpile Sizing Module Documentation for Version 4.4*. Vol. I: *Theoretical Foundations and User's Guide*, Vol. II: *SSM Inputs*, and Vol. III: *SSM Outputs*.

<sup>3</sup> Robert J. Atwell et al., *Generic Unclassified Stockpile Sizing Module (SSM) Training and Testing for the National Defense Stockpile (NDS) 2015*.

chapter touches on several issues that are explained more thoroughly in various places in the subsequent chapters. For a general orientation about what the SSM does, it is advisable to read Chapter 3 before reading the detail-oriented Chapter 2.

Chapter 4 focuses on the SSM input files. It provides more detailed discussions of selected input files—those that had not been sufficiently described in D-5270 and Chapter 2. The combination of D-5270, Chapter 2, and Chapter 4 should provide sufficient information on how to set up input data for the SSM and run the model.

The first part of Chapter 5 discusses some modeling options that are available in the SSM. Some of these options are described in D-5270; others have been added since then. The second part of Chapter 5 describes the output files that the SSM generates.

Chapter 6 provides detail about several methodological issues. The reader is especially referred to Chapter 6, Section F, which addresses Substep 2d of RAMF-SM—responses of the market to material shortfalls—and how the SSM can model these.

This documentation is consistent with SSM Version 12.2, which was prepared in November 2021. The focus is on the SSM's methodology and file structure rather than the computer program's routines and variables. The objective is to familiarize a new user with the SSM enough to be able to set up runs and interpret their output. Some topics are discussed in several places from slightly different viewpoints. This is so the redundancy will enhance the reader's understanding of the SSM.

## 2. Annotations to Document D-5270

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Table 1 provides annotations for the various slides and pages in Document D-5270, indicating selected updates and details. Page numbers mentioned in Table 1 refer to pages *in D-5270*, not in the current paper. The reader is urged to have a copy of D-5270 available and to read Table 1 alongside it.

One publication that is frequently referred to in Table 1 is IDA Document D-5564, *The Material Supply Adjustment Process in RAMF-SM*.<sup>4</sup> That document discusses in detail a number of different procedures that can and should be applied to the “raw” data to generate meaningful input files for the SSM. Those procedures are an essential part of the RAMF-SM data preparation process.

**Table 1. Annotations to IDA Document D-5270**

<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
vi		Concerning the adjustment input files. The “GDPs of Demanding Countries” file has been repurposed as a table of factors to determine delay times in obtaining materials and was renamed Delay Time Factors (input file 4).
11-12	5	Adjustments. The zero-out of supply from adversary countries is also an important decrement. It is implemented on the war damage factors file. See the discussion about slide 28, pages 57-58.
17-18	8	The extension .sbf is mnemonic for “stockpile batch file”; .cas stands for case. The .sbf and .cas files are unformatted text files that have been given those extensions. Use a text editor such as Notepad to edit those files. The use of special extensions is a holdover from pre-Windows days when extensions did not specify the type of file but were treated as an additional part of the file name.
17-18	8	For each case processed, the program sets up a subdirectory of the modeling outputs directory and puts the output files for that case in that subdirectory. The subdirectory name is the case name.
19-20	9	Batch (.sbf) file. The section headers in brackets are hard coded, and should not be changed. The SSM computer program looks for those specific text strings, including the brackets.

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<sup>4</sup> Eleanor L. Schwartz and James S. Thomason, *The Material Supply Adjustment Process in RAMF-SM Step 2*, IDA Document D-5564 (Alexandria, VA: Institute for Defense Analyses, June 2016).

<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
		Several runs (i.e., case file names) can be listed in the [runs] section. This feature allows batch processing. Just list the case file names, one per line.
21ff	10ff	<p>Concerning the case file:</p> <p>The case file is an unformatted text file that has been given the extension .cas. It is sometimes referred to as the “control inputs file” for the run.</p> <p>It is recommended that the case file information be comma-delimited (although the program can also read tab-delimiting). Best practice is to edit it in a text editor such as Notepad, although as D-5270 indicates, it can be edited in Excel. Comma-delimiting can be hard to read, but avoids the use of invisible tab characters. Be sure to avoid commas in the long file names. Commas in the text in the Notes section will be read as text and not as delimiters.</p> <p>The line numbers appearing at the left of the lines in the various sections of the case file should not be changed. The program will read each line number; the specific operations the program performs are based on that line number’s value. The text phrases that appear after the line numbers are for informative purposes only; the program reads and ignores them (they should not contain commas). Similar descriptive phrases are printed on the casedesc.rpt (case description report) output file; see Chapter 5.</p> <p>The case file section titles in brackets, and the brackets (e.g. [notes] on slide 10 and [scenario parameters] on slide 11) should not be changed. The program looks for those specific text strings, including the brackets. However, this portion of the program does not distinguish lowercase from uppercase.</p>
25-26	12	Adjustment parameters. A legacy of early versions of the SSM, these were designed to allow quick sensitivity analyses to be performed. They have not been tested in many years. The current model should be able to interpret them correctly, but they are best left at 1 until further testing can be performed.
27-28	13	<p>Default parameters. The default parameters play an important role in the SSM. The user should read the annotations for pages 51-60 (slides 25-29). The value of 1, or R for the supply political reliability code (now called the supply usability code), is almost always the best value for these parameters.</p> <p>The demand war damage parameter (parameter 1), which was used in the now-non-operative internal market share computation, has been repurposed to serve as a default value for the delay time factors (see Chapter 4, Section C.4).</p>
29-30	14	Default supply parameters. Although this section title is hard-coded within the SSM, it is perhaps misleading; supply usability code methods might be a better title. The different methods specified in this section constitute an important part of the SSM’s modeling power. They are not trivial to explain; see the discussion in Chapter 3, Section B.2.



<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
		<p>The threshold and decrement values are integers (between 0 and 100), which are interpreted as percentages. The decrement percentages for methods 3 and 4 are not reduction factors but actual multipliers. For example, a decrement value of 25 will result in the initial supply value being multiplied by 25%.</p> <p>The most frequently invoked method is the one shown on the slide: method 2 (as shown on the line with initial number 1) with a threshold of 50% (line with initial number 2).</p> <p>The concentration rule has not been invoked since the early 1990s. Its use is not recommended at the present time; keep the values at zero.</p>
31-32	15	<p>Each line in the [files] section contains four fields (in order): the file type number, the file type name, the short file name, and the long file name. The file type numbers are hard-coded and should not be changed; the program uses them to identify the specific type of file being considered. The file type names are for informative purposes only; the SSM reads but ignores them. The short file names have a 12-character limit (not 8); the SSM will look for the file with that name and the extension .txt. The long file names (50-character limit) can provide a brief description of the file.</p> <p>Comma-delimiting can be hard to read, but avoids the use of invisible tab characters. Do not use commas in any of the names or spaces in the short file names.</p> <p>The program looks for the files in the .\database subdirectory of the home directory. The name "database" is hard-coded.</p> <p>In addition to the sample files listed on the slide, there are two optional input data files:</p> <ul style="list-style-type: none"> <li>• 14, US Imports, which is seldom used;</li> <li>• 16, Production-to-Capacity Ratios, which is used in the extra sell and expanded market share calculations, as explained in Chapter 4, Section C.16 and Chapter 6, Section A.</li> </ul> <p>See Chapter 4 for more information about the input files.</p>
33-34	16	<p>The longname.ini file was a legacy from the time the SSM was a Windows program. The long file names listed in the longname.ini file were loaded into a dialog box and the user could click on the file desired. The program would then use the file with the corresponding short file name.</p> <p>In the latest SSM version, the longname.ini file is not used or required.</p>
35-36	17	<p>Materials. The materials listed in this section of the case file will be processed in the order listed, which need not be alphabetical. The SSM output files will display the results in that order. As noted, not all the materials in the material.txt file need be listed in the case file.</p>

<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
		<p>The material names listed here, and those listed in the material.txt file, are the short material names, not the longer descriptive names (see slide 20, pp. 41-42). However, the longer names are used on the output files.</p> <p>Although the sample file simply uses a number for the material names, any name (30 characters or less, no spaces or commas) can be used, e.g. UNOBTAINIUM. Most actual databases have had the short material names shown in all caps, though the SSM is case-insensitive for the input data.</p> <p>If the word “all” (no quotes) appears under the [materials] section header, the program will process all the materials in the material.txt file in the order listed there. Best practice is to list the names on the material.txt file in alphabetical order.</p>
37-38	18	<p>Options. A number of new options have been added to the SSM. All of the current options are discussed in Chapter 5, Section A, to which the reader is referred.</p>
39-40	19	<p>Country list, file country.txt. The United States should be listed with that name. Best practice is to list the countries in alphabetical order.</p> <p>Country names have a limit of 30 characters and should not contain commas (spaces are acceptable).</p> <p>The country spellings that appear in the country.txt file are treated as definitive. If a country name in another input file does not appear in the country.txt file (perhaps due to a misspelling or trailing space), then the program prints a message and terminates in error.</p> <p>The country.txt file should reside in the database subdirectory.</p>
41-42	20	<p>The file of material-specific information is generally called the Basic Information file. It is one of the formal input files to the SSM (input file 12); its name is input on the case file.</p> <p>The file is a tab-delimited text file that is best viewed and edited in Excel. The figure in the slide is from Notepad and doesn’t show the column lineup completely correctly. This remark also applies to slides 23, 25, 26, 27, 28, 29, and 31.</p> <p>Short material names have a limit of 30 characters; long (i.e., descriptive) material names have a limit of 75 characters; units of measure have a limit of 25 characters. To avoid parsing problems, do not use spaces or commas in the short material names and do not use commas in the units of measure or long material names (semicolons are acceptable).</p> <p>The short material names are used in the SSM input files; the SSM output files show the long material names.</p> <p>All material demand and supply amounts in the various input files must be expressed in the units of measure shown in the Basic Information file. (The word “target” in the header has no significance.)</p>

Pages	Slide	Comments
45-46	22	<p>The material prices are usually developed by the sponsor and generally reflect current market values. The user should check that the prices are consistent with the units of measure.</p> <p>U.S. material supply. Generally, these values indicate the <i>capacity</i> to supply material. For the first scenario year, however, the supply values are often adjusted downward to model the time needed to ramp up to full capacity. Other adjustments can be made to ensure that the input demand and supply values are not in too much imbalance. These adjustments must be made by the user during the data preparation process, before input to the SSM. The process is explained in IDA Document D-5564.</p> <p>In addition, some of the U.S. supply might be reduced or zeroed because of domestic single point of failure (DSPOF) considerations. These reductions are specified by the sponsor and must be implemented during the data preparation process prior to input to the SSM.</p> <p>Although concerted programs (restarts and new starts) have not been used in the last few Requirements Report cycles, some words about the SSM's treatment of them are in order. See the discussion in Chapter 6, Section B. The second and third sections of columns of the U.S. supply file concern concerted programs.</p>
47-48	23	<p>Foreign material supply. Like the U.S. supply, the values generally indicate the country's <i>capacity</i> to supply material, but are often adjusted downward in the first scenario year to model the time needed to ramp up to full capacity. Other adjustments might need to be made during the data preparation process, as discussed in IDA Document D-5564.</p> <p>The United States should not appear as a country in the foreign material supply file.</p>
49-50		<p>Decrement factors. A general note: although frequently referred to as decrement factors, the values for ability factors, pro-U.S. (willingness) factors, war damage factors, and shipping loss factors specify the portion of supply that is <i>undecrement</i>ed. For example, a war damage factor of 0.8 means that 20% of the supply capability is unavailable due to the effects of conflict (and 80% of the capability is still operational). The factors operate in a multiplicative manner.</p>
51-52	25	<p>Although it had traditionally been used, the term supply political reliability codes is misleading. Supply usability codes is a better name for this file and will be used in subsequent chapters of this paper.</p> <p>The words Assured, Reliable, and Unreliable should be regarded as terms of art specific to the SSM. In the current paper, they are capitalized to emphasize this interpretation.</p> <p>Strictly speaking, the A and R supply usability codes do not model decrements to supply; rather, they affect how available supply can be used.</p>

<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
		<p>Countries not listed in the file receive the default usability code listed in the [default parameters] section of the case file (parameter 4), which frequently is R.</p> <p>The code value in the file and the default code value are initial values only; the usability of the country’s available supply can be affected by several other factors. See the discussion in Chapter 3, Section B.2.</p>
53-54	26	<p>At times, the political reliability factors are referred to as supply ability factors, ability factors, or infrastructure reliability factors. These terms are used synonymously. The SSM code uses Supply Ability Factors as the file type name.</p> <p>The values are generally classified.</p> <p>Countries not listed in the file receive the default value listed in the [default parameters] section of the case file (parameter 5, called in the example, somewhat misleadingly, supply infrastructure code). It is good practice, however, to try to determine a factor value for each country, especially those that produce materials.</p> <p>Misleadingly, the slide shows the United States listed. The SSM is not intended to apply an ability factor to U.S. supply. If appropriate, diminution of U.S. supply can be accomplished by adjusting the U.S. supply inputs. The SSM will ignore the United States line.</p>
55-56	27	<p>The terms “pro-U.S. factors” and “willingness factors” are used synonymously. In the context of the SSM, “willingness” denotes willingness of a given country to supply material <i>to the U.S.</i>, and is an indicator of pro-U.S. sentiment.</p> <p>The values, if used, are generally classified.</p> <p>Countries not listed in the file receive the default value listed in the [default parameters] section of the case file (parameter 6, supply_pro_US_factors).</p> <p>For the 2021 Requirements Report study, per a decision by the sponsor, the willingness factors were not used. The file had a header line only, and every country received the default value of 1, indicating perfect willingness.</p>
57-58	28	<p>War damage factors.</p> <p>In general, the war damage factor values are classified.</p> <p>Often it is desired to model the complete shutoff or zero-out of materials from the designated adversary countries during some part of the scenario (generally the first year or first two years). Instead of having a separate input to model this shutoff, the SSM uses the war damage factor. The adversary country or countries should be listed in the war damage factors file with a value of zero for the years of shutoff, and the appropriate war damage factor for the other scenario years.</p>

<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
		<p>Countries not listed in the file receive the default value listed in the [default parameters] section of the case file (parameter 2, supply_war_damage). This default value is generally 1, indicating no war damage.</p> <p>Misleadingly, the slide shows the United States listed. The SSM will ignore that line. If appropriate, diminution of U.S. supply due to homeland damage can be accomplished by adjusting the U.S. supply inputs, not the war damage factors.</p>
59-60	29	<p>The shipping loss factors are often classified.</p> <p>Countries not listed in the file receive the default value listed in the [default parameters] section of the case file (parameter 3, shipping_loss_factor). This default value is generally 1, indicating no shipping losses.</p>
61-62	30	<p>U.S. market shares.</p> <p>Each market share is a value between 0 and 1, inclusive rather than a percentage. Every modeled material should be listed; no default values are applied.</p> <p>An explicit market share file (input file 13) should be input. The internal SSM routine that had been an option for computing market share is now non-operational, and some of the input files used by it have been repurposed.</p> <p>IDA Document D-5564 provides an in-depth discussion of the “three market share calculation methods” mentioned on page 62 (of D-5270), and shows how to use them to develop values for the market share inputs.</p> <p>The “decrement factors” referred to on line 4 of page 62 only refer to certain factors used to decrement GDPs (Gross Domestic Product), as discussed in D-5564. They do <i>not</i> refer to the supply ability and other factors discussed on pages 49-60.</p> <p>The extra capacity market share and extra sell calculations use the input market share value as a starting point. See the discussion in Chapter 6, Section A.</p> <p>Several of the SSM input files that had been used in the internal market share computation have been repurposed for other uses. The Demand Factor Political Reliability file (input file 3) is now called the Extra Sell Countries file; it contains a list of countries from which extra sell is allowed. The GDP of Demanding Countries file (input file 4; see below) has been renamed and repurposed to contain factors that affect the delay time of material delayed due to country unwillingness. See the discussion in Chapter 4, Sections C.3 and C.4. These are required SSM input files.</p> <p>The Foreign Demanders file (input file 1) and Demand Factor War Damage file (input file 2) are no longer required input files for the SSM; any input file specified for these file types will be ignored. The information that was contained in these files is used in the offline calculation of the input market share values, as discussed in D-5564.</p>

Pages	Slide	Comments
63-64	31	<p>Country Gross Domestic Products</p> <p>The SSM input file entitled GDPs of Demanding Countries (input file 4) has been repurposed to contain factors that affect the delay time of material delayed due to country unwillingness. Accordingly, it has been renamed the Delay Time Factors file. The sample file is consistent with this repurposing.</p> <p>Countries not listed in the file receive the value of the first parameter (parameter 1) in the [default parameters] section of the case file. Formerly called the demand war damage parameter and used in the now-non-operative internal market share computation, the parameter has been repurposed to serve as a default value for the delay time factors; 1 is a good default value.</p> <p>See the discussion in Chapter 4, Section C.4, which provides more detail and explication of the issues involved.</p> <p>As of now, GDP information is collected from the CIA [Central Intelligence Agency] World Factbook<sup>5</sup>, but is used offline in preparing the market share file (input file 13) rather than as explicit input to the SSM. See IDA Document D-5564.</p>
67-68	33	<p>The material demand input file is calculated by a separate computer program (named, appropriately, the Material Demand Computation Program (MDCP)). The output files of MDCP are ready to be input to the SSM with no further editing. The MDCP implements Substep 2b of RAMF-SM and also part of Substep 2d; separate MDCP output files are produced for each combination of market responses that affects demand (see Chapter 6, Section F).</p> <p>Description of the MDCP is contained in IDA Document D-5477 and in IDA Paper P-22689.<sup>6</sup></p>
71-72	35	<p>The last section of the case file specifies which output reports are desired. This section has the header line [selected reports], a hard-coded text string (including the brackets).</p> <p>Many of the output reports have an associated number, and the user can select the output reports desired by number. It is recommended, however, that the user simply have the word “all” (not in quotes) appear below the header line. The SSM will then generate all of the output files.</p>

<sup>5</sup> “The World Factbook,” United States Central Intelligence Agency Website, accessed April 2020, <http://www.cia.gov/the-world-factbook/>.

<sup>6</sup> Eleanor L. Schwartz and James S. Thomason, *Computation of Material Demand in the Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM) Process*, IDA Document D-5477 (Alexandria, VA: Institute for Defense Analyses, August 2015). Eleanor L. Schwartz, *The RAMF-SM Material Demand Computation Program: Documentation and User’s Guide*, IDA Paper P-22689 (Alexandria, VA: Institute for Defense Analyses, March 2022).

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<b>Pages</b>	<b>Slide</b>	<b>Comments</b>
		In recent years, a number of new output reports have been added to the SSM, some of which do not have an associated number. Chapter 5, Section B provides a discussion of all the output reports.
75	37	The second sub-bullet is not completely accurate. For each case, the program sets up a subdirectory under the output file directory that is specified in the batch file. The subdirectory name is the case name and the output files for that case are put in that subdirectory. Rerunning a case with the “delete old output” option will delete old output files in that case subdirectory only. There is no need to rename output files before rerunning a case.
81	41	In the first bullet, first sub-bullet, both the Forces Mobilization Model (FORCEMOB) and the MDCP would need to be rerun in order to generate the revised material requirements.

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### 3. SSM Methodology—Calculation of Available Material Supply

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#### A. Introduction and Terminology

This chapter describes the procedure the Stockpile Sizing Module uses to compute available material supply. This computation constitutes the first part of Substep 2c of RAMF-SM. In the second part of Substep 2c, the available material supply is compared to material demand to determine shortfalls, as discussed in Chapter 6, Section D.

The SSM, via its input files and parameters, has a number of options that can be exercised to model a variety of assumptions about supply availability and usability. Recent improvements to the SSM have resulted in several additional options being available. This chapter attempts to touch on them all.

Note that the SSM treats different materials independently of one another.

#### 1. SSM Basics

The SSM is designed to compute material shortfalls during an emergency scenario. The scenario takes place over a multi-year period. The starting year of the scenario (a calendar year, such as 2021) and the number of years in the scenario period are read from the case file. Generally, the inputs vary by scenario year and different output quantities are computed for each scenario year.

The SSM separates material demand into three broad categories, or tiers: military demand, emergency investment demand, and civilian demand. Substep 2b of RAMF-SM computes the demands by material, tier, and scenario year, and writes them on a file, which is one of the input files to the SSM (input file 10).<sup>7</sup> For material supply, the SSM keeps track of domestic (U.S.) supply and foreign supply by country. Separate values are tracked for each year of the scenario period. The model distinguishes between “totally-usable” supply, which can be used to satisfy any type of demand (defense, emergency investment, or civilian) and “civilian-usable-only” supply that can satisfy only civilian demand. In previous SSM versions, this distinction applied to foreign supply only; now it also applies to domestic supply.

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<sup>7</sup> File numbers in this chapter refer to the identifier numbers used in the [files] section of the SSM case file for the various input data files. The discussion of those files in Chapter 4 also uses those identifier numbers.

Via its input files, the SSM accepts initial values of domestic supply and foreign supply. The total amount of domestic supply is not decremented from its input value. Foreign supply is subject to a number of decrement and delay factors (explained in context below); the available foreign supply after these factors have been applied can be considerably less than the initial value. The SSM also computes, based on certain inputs, the portions of foreign and domestic supply that are civilian-usable-only.

Previous versions of the SSM satisfied demand in the strict priority order: defense demands, then emergency investment demands, then civilian demands, subject to the proviso that civilian-usable-only supply could not be used to satisfy the first two types of demand. Recent changes to the SSM can model a delay time in allowing defense demand to get strict priority for satisfaction. This is done by first computing the available supply in the previous manner and then reassigning some of the totally-usable available supply to civilian-usable-only status.<sup>8</sup> The amount reassigned depends on the delay time. Accordingly, the computation of available supply is best described as a two-stage process: Stage 1 is the previous procedure to compute available supply and Stage 2 is the reassignment process. The description in this chapter follows this organization.

## 2. Terminology

The traditional terminology was consistent with three categories of supply:

- “Domestic” supply, which was assumed to be totally-usable and completely available;
- “Assured” supply—available foreign supply that was totally-usable;
- “Reliable” supply—available foreign supply that was civilian-usable only.

This terminology will be used for the quantities that Stage 1 of the process computes. The words Assured and Reliable will be capitalized to emphasize that they are terms of art. (“Domestic” is an actual word, referring to U.S. supply.) The available country-by-country Assured and Reliable foreign supplies resulting from Stage 1 are summed over country to form total pools of Assured and Reliable foreign supplies. The Stage 2 algorithm is then applied to these total pools.

As noted above, Stage 2 reassigns some domestic supply and some Assured supply to civilian-usable-only status. The results of Stage 2 can be regarded as:

- Domestic totally-usable supply (subset of initial domestic supply);
- Foreign totally-usable supply (subset of Assured supply);

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<sup>8</sup> The methodology is explained in James S. Thomason, Michael F. Niles, Justin M. Lloyd, and Eleanor L. Schwartz, “*Defense Demand First*” *Prioritization Uncertainty Analysis and Stockpile Sizing Module Enhancements*, IDA Paper P-10451 (Alexandria, VA: Institute for Defense Analyses, March 2019).

- Civilian-usable-only supply (includes Reliable supply from Stage 1, plus those portions of the initial domestic and Assured foreign supply that were reassigned).

One might call the initial domestic supply “potentially-totally-usable domestic supply,” some of which becomes totally-usable. Similarly, one might call the Assured supply “potentially-totally-usable foreign supply.” The simple words “domestic” and “Assured” are less cumbersome. Reliable supply can be thought of as interim civilian-usable-only supply; Stage 2 increments the interim value by portions of the domestic and Assured supply.

“Vectors” refer to arrays by year of the scenario. E.g., a vector of Assured supply from country X refers to a set of amounts of Assured supply from country X in the first scenario year, Assured supply from country X in the second scenario year, and so forth. Most of the decrement and delay factors that are inputs to the SSM vary by scenario year.

### **3. Relevant SSM Input Files**

This section discusses briefly the major input files to the SSM that affect material supply availability. The purpose of this section is to aid the reader’s understanding of the methodology. Chapter 4 contains a more comprehensive description of the input files.

#### **a. U.S. Supply File (input file 11)**

The U.S. supply file contains amounts of U.S. supply for each combination of material and year of the scenario. The SSM defaults missing values to zero, so materials that the U.S. does not produce need not be listed. The file has space to include material arising from concerted programs, but this option has not been exercised in recent years. (See Chapter 6, Section B for more information on concerted programs.)

The values in the file are the *end result* of all the material supply adjustments such as peacetime equilibrium adjustment and ramp-up, as discussed in IDA Document D-5564. Reductions or zeroing of U.S. supply due to DSPOF considerations, as specified by the sponsor, must also be reflected in the input values; the SSM itself does not model such decrementation.

#### **b. Foreign Supply File (input file 5)**

The foreign supply file contains initial amounts of supply for each combination of foreign country, material, and year of the scenario. Only those countries that produce a given material need be listed. The values are the *end result* of all the material supply adjustments such as peacetime equilibrium adjustment and ramp-up, as discussed in IDA Document D-5564 (but not the decrement factors, which the SSM applies). Each line of

the foreign supply file contains a material name, a country name, and a vector of the amounts of that material supplied by that country.

**c. Market Share File (input file 13)**

In the context of RAMF-SM, the term “market share” refers to the fraction of foreign supply that the U.S. can obtain after the other decrement factors have been considered. The market share file contains separate values for each combination of material and scenario year. Each value should be between 0 and 1, inclusive. The construction of the market share values is discussed in IDA Document D-5564. The input values should not include consideration of extra capacity market share and extra sell; these effects are calculated within the SSM itself (see Chapter 6, Section A).

**d. Supply Usability Codes File (input file 7)**

This file plays an important role in the determination of what kinds of demand the available material supplies can satisfy. The reader is strongly encouraged to read the description of this file in Chapter 4, Section C.7. Below is a brief summary.

The file is a matrix of code letter values. Rows correspond to countries, columns to the years of the scenario. For each country/year combination listed, the file specifies a code value:

A = “Assured”—supply can satisfy demand in all tiers;

R = “Reliable”—supply can satisfy civilian demand only;

U = “Unreliable”—supply cannot be used at all.

As noted earlier, the words Assured, Reliable, and Unreliable should be interpreted as terms of art. Countries not listed in the file receive the default usability code value specified in the [default parameters] section of the case file (parameter 4). In fact, the supply usability code file often has few entries; the default code, which generally is R, is used most of the time. These inputs seldom vary by year, although the model allows them to. The set of countries that are given an Assured value in the file is called the assured country list.

For each material/country/year combination, the SSM assigns an initial usability code value based on the country and year using the file value or the default value. This initial code is the springboard for a number of important calculations, as explained in Section B.

**e. Other Files**

Other decrement and delay factors files include the:

- War damage factors file (input file 6),
- Ability factors file (ability to supply material) (input file 8),

- Willingness factors file (willingness to supply material to the U.S.) (input file 15),
- Shipping loss factors file (input file 9),
- Delay time adjustment factors file (input file 4).

All of these files specify separate values for each combination of country and scenario year. Countries not listed in a file receive the default value specified in the case file ([default parameters] section) for the SSM run. Note that although referred to as decrement factors, the first four files specify the portion of supply that is *undecremented*. E.g., a war damage factor of 0.8 means that 80% of the supply is *not* degraded by conflict-related damage. The factors interact as explained in Section B.2.d.

## B. Stage 1 Calculations

This section describes the Stage 1 calculations of available foreign supply. The end result of Stage 1 is two vectors for each material:

- Assured supply by year, total over all foreign countries.
- Reliable supply by year, total over all foreign countries.

### 1. Initial Work

At the outset, the SSM sets up vector variables (by year) for the Assured and Reliable supply quantities for each material, and initializes them to zero.

A preliminary read of the input foreign supply file (input file 5) is then performed. As noted earlier, each line of the foreign supply file specifies a material name, a country name, and a vector of foreign supply amounts by year (for that material from that country). The program sums these values over country to compute a total initial foreign supply for each combination of material and year.<sup>9</sup> The U.S. supply file (input file 11) is also read; it specifies an initial U.S. supply amount for each material/year combination. (The current facilities levels of U.S. supply are used; concerted programs are not included.<sup>10</sup>) A total world supply is computed as the sum of the U.S. and foreign supply amounts for each material/year combination.

The program then opens the foreign supply file again and reads it line by line. Each line contains a material name, a country name, and a vector of initial supply amounts for

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<sup>9</sup> The values are used as they appear on the foreign supply file before any decrement and delay factors have been applied. The first-year values in that file might be less than capacity to reflect ramp-up; see Eleanor L. Schwartz and James S. Thomason, *The Material Supply Adjustment Process in RAMF-SM Step 2*.

<sup>10</sup> See Chapter 6, Section B for more information about concerted programs and their use by the SSM.

each scenario year. For a given line, the program sets up two vectors (by scenario year) for that material/country combination to hold the Assured supply and Reliable supply values. The vectors are initialized to zero. The program then enters a loop on scenario year. On a given pass of the loop, the procedure applies the calculations described in Section B.2 to the supply (for the given material/country combination) that originates in that year (which, not surprisingly, can be called the year of origination). Those calculations result in increments to the values in the working vectors. Because of delays in supply arrival, values for years after the year of origination might be incremented. After all the scenario years have been processed, the result is vectors of amounts of Assured and Reliable supply, by year, of that material from that country that are available to the United States.

## **2. Calculations Dependent on Material/Country/Year Combination**

### **a. Determination of Initial Supply Value and Usability Code**

For the given material/country/year combination, an initial supply value is set to the entry in the foreign supply file for that combination. An initial usability code is set to the value for that country/year combination in the input supply usability codes file (input file 7). If the country does not appear in that file, the default code for that year from the [default parameters] section of the case file is used. The program allows these input code usability values to vary by year, but they seldom do.

### **b. Determination of Final Usability Code and Interim Supply Value**

From the initial usability code and supply value, the usability code methods are applied to determine a final usability code and an interim supply value for the year in question. The interim supply value might be equal to the initial supply value, or it might be less. The usability code methods and their associated parameters are specified in the [default supply parameters] section of the case file. The subsequent paragraphs explain how these methods operate.

First of all, a usability code of U denotes *total* unreliability and indicates that supply from the country in question is not to be used. The code stays U and the interim supply value is set to zero. The use of the U code is not necessary; the same effect can be accomplished by setting the war damage or ability factor for the country to zero.

If the initial usability code is A (“Assured”), the code stays A and the interim supply value is set to the initial supply value.

The interesting cases occur when the initial usability code is R (“Reliable”), which in context means somewhat reliable or fairly reliable. The subsequent treatment depends on the usability code method chosen and the percentage of total world supply that the country in question provides. The usability code method is selected on the first line of the [default

supply parameters] section of the case file. The total world supply was computed as described in Section B.1. The program computes a “world supply percentage” as the ratio of the initial supply value to the total world supply (of the material being processed) for the given scenario year. The thresholds and decrementation factors associated with the usability code methods are input in the [default supply parameters] section of the case file. They are integers that are to be interpreted as percentages. Caution: there are three different kinds of percentages in use here—the world supply percentage, the threshold percentages, and the decrement percentage. The code methods and percentages affect the interim material supply value as follows.

1. If Method 1 is used, the code remains R and the interim supply value is set to the initial supply value.
2. If Method 2 is used, and the world supply percentage is less than the threshold percentage, the code becomes A; otherwise, it remains R. The interim supply value remains at the initial supply value.
3. If Method 3 is used, then the code remains R. If the world supply percentage is greater than or equal to the threshold percentage, the decrement percentage is applied to the initial supply value to yield the interim supply value. The decrement percentages (input on the case file) for methods 3 and 4 are not reduction factors but actual multipliers. For example, a decrement percentage of 25 will result in the initial supply value being multiplied by 0.25. Often, the decrement percentage is input as zero, resulting in an interim supply value of zero. This kind of calculation is performed in order to not allow use of supply from dominator countries; see subsection c.
4. Method 4 is a combination of Method 2 and Method 3. It accepts two threshold percentages and a decrement percentage. The algorithm proceeds as follows.
  - a. If the world supply percentage is less than the first threshold, the code becomes A and the interim supply value equals the initial supply value.
  - b. If the world supply percentage is greater than or equal to the second threshold, the code remains R and the initial supply is multiplied by the decrement percentage to yield the interim supply value.
  - c. If the world supply percentage is between the two thresholds, the code remains R and the interim supply value is the same as the initial supply value.

The most commonly used setting is Method 2 with a threshold of 50%. This has been the Base Case assumption for all of the recent Requirements Reports.

### c. A Note on Dominator Countries

The description of the mechanics of the usability code methods in the previous section might have obscured the reason for those methods' being part of the model. A country that supplies a substantial percentage of world supply—greater than some threshold—can be termed a dominator country. If a dominator country fails to supply its material (for some reason) the consequences could be serious. A policy judgment might be made—especially in the context of setting goals for the National Defense Stockpile—that supply from a dominator country is too risk-prone to be counted on to meet defense (or emergency investment) demands, and should be used to satisfy civilian demand only. If a country's percentage of world supply is very large, it might be wise not to count on that country's supply at all. Conversely, if a country is a relatively small player in the world market—as measured by its world supply percentage being below a threshold—it could be eminently reasonable to count that country's supply as being usable to meet all types of demand. The various usability code methods, with their associated thresholds and decrements, are merely a way of modeling these concepts in a simple manner.

The term dominator country applies only in the context of a specific material. That is, a given country can be a dominator for some materials but not others. Often, a country is a dominator for just one or two materials. It is also possible (though uncommon) for a country to be a dominator for a given material in some years but not others.

The most commonly used method is Method 2 with a threshold value of 50%. Under this rule, countries that supply less than 50% of world supply of a given material are considered Assured, i.e. their supply of that material is considered totally usable. Countries that supply over 50% of a material are considered dominators; their supply of that material is considered civilian-usable-only.

One of the sensitivity cases for the 2019 Requirements Report used Method 4 with thresholds of 50% and 80% and a decrement percentage of zero.<sup>11</sup> This parameter setting modeled a situation in which supply from “extreme dominators”—those that provided over 80% of world supply—was not to be counted on at all. Supply from “moderate dominators,” defined as countries that provided between 50% and 79% of world supply, was allowed to satisfy civilian demand, but not the other kinds. Supply from countries that provided less than 50% of world supply was considered totally usable.

A similar excursion used Method 4 with both thresholds set to 50% and the decrement percentage set to zero. This modeled a situation in which: 1) dominators were defined as countries producing 50% or more of world supply; 2) supply from dominators was considered not to be available; and 3) supply from non-dominators was totally usable.

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<sup>11</sup> Office of the Under Secretary of Defense for Acquisition and Sustainment, *Strategic and Critical Materials 2019 Report on Stockpile Requirements* (U.S. Department of Defense, n.p., January 2019).



Note that if the initial usability code of a country is A (Assured) then its supply will continue to be considered totally usable and will not be decremented in this portion of the calculations (i.e., the interim supply value will equal the initial supply value), even if the country technically is a dominator in that it provides a percentage of world supply that exceeds the threshold value. That is, usability code methods 2, 3, and 4 apply only to countries with an initial usability code of R (Reliable). For this reason, the set of countries that are to be put on the assured country list—i.e., those countries given a code of A in the supply usability codes file—should be vetted carefully.

The not-reliable-to-assured output report (file `nrelass.rpt`) contains a list of dominator material/country/year combinations (for countries not on the assured country list) along with the percentage of world supply of the material that the country provides. See Chapter 5, Section B.2.q for more information.

#### **d. Application of Decrement and Delay Factors**

Once the final supply usability code and the interim supply amount have been determined, the next step is to apply the decrement and delay factors to the interim supply amount.<sup>12</sup> This process can affect supply values for that country/material combination for several different years. The decrement and delay factors are applied according to the following sequence of steps. At each step, the resultant supply is written on a file named `supdbg.txt`, to aid in detailed analysis and, if necessary, debugging. (The sentences below are written in the imperative mood, but they pertain to what the SSM computer program does, not to what the user should do.)

Multiply the interim supply amount by the war damage and ability factors (for that country and year) to get a second interim supply amount. (The war damage factor for an adversary country can be input as zero to model zero-out of supply from that country. The second interim supply amount will then be zero, as will all subsequent supply values.)

Determine the market share. This is a complicated algorithm. It involves the input market share along with extra sell and/or extra capacity market share parameters. The input market share depends on the material and year, but the additional computations can depend on the country. See the discussion in Chapter 6, Section A.<sup>13</sup>

Multiply the second interim supply amount by the market share to get a third interim supply amount.

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<sup>12</sup> If the interim supply amount is zero, either because the initial code is U or because of decrementation via usability code methods 3 or 4, then no further computation is necessary.

<sup>13</sup> Also see the discussion in Chapter 8 of Volume I of IDA P-10727 (James S. Thomason et al. *IDA Contributions to the Strategic and Critical Materials 2019 Report on Stockpile Requirements*, IDA Paper P-10727 (Alexandria, VA: Institute for Defense Analyses, October 2019).

Look at the willingness factor (pro-U.S. factor), which depends on the country and the scenario year. Of the third interim amount, the willingness factor fraction arrives without delay, and the remainder is delayed. Accordingly, separate the third interim amount into an amount arriving “now” (in the current year) and an amount that is delayed.

Compute the delay time (in years). This calculation is also fairly complicated depending on values in the delay time file, which can vary by country, and an input on the case file. For details, see Chapter 5, Section A.3. Usually, the inputs are set so that the delay time is a constant, regardless of country.

Based on the delay time, separate the amount delayed into amounts that arrive in various years. In the modeling context, a delay time of 0.5 years means that half the delayed supply arrives in the current year and the other half arrives in the next year. To give a more general example, if the delay time is 1.3 years, and  $t$  denotes the year of origination, then 70% of the delayed supply arrives in year  $t+1$  and 30% arrives in year  $t+2$ . (Of course, the non-delayed supply arrives in year  $t$ .) If a year of arrival is beyond the end of the scenario period, the supply that is computed to arrive in that year simply is not counted.

Apply the shipping loss factor to the amounts arriving a given year. The shipping loss factors vary by country and scenario year. Currently, the SSM uses the shipping loss factor for the year of *arrival*. The resultant supply is thus separated into three components:

1. Supply that is not delayed;
2. Supply that is delayed but arrives in the earlier delay year;
3. Supply that is delayed but arrives in the later delay year.

The amount not delayed has the usability status (given by the final usability code) of the country in question (Assured or Reliable).<sup>14</sup> For delayed material, the following constructs operate. If the country’s usability status is Reliable, then all delayed material has status Reliable. If the country’s usability status is Assured, then apply the delayed material defense usability fraction. This fraction is input as a percentage on the on the case file, as option 7 in the [options] section. (See the discussion in Chapter 5, Section A.5.) That fraction of the delayed material amount is considered Assured; the remainder is Reliable. In recent Requirements Report studies, the delayed material defense usability fraction was set to zero; i.e., all the delayed material amount is Reliable.

For each component of the resultant supply, in turn, increment the amount of supply in the year of *arrival* of the appropriate vector (Assured or Reliable) for that component.

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<sup>14</sup> As noted in Section B.2.a, it is possible, though not common, for a country’s usability status to vary by year. The current SSM version uses the status for the year of origination.

Material that is delayed beyond the end of the scenario does not contribute to the available supply for the SSM run.

Go on to the next year of origination (start of subsection B.2.a).

### **3. Calculations Dependent on Material/Country Combination**

After all the years of origination have been processed, the working vectors of Assured and Reliable supply for that material/country combination have been filled with available supply amounts. These vectors are written to a diagnostic file named avsupcoun.txt (mnemonic for available supply by country; see Chapter 5, Section B.3).

The algorithm then increments the overall vectors of available Assured and Reliable supply of the material by these working vectors.

After all lines of the foreign supply file have been processed, the program has computed total pools of Assured and Reliable supply, by year, for each material. These results then go into Stage 2, which computes pools, by material and year, of totally-usable and civilian-usable-only supply.

## **C. Stage 2 Calculations**

Stage 2 implements the modeling of delayed defense priority. The details of the algorithm, as well as the rationale behind it, are explained in detail in IDA Paper P-10451. This section simply presents a summary.<sup>15</sup>

First, the SSM looks at options 8, 9, and 10, which have been read from the [options] section of the case file. (Omitted values are treated as zero.) Option 8 is 1 if the delayed defense priority option is to be exercised, 0 if not. Options 9 (for domestic supply) and 10 (for foreign Assured supply) represent the delay times (in months) for defense priority to become effective. For ease in presentation, assume that the delay times are a year (i.e., 12 months) or less (the model can treat longer delay times). (Of course, options 9 and 10 are moot if option 8 is 0.)

If option 8 is zero, indicating that delay times are not to operate, then the following calculations are made (for each material/year combination):

- All the available domestic supply becomes domestic totally-usable;
- All the Assured foreign supply becomes foreign-totally-usable;
- The Reliable supply becomes the pool of civilian-usable-only supply, without any incrementation.

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<sup>15</sup> The option of a delay in defense priority was not available in Requirements Report studies prior to the 2019 one. Delay times can be set to zero to replicate the previous assumptions.

Otherwise, the procedure below is performed for each material in turn. It starts with:

- The vector of domestic supply, by year, read from the U.S. supply input file (input file 11; for this exposition, ignore concerted programs);
- The vector of Assured foreign supply by year, for the material, as computed in Stage 1 (total over all foreign countries);
- The vector of Reliable foreign supply by year, for the material, as computed in Stage 1 (total over all foreign countries).

During peacetime, a certain fraction of supply is already going to satisfy defense demands. The SSM approximates this fraction by taking the ratio of defense demand to total demand for that material for the first scenario year. Call this the peacetime defense fraction.

Assuming the delay times are a year or less, the calculations in this paragraph apply only to supply in the first scenario year. The peacetime defense fraction of (first year) supply is assumed to be available (i.e., totally-usable) without delay. Of the remaining supply, a delay of  $m$  months means that fraction  $(12-m)/12$  of it is defense usable in the first year, while fraction  $m/12$  is civilian-usable-only. The calculations, which are written out in detail in IDA Paper P-10451, use the peacetime defense fraction and the two delay times (for domestic and foreign material). The first-year supply results for the material in question are thus:

- Amount of domestic totally-usable supply (subset of initial domestic supply);
- Amount of foreign totally-usable supply (subset of Assured foreign supply, not separated by country);
- Amount of civilian-usable-only supply (includes Reliable foreign supply from Stage 1, plus the portions of the initial domestic and Assured foreign supplies that are reassigned to civilian-usable-only status).

In subsequent years of the scenario, the defense priorities are in place, so all of the domestic and Assured supply for those years is considered totally-usable. Overall, the available supply results for the material in question are:

- A vector of domestic totally-usable supply, by year;
- A vector of foreign totally-usable supply, by year;
- A vector of civilian-usable-only supply, by year.

The SSM compares these vectors against the demands to determine material shortfalls, as discussed in Chapter 6, Section D.

## **D. Remarks about Relevant SSM Output Files**

Recent improvements to the SSM have greatly increased the variety of intermediate quantities that the SSM prints out. In particular, certain SSM output files have been expanded to articulate the results of the two-stage computation of available supply. This section briefly discusses some of the relevant output files. (Chapter 5 lists and briefly discusses all the SSM output files.) The files are tab-delimited text files that can be viewed in Excel.

### **1. Available Supply by Country File**

This file, named avsupcoun.txt, contains, for each material/country combination listed in the input foreign supply file, the Assured and Reliable supply vectors for that combination resulting from Stage 1. The sum of the two vectors is also shown.

### **2. U.S. Supply File (Current Facilities)**

The top part of this file contains, for each material, the domestic supply, by scenario year, as read from the input file. The bottom part contains the amount of domestic supply that is totally-usable, as computed by Stage 2. The file is named usprod1.rpt.

### **3. Assured Foreign Supply File**

The top part of the file contains the Assured foreign supply, as computed by Stage 1, for each material and scenario year, encompassing all supplier countries. For each material, this is the sum of the Assured vectors for that material in the avsupcoun.txt file. The bottom part of the file, which is new, contains the foreign totally-usable supply, as computed by Stage 2. The file is named forprod1.rpt.

### **4. Reliable Foreign Supply File**

The top part of the file contains the Reliable foreign supply, as computed by Stage 1, for each material and scenario year, encompassing all supplier countries. For each material, this is the sum of the Reliable vectors for that material in the avsupcoun.txt file. The bottom part of the file, which is new, contains the overall civilian-usable-only supply, domestic plus foreign, as computed by Stage 2. The file is named forprod2.rpt.

### **5. Assured plus Reliable Foreign Supply File**

This file is unchanged from previous versions of the SSM. The file contains the total of the Assured and Reliable foreign supply, as computed by Stage 1, for each material and scenario year, encompassing all supplier countries. The file is named forprod3.rpt.

## **6. Debug Report File**

The debug information report file (named debug.rpt) has been expanded to include, for each material, entries for the initial domestic supply, the Assured foreign supply, the Reliable foreign supply, the totally-usable domestic supply (with no concerted programs), the totally-usable foreign supply, and the civilian-usable-only supply. These are all vectors by year of the scenario. The information is useful for detailed analysis (including debugging if necessary). A recent use of the debug.rpt file has been to ascertain reasons for the differences in shortfall results between two SSM runs. Further information about the file appears in Chapter 5, Section B.4.

## 4. SSM Input Files

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This chapter discusses the SSM input files. Many of the input files have been discussed adequately in D-5270 along with the annotations in Chapter 2. This chapter presents some additional details that were not covered previously, and provides descriptions of two optional files not mentioned in D-5270, the U.S. imports file (input file 14) and the production-to-capacity ratios file (input file 16). Section A contains information about the directory structure and running the program; it also provides additional detail about the batch file and case file. Section B contains general information about the input data files, and Section C discusses each individual data file in turn.

As noted earlier, this paper explains the structure and format of the data files, but not the process of developing the actual data values, which come from a variety of government agencies and subject matter experts. Data sources are mentioned as appropriate.

### A. Directory Structure and Running the Program

This section discusses the directory structure for the SSM files, building on the brief description in D-5270. It provides some details about the batch file and case file. Section A.4 tells how to run the program.

#### 1. SSM File Directory Structure

The user should set up a “home directory” from which to run the SSM. Any subdirectory on the computer can be used.<sup>16</sup> The home directory should contain the SSM executable file and all batch files (.sbf extension). Under the home directory, the user should set up the following subdirectories:

- Database directory (hard-coded name “database”). The SSM input data files should be located here.<sup>17</sup> The computer program looks for the input data files in a subdirectory with the name “database”.
- Case directory (recommended name “ssmcases”). The SSM case files should be located here.

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<sup>16</sup> Robert J. Atwell, Eleanor L. Schwartz, James S. Thomason, and Thomas J. Wallace, *Generic Unclassified Stockpile Sizing Module (SSM) Training and Testing for the National Defense Stockpile (NDS) 2015* uses the term main directory instead of home directory.

<sup>17</sup> “Input data files” excludes the case file and the batch file.

- Output directory (recommended name “ssmout”). The output of the SSM will be located in subdirectories of the output directory. During execution, the SSM creates a separate subdirectory of the output directory for each case listed in the batch file for the run; the case name is used as the name of that subdirectory, and the output files for that case are put in that subdirectory.

Additional subdirectories of the home directory can be set up as desired. For example, subdirectories can be created to hold the data, models, and output for RAMF-SM Substeps 2a and 2b.

## 2. SSM Batch File

The structure of the SSM batch file has been discussed in D-5270, slide 9 (pages 19-20), and in the annotation to those slides in Chapter 2. As noted there, the section header lines [output directory], [default case directory], and [runs] are hard-coded text strings, including the brackets. *Caution: the program expects to find and read those lines; a missing or misspelled section header can cause errors or incorrect results.* If desired, notes can be added at the top of the file, above the first header line; the program will ignore them. Traditionally, the extension .sbf (mnemonic for “stockpile batch file”) has been given to the batch file, but any extension can be used.

## 3. SSM Case File

Each run of the SSM is associated with one or more case files. One can consider the case file as the basic input to an SSM run.<sup>18</sup> The case file specifies the other data files for the SSM to read, as well as many parameters and option values. The structure of the case file has been discussed extensively in Document D-5270 and Chapter 2. This section adds just a few supplementary remarks.

The case file is divided into several sections, each headed by a hard-coded name enclosed in brackets. These names are listed in Figure 1. The SSM looks for these header names, including the brackets. *Caution: the case file section headers must all appear in the case file and must all be spelled as shown in Figure 1, including the brackets. Missing or misspelled section headers can cause errors or incorrect results to occur.*<sup>19</sup>

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<sup>18</sup> An SSM case is associated with one case file, but the term “run” is ambiguous. Sometimes, it is just used as a synonym for case. But it can be used to mean an execution of the SSM program, which is associated with one batch file, which can list several case files. The meaning of run should be clear from context.

<sup>19</sup> However, the SSM routine that parses the section headers is case-insensitive, so some or all of the lowercase letters can be replaced by capital letters.



[notes]
[scenario parameters]
[adjustment parameters]
[default parameters]
[default supply parameters]
[concentration rule]
[files]
[options]
[materials]
[selected reports]

**Figure 1. Case File Section Headers**

It is strongly recommended that the case file have descriptive notes in the [notes] section at the top. Notes help greatly in keeping track of different SSM runs and the variations made between them (see D-5270, page 21, slide 10 for an example).

D-5270 (with annotations in Chapter 2) contains descriptions of all the sections except [selected reports]. For information on the SSM output reports, see Chapter 5, Section B.

Case files have traditionally been given the extension .cas, but any extension name or full path name can be specified in the batch file.

#### **4. Running the SSM**

The SSM is a Windows console application written in C and is run via an executable file. There are two ways to run the SSM.

1. In Windows Explorer, the user can go to the home directory and double-click on the name of the executable file. A window will pop up and ask the user to type in the name of the batch file; the user should enter it, including the extension (e.g., myrun1.sbf). It is not necessary to enter the full path of the batch file.
2. Alternatively, the user can invoke a command window, move to the home directory, and type the name of the executable file. The program will prompt for the name of the home directory; the user should enter it, including the full path. The program will then prompt for the name of the batch file; the user should enter it, including the extension (e.g., myrun1.sbf). It is not necessary to enter the full path of the batch file.

During execution, the program displays a number of on-screen messages that will inform the user about program progress. If the program runs to completion, it will ask the user to press the Enter key to terminate execution.

#### **B. Input Data Files—General Remarks**

The term “input data files” is often used to encompass the SSM input files, excluding the batch file and case file. Of the input data files, 16 of them have associated file numbers

and are specified on the case file for the SSM run ([files] section); the other two, material.txt and country.txt, have hard-coded names. All the input data files must reside in the \database subdirectory of the home directory for the SSM run. Chapter 2, in the annotations to slide 15 of Document D-5270, shows how to list the input data files in the case file for the SSM run. Table 2 lists the SSM input data files along with references to the pages and slide numbers in D-5270 where they are discussed. For some of these files, the description in D-5270 plus the annotations in Chapter 2 will provide sufficient understanding. For others, additional documentation will be helpful, and is presented in the sections below.

**Table 2. SSM Input Data Files**

<b>File Type No.</b>	<b>File Type Name</b>	<b>Page(s) in D-5270</b>	<b>Slide in D-5270</b>
<b>Files input on the SSM case file</b>			
1	Foreign Demanders of Material (any input will be ignored)	62	
2	Demand War Damage Factors (any input will be ignored)	62	
3	Extra Sell Countries (formerly Demand Factor Political Reliability)	62	
4	Delay Time Factors (formerly GDPs, and referred to as GDPs in D-5270)	63-64	31
5	Foreign Supply of Material (called Foreign Material Supply in D-5270)	47-48	23
6	Supply War Damage Factors (called Country War Damage Factors in D-5270)	57-58	28
7	Supply Usability Codes (called Supply Political Reliability Codes in D-5270)	51-52	25
8	Supply Ability Factors (called Country Political Reliability Factors in D-5270)	53-54	26
9	Supply Shipping Loss Factors (called Country Shipping Losses in D-5270)	59-60	29
10	U.S. Requirements (called U.S. Demand/Requirements in D-5270)	67-68	33
11	U.S. Supply (called U.S. Material Supplies in D-5270)	45-46	22
12	Basic Information (called Material-Specific Information in D-5270)	41-42	20
13	U.S. Market Share	61-62	30
14	U.S. Imports (optional)		

<b>File Type No.</b>	<b>File Type Name</b>	<b>Page(s) in D-5270</b>	<b>Slide in D-5270</b>
15	Supply Willingness Factors (called Pro-U.S. Sentiment in D-5270)	55-56	27
16	Production-to-Capacity Ratios (optional)		
<b>Additional SSM input data files</b>			
	country.txt file	39-40	19
	material.txt file	35-36	17

The file type names in the table are the ones actually used in the most recent version of the SSM computer code. Document D-5270, generally following earlier SSM versions, often used different file type names, as indicated in the table. The file type numbers are hard-coded and must be used as such.

The SSM requires that the input data file names (not including the extension) have 12 or fewer characters. The name should not have spaces or commas; underscore characters are allowed. The extension “.txt” should be used.

It is highly recommended that each data file have an associated notes file that explains the contents of the data file. The notes files aid greatly in keeping track of different data files. Generally, the notes file has the same name as the data file, with the extension “.not”. The notes files are unformatted text files that can be created in a text editor such as Notepad. At a minimum, the notes file should contain the data file name, the file type name, the date prepared, and the preparer’s name. If the data file was a worksheet in an Excel file, the Excel file, with full path, should be mentioned. In general, the more detailed the notes, the easier it will be to understand the contents of the data file.

The long file names (50-character limit), which are listed in the case file and appear on the Case Description output report (see Chapter 5, Section B.2.e), can provide a very brief description of the data file, but do not replace the function of the notes files.

## **C. Discussion of Individual Input Data Files**

### **1. Input File 1. Foreign Demanders of Material**

This file is now not operative. The SSM will not read or process any file input for this file type. The remarks below are for informative purposes only.

This file is a legacy from the time when the option existed to have the U.S. market shares computed within the SSM itself. Information on foreign countries that demand materials is still collected (from the information sheets prepared by the U.S. Geological Survey), but is used in the computation of the input market shares (input file 13) during the data preparation process rather than in the SSM itself. (See IDA Document D-5564.)

## **2. Input File 2. Demand War Damage Factors**

This file is now not operative. The SSM will not read or process any file input for this file type. The remarks below are for informative purposes only.

Demand war damage factors is probably a better term than the ungrammatical “demand factor war damage” that had been used. This file is a legacy from the time when the option existed to have the U.S. market shares computed within the SSM itself. The idea is that a war-damaged country might have less economic strength and hence less ability to bid for materials on world markets. The country’s GDP is multiplied by the factor; the reduced GDP is used in the GDP ratio calculations that are one measure of the U.S. market share value.

This information is still collected, but is used in the computation of the input market shares (input file 13) during the data preparation process rather than in the SSM itself. Usually, the demand war damage factors are set to be the same as the supply war damage factors that are used degrade a country’s ability to supply materials (input file 6). For more information see IDA Document D-5564.

## **3. Input File 3. Extra Sell Countries**

In earlier SSM versions, this file was called Demand Factor Political Reliability (a somewhat misleading name) and was used in the optional internal calculation of market share, which is now not operative. In the current version, input file 3 has been repurposed to implement the extra sell option for material supply; see the discussion in Chapter 6, Section A.

The file consists of one column of data. The top line should have the text “COUNTRY” (no quotes). The subsequent lines should be the names of those countries from which extra sell is allowed. If no extra sell is allowed, a file with the header line only should be input. Best practice is to list the countries in alphabetical order, although this is not necessary.

## **4. Input File 4. Delay Time Factors**

In earlier SSM versions, this file was called GDPs of Demanding Countries and was used in the optional internal calculation of market share, which is now not operative. Information on country GDPs is still collected (from the CIA World Factbook), but is used in the offline calculation of market share (input file 13), as discussed in IDA Document D-5564. SSM Input file 4 has been repurposed to hold factors that can be used to compute the length of delay time for material that is delayed because of supplier country unwillingness.

The graphic in Document D-5270, page 63 (slide 31) illustrates the structure of this file. The first column has the country names; the remaining columns show the values for each scenario year, respectively. As shown in the graphic, the value 1 is frequently used

for these data; the effect will be to have the delay time be constant and not depend on the country of origin. Countries not listed in the file (including the United States) receive the value specified by default parameter 1 (in the [default parameters] section of the case file) for the given year. (A reasonable value for that default parameter value is 1.)<sup>20</sup>

The factors are used to compute a delay time length for material that is subject to delay. More discussion of this delay time length, and how it is computed and used, appears in the discussion of option 4, the delay time ratio cutoff, in Chapter 5, Section A.3.

At one point, the idea was entertained that the GDPs could do double duty and be used to compute delay times as well as market shares, so this one file could serve both purposes. The delay time could depend on the relative economic strength of the country, as measured by the ratio of its GDP to the U.S. GDP. In such modeling, if the economic strength of the country is close to that of the U.S., the delay will be lengthy. Conversely, an economically weak country will be unable to keep its commodities away from the U.S. for very long. There was some thought, however, that GDP, while being a measure of economic strength, might not be a good measure of a country's ability to enforce a delay time. In the absence of data for such measures, one can simply set the inputs so that the delay time is a constant, irrespective of country or material. This setting—where all the factors have the value of 1—has been the approach taken for the Requirements Report studies since 2005. Moreover, the existing methodology for modeling delay to goods and services imports caused by supplier country unwillingness can only handle constant delay times; see Chapter 6, Section E.

The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

## **5. Input File 5. Foreign Supply of Material**

The foreign supply file contains initial amounts of supply for each combination of foreign country, material, and year of the scenario. In general, the supply value represents capacity to produce material; the assumption is that in a national emergency, the United States could get foreign producers to produce at capacity, perhaps by a monetary incentive. In the first scenario year, adjustment is made for producers to ramp up to capacity, so the first-year supply value is somewhere between estimated production and capacity. Only those countries that can produce a given material need be listed. The values are the *end result* of the peacetime equilibrium and ramp-up adjustments, as discussed in IDA

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<sup>20</sup> The first default parameter formerly was called demand war damage and was used as the default value of the demand war damage factors used in the internal market share calculation. Since that internal calculation is now not operative, the parameter was repurposed to serve as a default value of the delay time factor.

Document D-5564 (but not the decrement factors, which the SSM applies). Each line of the foreign supply file contains a material name, a country name, and a vector (by year) of the amounts of that material supplied by that country. The amounts can include foreign secondary supply (i.e., recycled material) subject to data availability and sponsor approval.

The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

The user should check that the same material/country combination does not appear on two or more lines in the file; otherwise, unpredictable results can occur. Best practice is to list the materials alphabetically by name and alphabetically by country within each material name. Also, the United States should not appear as a country in the foreign supply file; if it does, the program prints a message and terminates. U.S. supply is tracked via the U.S. supply file (input file 11).

## **6. Input File 6. Supply War Damage Factors**

The supply war damage factors are described in Document D-5270, slide 28 (page 57), and in the annotations to that slide in Chapter 2.

The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

As noted earlier, zero-out of supply from an adversary country is modeled by setting the war damage factor for that country to zero. The reason was simply to avoid the coding involved with having a separate input for zero-out. The war damage factor is an overall decrement, applied at the beginning of the procedure for computing available supply (see Chapter 3, Section B.2.d), and the parameter can accommodate the additional overall decrement of a zero-out in a straightforward manner.

## **7. Input File 7. Supply Usability Codes<sup>21</sup>**

The model separates material demand into three broad categories, or tiers: military demand, emergency investment demand, and civilian demand. Some foreign countries might be sufficiently unreliable that the U.S. does not want to plan for their material supply to be usable to offset defense demands.<sup>22</sup> And some countries might be so unreliable that the U.S. does not want to count on their supply at all (this category includes countries against which the U.S. has comprehensive trade embargoes). An additional concern is so-called dominator countries—countries that provide a substantial percentage of world

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<sup>21</sup> Much of the information in this section is also discussed in Chapter 3, Section B.

<sup>22</sup> Or emergency investment demands, though in practice, these tend to be very small.

supply. It might be good policy to restrict the usability of a dominator country’s supply in some fashion.

The model addresses these issues via the supply usability codes. (These codes apply to foreign countries, not to the United States. Usability of U.S. supply is a separate modeling issue, as discussed in the Stage 2 calculations explained in Chapter 3, Section C.) Traditionally, the usability codes were referred to as political reliability codes. However, they are an entirely different set of inputs from the supply ability factors, sometimes called the political reliability factors (input file 8), which are used to degrade a country’s ability to produce material.

The usability codes are indicators, not numerical values. The designations are "Assured," "Reliable," and "Unreliable"; but these words should be treated as terms of art. The codes could better be thought of as in the following table.

**Table 3. Foreign Supply Usability Codes**

<b>Code Letter</b>	<b>Traditional Terminology</b>	<b>Explanation</b>
A	Assured	"Totally usable": the supply can offset demands in the defense, emergency investment, and/or civilian tiers.
R	Reliable	"Civilian usable": the supply can offset demands in the civilian tier, but not the other tiers.
U	Unreliable	"Not usable": the supply cannot be used. Any supply value that has been input is ignored, and a zero value is used instead. The application of decrement and delay factors is not performed.

Note that these codes are judgmental inputs; they are set by the sponsor and project team to be consistent with policy objectives and the nature of the scenario. The SSM computes a separate code value for each country/material/year combination, but the inputs can directly specify values only for country/year combinations. Under certain circumstances, the computer program can then make adjustments that depend on the material. Three different kinds of SSM inputs relate to the supply usability codes:

- The values in the Supply Usability Codes input file (can vary by country and year);
- The default codes, specified in the [default parameters] section of the case file (parameter 4, can vary by year);
- The usability code method and its associated threshold and decrement values (specified in the [default supply parameters] section of the case file).

The structure of the Supply Usability Codes file is discussed and illustrated in Document D-5270, slide 25 (page 51), and in the annotation to that slide in Chapter 2. It is

a matrix of code letters (A, R, or U); the rows correspond to countries and the columns, to year of the scenario. Usually, a given country is assigned the same code for all years of the scenario. Countries not listed in the file receive the default code. Generally, very few countries are listed in this file; most countries receive the default code, which often is R.

No supply is available from the countries marked U. The U designation is not really necessary; the same effect can be accomplished by setting the war damage or supply ability factors of these countries to zero. The set of countries in the file with an A code is sometimes called the assured country list. Care should be taken before assigning a country a code of A because that implies that the country's supply can satisfy all types of demand, even if the country is a dominator. The assured country list is often very small, and can be null. (If all countries are to be given the default code, the Supply Usability Codes file should consist of a header line only.)

For each country/year combination, the SSM assigns an initial usability code value using the value in the file or, if that is not specified, the default value. For each material that the country produces, the model then takes this initial value and applies the supply usability code methods in conjunction with information on the material supply patterns to compute an updated usability code for the material/country/year combination. Chapter 3, Section B.2.b explains the details. The major objective of the set of calculations is to account for supply usability from dominator countries, as explained in Chapter 3, Section B.2.c.

The model allows the usability codes to vary by year, but they seldom do. The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

## **8. Input File 8. Supply Ability Factors**

Referred to variously as ability factors, reliability factors, or infrastructure reliability factors, these quantities are used to degrade foreign countries' ability to supply materials. This decrease in ability might be due to a number of factors, such as fragility of a country's industry, government, or infrastructure. In early versions of the SSM, these factors also included anti-U.S. sentiment, which now is modeled via the willingness factors (input file 15).

The structure of the supply ability factors file is shown in D-5270, slide 26 (page 53), and in the annotation to that slide in Chapter 2. Countries not listed in the file receive the default ability factor indicated in the [default parameters] section of the case file (parameter 5, called `supply_infrastructure_code` in D-5270, slide 13, page 27). It is recommended, however, that an effort be made to develop data values for every country, especially those



that supply materials. The shortfall results can be highly sensitive to the ability factors. Generally, the data come from the intelligence community.

The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

## **9. Input File 9. Supply Shipping Loss Factors**

These factors model losses of foreign material in transit due to attacks on shipping. The structure of this file is shown in D-5270, slide 29 (page 59), and in the annotation to that slide in Chapter 2. Countries not listed in the file receive the default shipping loss factor indicated in the [default parameters] section of the case file (parameter 3; see D-5270, slide 13, page 27).

The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

## **10. Input File 10. U.S. Requirements**

This file shows the U.S. demands for material. A separate demand value is input for each combination of material, scenario year, and tier. The determination of these demands is the purview of Substep 2b of RAMF-SM, and is performed by a separate model, named appropriately enough, the Material Demand Computation Program (MDCP). The MDCP outputs four different files, consistent with four different levels of market response (no market response, substitution only, thrift only, or substitution and thrift). Each of these files is ready for input to the SSM with no further editing.

For more information on the structure of this file, see D-5270, slide 33 (page 67), and the annotation to that slide in Chapter 2. IDA Paper P-22689<sup>23</sup> contains more information on the MDCP, including descriptions of the thrift and substitution market responses. For additional information about the market responses, see Chapter 6, Section F.

## **11. Input File 11. U.S. Supply**

The U.S. supply file contains amounts of U.S. supply for each combination of material and year of the scenario. The SSM defaults missing values to zero, so materials that the U.S. does not produce need not be listed. The user should check that the same material does not appear on two or more lines in the file; that can cause unpredictable results. Best practice is to list the materials in alphabetical order. In general, the supply value represents

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<sup>23</sup> Eleanor L. Schwartz, *The RAMF-SM Material Demand Computation Program: Documentation and User's Guide*.

capacity to produce material; the assumption is that in a national emergency, the United States could get domestic producers to produce at capacity, perhaps via monetary incentive. In the first scenario year, adjustment is made for producers to ramp up to capacity, so the first-year supply value is somewhere between estimated production and capacity.

The values are the *end result* of all the material supply adjustments such as peacetime equilibrium adjustment and ramp-up, as discussed in IDA Document D-5564. Reductions or zeroing of U.S. supply due to DSPOF considerations (as directed by the sponsor) must also be reflected in the input values; the SSM itself does not model such decrementation.<sup>24</sup> Secondary supply (i.e., recycled material) can be included in the supply amounts, subject to sponsor approval.

It is desirable for the user to have some knowledge of concerted programs and how the SSM handles them; see the discussion in Chapter 6, Section B. The U.S. supply file has space to include material supply arising from concerted programs. The file has three sets of columns; each set has a column for each scenario year (and possibly other years as well, but each set must have the same year span of columns). The first set contains the regular, “current facilities” U.S. supply.<sup>25</sup> The second set contains the data for restart concerted programs (sum of all such programs considered), and the third set contains the data for the new concerted programs (sum of all such programs considered). If concerted programs are not to be included, the second and third sets of columns should be filled with zeroes—meaning they still need to appear in the file.

Each set of columns can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

## 12. Input File 12. Basic Information

This file shows the short material names (used by the program), more descriptive long material names, units of measure, prices, and legal stockpile goals (if any). The structure of this file is shown in D-5270, slide 20 (page 41), and in the notations to that slide in Chapter 2. All the SSM inputs that relate to quantities of material (demands, U.S. supplies, foreign supplies, imports if used) must be expressed in the units of measure listed in the basic information file.

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<sup>24</sup> For information about domestic single points of failure (also simply called single points of failure, or SPOFs) and the modeling of them, see James S. Thomason et al., *Analyses for the 2015 National Defense Stockpile Requirements Report to Congress on Strategic Materials*, Vol. I: *Material Assessments and Associated Analyses*, IDA Paper P-5190 (Alexandria, VA: Institute for Defense Analyses, August 2015). Especially see Chapter 5.

<sup>25</sup> Planned future facilities with a high expectation of being operational in the scenario period should also be included.

### **13. Input File 13. U.S. Market Share**

In the context of RAMF-SM, the term “market share” refers to the fraction of foreign supply that the U.S. can obtain (after other decrement factors have been considered). The market share file contains separate values for each combination of material and scenario year. Each value should be between 0 and 1, inclusive. The construction of the market share values, which generally involves taking the maximum of three different candidate measures, is discussed in IDA Document D-5564.

Older SSM versions had the capability of computing the market share internally in the SSM itself, and thus input file 13 was considered optional. The internal computation is no longer operative; the input market share file is a required file. Every modeled material must be listed in the file; if not, the program prints a message and terminates.

The input market share values are used as a starting point for the calculation of the extra sell and extra capacity market share effects, as explained in Chapter 6, Section A. The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

### **14. Input File 14. U.S. Imports (optional)**

Caution: This file is used in conjunction with option 1, capping imports at a percentage of peacetime imports, as explained in Chapter 5, Section A.1. The U.S. Imports file contains those peacetime import values. The cap imports option has not been exercised in a long time, and it is unclear whether it still works. It is recommended that this option not be invoked now, pending further research. The U.S. imports file is then not relevant and is not used.

Given that the file is used, its structure is as follows. Like many other files, it is a rectangular array. It is a tab-delimited text file, and can be viewed and prepared in Excel. The first column contains a list of materials with the header MATERIAL in the first row. The subsequent columns correspond to the scenario years with the header value being the year (4 digits). The entries correspond to peacetime imports for the indicated material/year combination. The U.S. Geological Survey provides recent historical import amounts; presumably they are flatlined or extrapolated in some way for use in this file.

### **15. Input File 15. Supply Willingness Factors**

This file gives the supply willingness factors, which are also referred to as the pro-U.S. factors. The term willingness connotes the willingness of a given country to sell goods, services, and materials *to the United States*, and is intended to be a measure of pro-U.S. sentiment. Each factor is between 0 and 1, with 1 meaning that the country in question is fully willing to sell to the U.S.; 0, totally unwilling. They vary by supplier country and

year of the scenario. The structure of this file is shown in slide 27 of D-5270 (page 55), and in the annotations to that slide in Chapter 2. Countries not shown in the file receive the default willingness factor indicated in the [default parameters] section of the case file (parameter 6, called the supply\_pro\_US\_factor in D-5270). Generally, this default value is 1, indicating complete willingness. As discussed in Chapter 3, unwillingness to supply material is modeled as causing a delay in the arrival of material.

The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

## **16. Input File 16. Production-to-Capacity Ratios**

This file is optional, but it must be included if the program is invoking the extra sell or extra capacity market share options (options 5 and 6). These options, which are discussed in Chapter 5, Section A.4, are used in the modeling of preferential U.S. access to unused foreign capacity. Unused foreign capacity is estimated by applying a production-to-capacity ratio (from this file) to a future capacity estimate. The product represents estimated production; the remaining capacity is assumed to be currently unused, and thus a potential source of preferential U.S. access.

The file is a tab-delimited text file; it can be prepared, viewed, and edited in Excel. It is a rectangular array of numbers. The first two columns are for material and country, respectively (headers MATERIAL and COUNTRY). The subsequent columns correspond to the years of the scenario; the headers are the years (4 digits). Values are between 0 and 1, inclusive. Each material/country combination that is listed in the foreign supply input file (input file 5) should also be listed in the production-to-capacity ratios file.<sup>26</sup> The two files can frequently be prepared together. The file can contain data for more years than the actual scenario period. The program will parse the header line and use only the data for the columns corresponding to years within the scenario period.

The SSM computer program requires that the entries in the file be organized by material name and then by country within material name. Otherwise, unpredictable results can occur. Best practice is to list the entries alphabetically by material name and then alphabetically by country within each material name.

The production-to-capacity ratios are estimated from recent historical data on material production and capacity; these data are generally furnished by the U.S. Geological Survey. The material supply adjustment process described in IDA Document D-5564 discusses procedures for estimating a production-to-capacity ratio for a given material/country

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<sup>26</sup> If an entry is missing, the SSM provides a default value of 1, consistent with an assumption that production is at capacity and no unused capacity is available.

combination. This ratio can be used in the file for all non-initial scenario years. (A value of 1 means that a country is producing at capacity, so there is no unused capacity to take advantage of.) If a ramp-up period is used for the foreign supply, then special adjustments are necessary for the first-year production-to-capacity ratio, as discussed in Chapter 6, Section C.

Figure 2 shows the top portion of a sample production-to-capacity ratios file. The values in this sample file were generated with random numbers, but illustrate the principle that the same ratio is used for all the non-initial scenario years, while the first-year values are adjusted to be consistent with a 6-month ramp-up to capacity. (Although it might seem paradoxical, the first-year values are greater than the subsequent-year ones; see the mathematical derivation in Chapter 6, Section C.)

MATERIAL	COUNTRY	2011	2012	2013	2014
Material_1	Country 1	0.5552	0.3843	0.3843	0.3843
Material_1	Country 2	0.8322	0.7126	0.7126	0.7126
Material_1	Country 3	0.5117	0.3438	0.3438	0.3438
Material_1	Country 4	0.7795	0.6386	0.6386	0.6386
Material_1	Country 5	0.6143	0.4433	0.4433	0.4433
Material_1	Country 6	0.9811	0.9628	0.9628	0.9628
Material_2	Country 2	0.2513	0.1437	0.1437	0.1437
Material_2	Country 3	0.3191	0.1899	0.1899	0.1899
Material_2	Country 4	0.6926	0.5298	0.5298	0.5298
Material_2	Country 5	0.9952	0.9904	0.9904	0.9904
(rest of lines)					

**Figure 2. Portion of Sample Production-to-Capacity Ratios File**

### 17. The country.txt File

This file contains a master list of names of the countries that supply materials. All composite supplier countries (if used; see Chapter 6, Section G) should be listed in the file. The United States should be listed with that name. Additional countries, e.g., those that supply goods and services but not materials, can be listed if desired. Each country name should be 30 characters or less and should not contain commas (spaces, semicolons, single quotes, and underscore characters are allowed). Best practice is to list the names alphabetically (no duplicates).

During program execution, the SSM will check that all the country names in the other input data files are listed in the country.txt file. If not, (perhaps due to a misspelling or a trailing space), a message is printed on the Countries Not In Master List output report (file misscnt.rpt; see Chapter 5, Section B.2.o) and program execution terminates.

### **18. The material.txt File**

This file contains a master list of names of the materials that are modeled. These are the short material names, not the longer descriptive names in the second column of the Basic Information file (input file 12). Each name should be 30 characters or less and should not contain spaces or commas (underscore characters are allowed). The SSM's search routines are case-insensitive, but it has been common practice to use all capital letters for the material names. Best practice is to list the names alphabetically (no duplicates).

During program execution, the SSM will check that all the material names in the other input data files are listed in the material.txt file. If not, (perhaps due to a misspelling or a trailing space), a message is printed on the Materials Not In Master List output report (file missmat.rpt; see Chapter 5, Section B.2.n) and program execution terminates.

A particular SSM run need not consider all the materials in the material.txt file. The [materials] section of the case file for the run lists the materials to be considered in that run.

## 5. SSM Options and Output Reports

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### A. SSM Options

As mentioned in Document D-5270 (slide 18), the SSM has a number of options that the user can invoke to model certain conditions. These options are formally listed in the [options] section of the case file. This section explains their meaning.

Figure 3 shows the [options] portion of an illustrative SSM case file with comma delimiting. The number at the left should not be changed; the SSM uses it to indicate the option being considered. The descriptive phrases are for informative purposes only; they are read but ignored. The numbers at the right of each line must be entered as integers (i.e., no decimal point). Often, they are simply indicator values (0 or 1); some of them are percentages; the delay times (options 9 and 10) represent numbers of months. If an option line is omitted, a value of 0 is used for that option.

```
[options]
1,cap_imports,0
2,cap_peacetime_percent,100
3,delete_old_output,1
4,delay_time_ratio_cutoff,800
5,extra_sell_percent,50
6,extra_capacity_market_share,0
7,delayed_defense_usability,0
8,delayed_defense_priority,1
9,domestic_delay,6
10,assured_foreign_delay,12
```

**Figure 3. Illustrative Case File Options Section**

#### 1. Options 1 and 2. Cap Imports and Cap Peacetime Percent

Caution: these options have not been tested in a long time. Until further testing can be performed, it is best to set option 1 to 0, i.e., not to invoke the imports cap option. If option 1 is 0, then option 2 is moot.

The idea behind the Cap Imports option is that imports of material, though necessary to satisfy demands in an emergency, should not be too much larger than peacetime imports—possibly to avoid market disruption. If option 1 is set to 1, indicating that the option should be invoked, the SSM reads optional input file 14, U.S. imports. The structure

of this file is explained in Chapter 4, Section C.14. For each material and scenario year, a value is read, corresponding to peacetime imports in that year.

Option 2 specifies a percentage value, which can range from 0 to 200%. This percentage is applied to the peacetime imports amount for each year to yield an upper bound on the foreign supply available in that year. This upper bound is applied, if necessary, to the available foreign supply amount that has been computed for the material, and the reduced amount is used in the supply-demand comparison.

## 2. Option 3—Delete Old Output

If a case is rerun, setting this option to 1 (recommended) will delete the old output for that case. If the option is 0, the new output files will not be written. The issue is not pressing because cases are seldom rerun; it is easy enough to run a new case. Every case has its own output subdirectory, so deleting the results of one case will not affect the status of other cases' output files.

## 3. Option 4—Delay Time Ratio Cutoff

This option is used to determine the length of the delay time that applies to material that is delayed because of supplier country unwillingness to supply to the U.S. The amount of material delayed depends on the willingness factors (pro-U.S. factors). Option 4 is moot if, as was the case in the 2021 Requirements Report, no foreign supply is delayed due to supplier country unwillingness (i.e., if all the willingness factors are 1). For legacy reasons, option 4 had been called the GDP ratio cutoff; that notation is used in D-5270 and in portions of the SSM code. The user should review the discussion of the delay time factors file (input file 4) in Chapter 4, Section C.4. Since the procedure for determining the appropriate option 4 value is somewhat non-intuitive, it is explained in detail here.

Option 4 specifies a percentage value, which the code converts to a number (by dividing by 100). To compute the delay time of material from a given country, the SSM first computes the ratio of that country's factor to the U.S. factor (in input file 4), for the given scenario year. Call this ratio  $r_0$ . The delay time (in years) is then computed as

$$\text{delay time} = (\text{scenario length in years}) \times r_0 / (\text{number value of option 4}).^{27}$$

Almost always, the assumption has been to use a constant delay time, one that does not depend on country or year.<sup>28</sup> This assumption is implemented by setting all the country factors (including the United States) in the delay time factors file to 1. Then the ratios  $r_0$

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<sup>27</sup> If a zero value is input for option 4, an infinite delay is assumed; the delayed material is assumed never to arrive. The computer program has procedures in place to avoid dividing by zero.

<sup>28</sup> The current modeling of delays in goods and services imports in RAMF-SM Substep 2a can only handle constant delay times. See Chapter 6, Section E.



are all 1. Given this setting, and assuming that the scenario is 4 years long, the following quick guide can be used for determining the parameter value for option 4:

- 800 = 6-month delay (the parameter value is 800%, i.e., 8, and the delay time is thus  $4/8 = 0.5$  years, i.e., 6 months).
- 400 = 1-year delay.
- 200 = 2-year delay.
- 0 = infinite delay (i.e., the delayed material never arrives).

For a scenario that is  $n$  years long, if a constant delay time of  $y$  years is desired, then the option 4 value should be set to  $100n/y$ , with all the factors in the delay time factors file set equal to 1.

#### **4. Options 5 and 6—Extra Sell Percent and Extra Capacity Market Share Percent**

In the national emergency scenario, the United States is assumed to be able to obtain a certain fraction of foreign material supply capacity (after the ability, war damage, and shipping loss factors have been applied). This fraction is given by the market share value, which is input on input file 13. The market share fraction can be applied to both foreign supply capacity that is currently being used to produce materials and to foreign supply capacity that is currently not in use. One might want to consider, however, *preferential* U.S. access to currently unused foreign supply. It might be possible for the U.S. to pay foreign suppliers to produce at or near capacity, with the proviso that the U.S. gets the extra amount over its regular market share that is produced from the capacity that had previously been unused.

In earlier SSM versions, the concept of such preferential U.S. access was modeled by one method, called the expanded market share. Document D-5270 uses that terminology. Recent changes to the SSM allow two different methods of modeling preferential U.S. access, called extra sell and extra capacity market share. Either method can be used or they can be used together. The term expanded market share is still used to encompass both these methods. The previous option 5 used in the expanded market share modeling has been replaced by two options, the extra sell percent (option 5), and the extra capacity market share (option 6). These options both specify percentages, which can vary between 0 and 100%.

If the extra sell percentage (option 5) is nonzero, then the SSM looks for input file 3, which contains a list of countries from which extra sell is allowed.

For information on how these options are used, see the discussion of expanded market share computation and preferential access modeling in Chapter 6, Section A. If both percentages are zero, preferential access is not modeled. If either percentage is nonzero,

the Production-to-Capacity Ratios file (input file 16) must be specified in the case file. See Chapter 4, Section C.16 for information about that file.

## **5. Option 7—Defense Usability of Delayed Material**

This option applies to material that is delayed in reaching the U.S. because of foreign country unwillingness to sell to the U.S. In earlier versions of the SSM, all such delayed material was considered as usable to offset civilian demands only, even if the supplier country had Assured status. Now, an input percentage, as specified by option 7 of the delayed material from Assured countries, can be considered usable to satisfy all tiers of demand: defense, emergency investment, and civilian. The same percentage applies to all Assured countries. The percentage should vary between 0 and 100. Setting it to 0 (a frequent choice) replicates the previous modeling. Material from countries with Reliable status is civilian-usable-only whether or not it is delayed.

The amount of supply subject to delay is a function of the willingness factors (pro-U.S. factors), which vary by supplier country and scenario year. Like option 4, option 7 is moot if no foreign supply is delayed due to supplier country unwillingness, i.e., if all the willingness factors are equal to 1.

## **6. Options 8, 9, and 10—Delayed Defense Priority**

Despite the similarity of the descriptive phrases for options 7 and 8, they deal with different parts of the modeling. Options 8 through 10 deal with Stage 2 of the supply availability modeling, i.e., the imposition of a delay time for allowing the satisfaction of defense demands (and emergency investment demands) to have priority over the civilian demands. The reader is referred to Chapter 3, Section C for discussion of Stage 2; also see IDA Paper P-10451.

Option 8, an indicator variable, specifies whether Stage 2 of the supply modeling is to be invoked (0 = no, 1 = yes). Options 9 and 10 specify the delay times, in months, for U.S. supply and foreign assured supply, respectively, to become usable to satisfy all types of demand. Options 9 and 10 are moot if option 8 is zero.

## **B. SSM Output Reports**

### **1. General Remarks**

The SSM can produce a number of different output reports. Most of the ones listed and discussed in IDA Paper P-2867 are still available; a few new ones have been added. In some earlier versions of the SSM, including the one documented in Paper P-2867, the output reports were actual Excel files. Now, they are tab-delimited text files that can be imported into Excel for viewing. Most output reports are given the suffix “.rpt” (mnemonic

for report). They are located in a subdirectory that the SSM creates specifically for the case in question; the subdirectory has the name of the case name and is located under the output directory specified in the batch (.sbf) file.<sup>29</sup> The names of the output files are hard-coded, but since output files for different cases appear in different subdirectories, this does not cause a problem with overwriting.

Many of the output reports files have numbers. These can be requested, by number, on the [selected reports] section of the case file. There are several other output reports that do not have numbers. (Most of these were added relatively recently.) They are always generated, and their names are hard-coded. For the most part, they are tab-delimited text files that can be viewed in Excel. If the user specifies the reserved word “all” (no quotes) under the [selected reports] header, then all of the output reports, numbered and unnumbered, will be generated, and the user can ignore the ones that are not useful.

Recent improvements to the SSM have greatly increased the variety of intermediate quantities that are written to output files. In particular, certain SSM output files have been expanded to articulate the results of the two-stage computation of available supply. On the other hand, some of the existing output files have not been modified to be fully consistent with the new supply modeling and are not currently useful. Both circumstances will be noted in the descriptions of the individual output files in the next section.

Several of the output files have the word “goal” in their file names or descriptions. This terminology (and also the name Stockpile Sizing Module for the model) is a legacy from the early days of the Requirements Report studies when the shortfalls computed by the model were to be considered as goals for the amounts of material to hold in the National Defense Stockpile. As noted in Chapter 1, the interpretation now is that the material shortfalls represent potential risks to national security; they become candidates for a number of risk mitigation options, of which stockpiling is one possibility. Thus, “goal” is to be interpreted as “shortfall.”

To aid in the interpretation of the output, the user might wish to review Chapter 6, Section B, on concerted programs and U.S. supply levels. Some reports have separate sections for each U.S. supply level, and sometimes a separate report is generated for each U.S. supply level.

Table 4 lists the numbered output reports with their numbers and file names. (Report numbers 25, 26, and 28 were relevant for earlier versions of the model, but are no longer current.) In the report titles in Table 4, the notations CF (current facilities), CF+RES (current facilities plus restart concerted programs), and CF+RES+NEW (current facilities plus restart concerted programs plus new concerted programs) refer to the U.S. supply level

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<sup>29</sup> The batch log file (.lgb extension) is located in the home directory. See Section B.3.h.

that report considers; see Chapter 6, Section B. Table 5 lists the non-numbered output reports with their file names.

**Table 4. SSM Numbered Output Reports**

<b>ID #</b>	<b>Title/Contents</b>	<b>Output File Name (hardcoded)</b>
1	Goals Summary	goalsum.rpt
2	Goals Summary by Year	goalyear.rpt
3	Total Goals Summary by Year	totglyr.rpt
4	Total Goals Summary (CF)	totgoal1.rpt
5	Total Goals Summary (CF+RES)	totgoal2.rpt
6	Total Goals Summary (CF+RES+NEW)	totgoal3.rpt
7	Case Description	casedesc.rpt
8	Delay Time Factors	delayfac.rpt
9	U.S. Production of Strategic and Critical Materials (CF)	usprod1.rpt
10	U.S. Production of Strategic and Critical Materials (CF+RES)	usprod2.rpt
11	U.S. Production of Strategic and Critical Materials (CF+RES+NEW)	usprod3.rpt
12	U.S. Market Share	mktshare.rpt
13	Available Foreign Production (Assured)	forprod1.rpt
14	Available Foreign Production (Reliable)	forprod2.rpt
15	Available Foreign Production (Assured + Reliable)	forprod3.rpt
16	Foreign Supply Summary (Assured)	forsup1.rpt
17	Foreign Supply Summary (Reliable)	forsup2.rpt
18	Foreign Supply Summary (Assured + Reliable)	forsup3.rpt
19	Material Summary	matsum.rpt
20	Carry Down, Carry Forward, Shortfall, and Supply Used	carrydwn.rpt
21	Debug Information	debug.rpt
22	Materials Not In Master List	missmat.rpt
23	Countries Not In Master List	misscnt.rpt
24	Reliable-to-Assured Report	relass.rpt
27	Not Reliable-to-Assured	nrelass.rpt
29	Supply and Demand Report	supdmd.rpt

**Table 5. Non-numbered SSM Output Reports**

<b>Title/Contents</b>	<b>Output File Name (hardcoded)</b>
Assignment Messages	assignment_messages.txt
Available Supply by Country	avsupcoun.txt
Supply Debug Report	supdbg.txt
Supply Used	supply_used.txt
Total Demand	total_demand.txt
Case File	<case name>.cas
Log File	<case name>.log
Batch Log File	<batch file name>.lgb

The following sections provide brief descriptions of the various reports.

## **2. Descriptions of Numbered Reports**

### **a. Goals Summary (file goalsum.rpt)**

This is arguably the most important output report, and the one that should be examined first. It gives material by material shortfall amounts, shown by demand tier in both units of material and in millions of dollars. Total dollar amounts and the number of materials with shortfall are also shown. The report has three sections of columns, one section for each U.S. supply level (see Chapter 6, Section B).

### **b. Goals Summary by Year (file goalyear.rpt)**

The format of this report is like the Goals Summary report, but a separate report section appears for each scenario year. The amounts on the Goals Summary report are totals over the scenario years of the corresponding yearly amounts on the Goals Summary by Year report. In recent studies, most of the shortfalls occur in the first scenario year.

### **c. Total Goals Summary by Year (file totglyr.rpt)**

This report shows the total shortfalls (total over all materials) in millions of dollars by demand tier and scenario year. The marginal totals are also shown. A separate section is generated for each U.S. supply level. This report is a useful summary of how the shortfall totals vary by year.

### **d. Total Goals Summary (files totgoal1.rpt, totgoal2.rpt, totgoal3.rpt)**

Three different reports are prepared, one for each U.S. supply level. Each report presents shortfall information in units, by tier, for each material, and compares the information with the legal goal shown in the basic information input file (input file 12).

Since all the shortfall values can be found in the Goals Summary report, and since the legal goals are not used much now, the Total Goals Summary reports are of limited usefulness.

**e. Case Description (file casedesc.rpt)**

This file displays the contents of the case file for the SSM run in a readable format. It is a tab-delimited text file that can be opened in Excel.

**f. Delay Time Factors (file delayfac.rpt)**

This file shows the delay time factors for all countries, including those listed on the delay time factors input file (input file 4) and those given the default value. (In earlier SSM versions, the file displayed the adjusted GDP values, which are now used in the offline calculation of the market shares.)

**g. U.S. Production of Strategic and Critical Materials (files usprod1.rpt, usprod2.rpt, usprod3.rpt)**

These reports are also called the U.S. Supply reports. Three different reports (usprod1, usprod2, and usprod3) are prepared, one for each U.S. supply level (Current Facilities, Current Facilities + Restarts, and Current Facilities + Restarts + New Facilities), respectively. Each file shows the U.S. supply for the corresponding level, as computed from the input U.S. supply file. See the discussion in Chapter 6, Section B.

For the Current Facilities report (file usprod1.rpt), a second section has been added. This section shows the amount of domestic supply that is totally-usable, as computed by Stage 2 of the supply availability computation process. The differences in values between the first section and the second section represent the amounts of U.S. supply that have been reassigned from totally-usable to civilian-usable-only status, to model delays in the establishment of the defense prioritization. Right now, this two-section structure is output only for the Current Facilities U.S. supply level (no concerted programs). If concerted programs start being included in the data again, similar second sections could be added to the U.S. supply reports for the other levels.

**h. U.S. Market Share (file mktshare.rpt)**

This file reproduces the information on the U.S. Market Share input file (input file 13).

**i. Available Foreign Production (files forprod1.rpt, forprod2.rpt, forprod3.rpt)**

These three files show the available foreign supply after all the decrement factors have been applied. The information in them can be important in tracing the reasons for

differences in the results of different runs. The files are referred to by the boldface titles below.

**Available Foreign Production (Assured) file** (file forprod1.rpt). The top section of the file contains the available Assured foreign supply, as computed by Stage 1 (see Chapter 3) after all decrements for each material and scenario year, encompassing the total over all supplier countries. The value is the sum of the Assured values for that material/year combination in the Available Supply by Country output file (file avsupcoun.txt; see Section B.3.b). The bottom section of the file contains the foreign totally-usable supply, as computed by Stage 2. The differences in values between the two sections represent the amounts of Assured foreign supply that have been reassigned to civilian-usable-only status to model delays in the establishment of the defense prioritization.

**Available Foreign Production (Reliable) file** (file forprod2.rpt). The top section of the file contains the Reliable foreign supply, as computed by Stage 1 after all decrements for each material and scenario year, encompassing the total over all supplier countries. For each material, the vector of values is the sum of the Reliable vectors for that material in the avsupcoun.txt file. The bottom section of the file contains the overall civilian-usable-only supply, domestic plus foreign, as computed by Stage 2.

**Available Foreign Production (Assured + Reliable) file** (file forprod3.rpt). This file is unchanged from previous versions of the SSM. The file contains the total of the Assured and Reliable foreign supply, as computed by Stage 1 for each material and scenario year, encompassing the total over all supplier countries.

**j. Foreign Supply Summary (files forsup1.rpt, forsup2.rpt, forsup3.rpt)**

These three files (one for Assured supply, one for Reliable supply, and one for Assured plus Reliable) purport to show the foreign supply used, the foreign supply used as a percentage of requirements, and the foreign supply used as a percentage of total foreign supply. Values are shown for each material, for each scenario year, and overall. Each report has three separate sections, one for each U.S. supply level.

These output reports have not been updated to reflect the Stage 2 supply modeling, and were oriented toward the legacy algorithm that assigned supply to meet demand. It is recommended that the user not look at these files pending further checking of the SSM computer program. The Supply Used output report (see Section B.3.d) has information on how much supply, U.S. and foreign, is actually used to satisfy demand.

**k. Material Summary (file matsum.rpt)**

This file is a legacy from the early years of the Requirements Report studies when the emergency scenario involved a long mobilization period. There are a number of inaccuracies in it, and it is recommended that the user not look at it.

**l. Carry Down, Carry Forward, Shortfall, and Supply Used (file carrydown.rpt)**

This file is a legacy from the older supply-to-demand assignment methodology. Its use is not recommended. The Supply Used output report (see Section B.3.d) contains the corresponding information for the current algorithm.

**m. Debug Information (file debug.rpt)**

This extremely useful file merits a larger section to discuss it; see Section B.4.

**n. Materials Not In Master List (file missmat.rpt)**

This output report identifies misspelled material names (strictly speaking, material names in the input data files that do not match the names in the material.txt file). Since this kind of mismatch causes the program to terminate prematurely, the file is useful for initial error-finding purposes. After the data have been checked, one expects that this file will have header information only.

**o. Countries Not In Master List (file misscnt.rpt)**

This output report serves the same function as the Materials Not In Master List, but for the country names (file country.txt). The report identifies country names in the input data files that do not match the names in the country.txt file (generally due to misspelling or trailing spaces). Since this kind of mismatch causes the program to terminate prematurely, the file is useful for initial error-finding purposes. After the data have been checked, one expects that this file will have header information only.

**p. Reliable to Assured Report (file relclass.rpt)**

As noted in Chapter 3, Section B.2, Supply Usability Code Methods 2 and 4 allow initially-Reliable countries to change to Assured status if they produce less than a threshold percentage of world supply for a given material. This report lists those countries that do undergo such a change. There are so many countries in this situation, however, that the report is not typically useful. The following report, however, is.

**q. Not Reliable to Assured (Dominator Countries) (file nrelclass.rpt)**

This report is the complement of the Reliable to Assured Report; it lists those country/material/year combinations where the country provides *more* than the threshold percentage of world supply, and thus does *not* change from Reliable to Assured status. The percentage of world supply is also indicated. That is, this report provides a list of all the so-called dominator countries (see Chapter 3, Section B.2.c) that are not on the assured country list (see Chapter 4, Section C.7).



The SSM generates the report if Supply Usability Code Method 2 or 4 is chosen, but does not currently generate a list of dominator countries for Method 3. This omission should be corrected in future SSM versions.

**r. Supply and Demand Report (file supdmd.rpt)**

This report shows, for each material and year combination, the total available supply (U.S. plus foreign), the total demand, and the supply/demand ratio. Especially in the first year, the ratios provide information on the tightness of supply or severity of the shortfall. This report can help identify “near shortfalls” in which the available supply is only slightly greater than the demand, and “severe shortfalls” where only a small portion of the demand is met. The file contains three separate sections, one for each U.S. supply level.

This report does not distinguish between totally-usable and civilian-usable-only supply. The report is not useful, therefore, for identifying so-called sectoral bottlenecks, where overall supply amount is sufficient but defense-usable supply is less than defense demand.

**3. Descriptions of Non-numbered Reports**

**a. Assignment Messages (file assignment\_messages.txt)**

This file shows the results of selected intermediate steps in the transportation problem formulation of the problem of assigning the available supply to meet demand (see Chapter 6, Section D). It is useful only for intensive debugging.

**b. Available Supply by Country (file avsupcoun.txt)**

This file, named avsupcoun.txt, contains, for each material/country combination listed in the input foreign supply file, the Assured and Reliable supply vectors for that combination resulting from the Stage 1 calculations of available supply (see Chapter 3, Section B). The sum of the two vectors is also shown.

This file can be useful in identifying the effect of country-specific decrements. Line-by-line comparison of this file with the input foreign material supply file (which also varies by material, country, and year) allows one to pinpoint those combinations where the available supply is much less than one might expect. Further examination might then lead to the finding that the data contained an unexpectedly low ability or willingness factor.

**c. Supply Debug Report (file supdbg.txt)**

Not to be confused with the Debug Information report (file debug.rpt), this file, named supdbg.txt, is not well formatted and is useful primarily for intensive debugging. It shows many of the intermediate steps in the computation of available supply, as described in

Chapter 3, Section B.2.d. It is best read in conjunction with the SSM computer program code.

One noteworthy thing about this file is that it shows the expanded market share value (including extra sell), if it is modeled (see Chapter 6, Section A). The expanded market share can be different for each supplier country. The regular market share output file and the market share values on the debug.rpt file merely reproduce the input market share values, which do not vary by country.

#### **d. Supply Used (file supply\_used.txt)**

This file reports the results of the algorithm that computes the assignment of available supply to satisfy demand, to minimize the overall amount of unsatisfied demand (see Chapter 6, Section D).

A separate value is shown for each nonzero combination of:

- Year of origination of the supply.
- Kind of supply (totally-usable domestic, totally-usable foreign, civilian-usable only).
- Tier (category) of demand—defense, emergency investment, or civilian.
- Year of the demand.

The value shows the amount of that kind of supply originating in that year of origination that is assigned to satisfy demand in the indicated tier and year. These values can be summed offline to compute total amounts of supply of various kinds used at various times. The algorithm follows the rule of never using supply from a given year to satisfy demand in a previous year; also, civilian-usable-only supply cannot be used to satisfy demand in the other tiers. In addition, the algorithm attempts to give priority to domestic supply.

#### **e. Total Demand File (file total\_demand.txt)**

This file shows the material demand in dollar terms, encompassing the sum over all the materials modeled in the particular SSM case being run. Values are shown for each combination of demand tier (defense, emergency investment, and civilian) and scenario year; the marginal totals also appear.

This file is especially useful when many sensitivity cases are run and the user wants a succinct summary of how overall material demand varies between the different sensitivity cases.

**f. Case File (file <case name>.cas)**

This file is an exact copy of the case file for the SSM run, but appearing in the output subdirectory for the run rather than the case files subdirectory. This output file has the extension .cas, even if the case file has some other extension. Its name is the case name.

**g. Log File (file <case name>.log)**

This file has messages about the progress of the SSM run. These messages are also shown on-screen as the SSM is executing. They are useful primarily if the program terminates prematurely; they can indicate which calculations were performed before the error occurred. The file name is the case name with the extension .log.

**h. Batch Log File (file <batch file name>.lgb)**

This file is a record that the batch file was read and processed. Unlike the other output files, it resides in the home directory. Its name is the name of the batch file; its extension is “.lgb” (mnemonic for “log batch”). The file has a message that each case listed in the batch file was processed, even if the case terminated prematurely. If the computer program actually stops due to a program error, the batch log file will show the cases that were processed before the error occurred.

**4. The Debug Information File (file debug.rpt)**

This file shows the demand, initial supply, and available supply, by year, for each material all together in one place. It can be very useful, especially in determining the reasons for differences between one SSM run and another. It has been recently revised to articulate the Stage 1 vs. Stage 2 material supply results. The fixed format structure of the information in the debug.rpt file makes it relatively easy to use Excel’s lookup and reference functions to access the particular variables desired.

In general, the analyst would want to examine material demand for each tier (defense, emergency investment, and civilian), initial U.S. supply, initial foreign supply (by usability status), market share, available post-decrement foreign supply by usability status, and other debug.rpt entries as appropriate. From these entries, the analyst can use Excel to compute additional quantities such as total demand, demand minus supply, and so forth, as desired.

The file has three major sections:

- A top section that contains the run name and date, the scenario dates, a list of material information, and a list of the input files.
- A long section called “Material Info.” This section contains a number of sets of entries, one set for each material listed in the material.txt file. The entries generally contain input information. Each set contains the entries listed in items 1 through 10 below.

- Another long section called “One Material Info.” This section contains a number of sets of entries, one set for each material actually analyzed, as listed in the case description file for the run. The entries generally contain intermediate computed quantities. Each set contains the entries listed in items 11 through 17 below.

Most of the entries are time streams (vectors) by scenario year. That is, the report shows the relevant quantity for each year of the scenario. Supply and demand amounts are expressed in the indicated units of measure for the material.

A set of entries in the Material Info section consists of the following entries.

1. Material short name, long name, units of measure, and price
2. Domestic (U.S.) supply, before adjustments, current facilities
3. Domestic (U.S.) supply, before adjustments, restart concerted programs (this has been zero in recent years)
4. Domestic (U.S.) supply, before adjustments, new concerted programs (this has been zero in recent years)
5. Military (defense) demand
6. Emergency investment demand
7. Civilian demand
8. Initial totally-usable foreign supply (total over all supplier foreign countries)
9. Initial civilian-usable-only foreign supply (total over all supplier foreign countries)
10. Initial foreign supply from countries with supply usability code U; such supply will be treated as zero and will not be used in the subsequent calculations.

A set of entries in the One Material Info section consists of the following entries.

1. Material short name
2. U.S. Market share (as input on file 13; does not include the results of extra sell and expanded market share calculations). This is a fraction
3. “Assured” foreign supply. Corresponds to totally-usable foreign supply after all decrement and delay factors have been applied (including market share), but not the defense priority adjustments
4. “Reliable” foreign supply. Corresponds to civilian-usable-only foreign supply after all decrement and delay factors have been applied (including market share), but not the defense priority adjustments

5. Totally-usable domestic supply after the defense priority adjustments have been applied (portion of the domestic supply)
6. Totally-usable foreign supply after the decrement/delay factors and defense priority adjustments have been applied. (portion of the assured foreign supply)
7. Civilian-usable-only supply after the decrement/delay factors and defense priority adjustments have been applied. This includes all of the reliable foreign supply and might include portions of the domestic supply and the assured foreign supply.

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## **6. SSM Methodology—Assorted Other Topics**

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### **A. Expanded Market Share Calculations**

This section explains how the SSM computes an increased value for market share over and above the regular or initial market share input to the SSM (input file 13). It provides context for the terms expanded market share, extra capacity market share, and extra sell. The mathematics of the expanded market share calculation are presented in subsection 3. First, some underlying concepts and modeling history are discussed.

#### **1. Underlying Concepts**

In the context of the SSM, the term “market share” factor refers to the fraction of foreign supply the United States can obtain. In general, the United States is assumed to be able to obtain only a certain percentage—a market share—of foreign material supply, not all of it. This limitation reflects the reality that friendly nations have legitimate uses for the material and that adversaries might be able to outbid the U.S. on world markets. The market share adjustment operates in addition to the decrement and delay factors of war damage, ability, willingness, and shipping losses. IDA document D-5564 discusses in detail RAMF-SM’s procedure for computing the “regular” market share. This procedure generally involves computing three candidate values via three different methodologies and selecting the largest one. These share values are computed using spreadsheets; the resultant values are transferred to a text file, which is then input to the SSM computer program (input file 13).

The expanded market share and extra sell computations rest on the concept of preferential U.S. access to currently unused foreign capacity. For a given combination of material, producing country, and scenario year, the supply is partitioned into:

- An amount corresponding to estimated production that would occur in non-emergency conditions, and
- An amount corresponding to unused capacity, i.e., potentially available capacity that would remain unutilized were the U.S. (or other nations) not actively seeking material.

This partitioning is modeled by applying a production-to-capacity ratio to the supply value. Of the first amount, the U.S. is assumed to get the regular market share. Of the second amount, the U.S. is assumed to get at least the regular market share, but could get an expanded amount, i.e. preferential access. This expanded amount is governed by several

parameters. The computations are performed within the SSM computer program using the values from the SSM input files.

## **2. History of SSM Market Share Modeling**

A market share input has always been part of the SSM. Also, the SSM has always been consistent with an assumption that the United States can access some of the projected foreign unused capacity. This assumption is meaningful in a national emergency scenario when U.S. funds might be available to pay foreign producers to utilize some of their excess capacity. However, this “some” amount was usually considered to be the regular market share of the excess capacity. The concept of *preferential* U.S. access to excess capacity, in which the U.S. could obtain an expanded market share higher than the regular market share, was first modeled in the 2001 and 2003 Requirements Report studies by means of side calculations. The expanded market share was computed only if the regular market share yielded a shortfall. For the 2005 study, the expanded market share calculation was made a formal option in the Stockpile Sizing Module computer program.

When the full RAMF-SM structure was developed, preferential access to previously unused capacity was reinterpreted as a possible shortfall mitigation strategy, or market response to shortfalls. In the 2013 Requirements Report study, it was referred to as the extra buy mitigation strategy and was allowed from all countries with excess capacity. In subsequent studies, it was called extra sell and was considered to be one of the market responses that the market might take to mitigate shortfalls. (The other two market responses considered were thrift and substitution, both of which acted to reduce demand for materials. See Chapter 4, Section C.10, and IDA Paper P-22689.) By direction of the sponsor, extra sell was restricted to a select list of countries with which the U.S. had formal understandings. The methodology remained the same as that implemented for the 2005 study.

Given that extra sell was allowed from only a few countries, it was desired to add an option to the SSM to take into account preferential access from all countries, an option that could be invoked independently of extra sell. The extra capacity market share modeling was developed to address this concern, and an extra option was added in the options section of the case file (see Chapter 5, Section A.4). The idea is that the U.S. can obtain some preferential access supply amount from every country that has some excess capacity, and can get an additional extra sell amount from the countries on the select list. Either or both of these options can be turned off. (All the extra supply amounts are then subject to the war damage, ability, willingness, and shipping loss decrements and delays.)

Previously, the extra sell concept was implemented in the SSM by adjusting the values in the input production-to-capacity ratios file and setting them to 1.0 for countries from which extra sell was not desired. Since the extra capacity market share modeling requires the use of the actual production-to-capacity ratios, a different way was needed to



identify the extra sell countries. The solution was to repurpose one of the input files formerly used for the SSM's internal market share calculation routine (which is now inoperative) to contain a list of countries from which extra sell of materials is allowed. The file is now referred to as the Extra Sell Countries file (input file 3).

### 3. Mathematics of the Expanded Market Share Calculation

The expanded market share is computed as follows. Consider one particular combination of material, foreign supplier country, and scenario year. Define the following quantities (notation applies to this subsection only):

#### Inputs

- $S$  = input value on the SSM foreign supply file for that combination, reduced if necessary by war damage and ability factors (the shipping loss and willingness factors are applied later).
- $m$  = regular market share for that material and year (read from the SSM market share file, input file 13).
- $c$  = extra capacity market share parameter (option 6 in the [options] section of the case file), converted from a percentage to a fraction. Note that  $c$  is a constant; it does not vary by material, country, or year.
- $x$  = extra sell parameter (option 5 in the [options] section), converted from a percentage to a fraction.
- $\rho$  = production-to-capacity ratio, for that combination, input on the production-to-capacity ratios file (input file 16; the ratio value cannot exceed 1).

#### Outputs

- $U_1$  = amount of supply the U.S. gets that corresponds to regular production.
- $U_2$  = amount of supply the U.S. gets that corresponds to unused capacity (not counting extra sell).
- $U_3$  = amount of supply the U.S. gets due to extra sell.

The algorithm starts by partitioning  $S$  into amounts  $S_1$  (regular production) and  $S_2$  (extra production, corresponding to previously unused capacity) via the production-to-capacity ratio:

$$S_1 = S\rho$$

$$S_2 = S(1-\rho).$$

In the absence of extra sell, the U.S. gets the amount  $U_1 + U_2$ , where

$$U_1 = S_1m$$

$$U_2 = S_2 \max\{m, c\}.$$

Note that  $\max\{m, c\}$  is used for the market share percentage of the amount corresponding to previously unused capacity (before extra sell is applied). This means that the market share of previously unused capacity is at least the regular share  $m$ . That is, if the input regular market share,  $m$ , is already higher than  $c$ ,  $m$  will be used. In particular, if the value of  $c$  (i.e., option 6) is set to zero, the market share will be  $m$ .

In order for extra sell to operate for a particular material-country-year combination, all three of the following conditions must be met.

1. The production-to-capacity ratio for that combination must be strictly less than 1.
2. The country must appear on the input file (input file 3) that contains the list of countries from which extra sell is allowed.
3. The extra sell parameter  $x$  must be strictly greater than zero.

If extra sell operates, the extra sell amount is computed as

$$U_3 = S_2(1 - \max\{m, c\})x,$$

Otherwise,  $U_3 = 0$ . All in all, the U.S. gets the amount  $U_1 + U_2 + U_3$ , i.e.

$$U_1 + U_2 + U_3 = S\rho m + S(1-\rho)\max\{m, c\} + S(1-\rho)(1-\max\{m, c\})x$$

(or just the first two terms if extras sell is not operative). Since the initial supply amount  $S$  is a multiplicative constant throughout the calculations, the resultant market share  $\mu$  (which is called the expanded market share) is simply  $(U_1 + U_2 + U_3)/S$ , or

$$\mu = \rho m + (1-\rho)\max\{m, c\} + (1-\rho)(1-\max\{m, c\})x$$

(or only the first two terms, if extra sell is not operative). The quantity  $\mu$  is the market share value referred to Chapter 3, Section B.2.d, and is used in the subsequent calculations of available supply as described in that section.

## B. Concerted Programs and U.S. Supply Levels

Although recent Requirements Report studies have not considered concerted programs, a few words about them and their treatment by the SSM are in order. Concerted programs represent possible sources of future material production, less certain than currently idle facilities or planned future facilities. They generally require a large investment of money and time to come to fruition. (The name “concerted program” refers to the concerted, coordinated effort of funding and labor that is needed to bring the facilities to a productive, operational state.) Concerted programs fall into two categories:

- Restarts of dormant facilities (mines or processing centers);

- New facilities, including expansions of operations at current facilities that involve literally breaking new ground.

Restart concerted programs often start producing output in the same year that they are undertaken; new concerted programs generally need about two years before they start producing output.

The commodity specialists at the U.S. Geological Survey provided lists of concerted programs from all over the world. A subset of the programs, usually those from the U.S. or Canada, was chosen for inclusion in the database for the study. Associated with each program is a year-by-year array of output from it (measured in mass units of material), starting from the year the program is initiated, which is generally assumed to be the first scenario year.

The SSM treats concerted programs as part of the U.S. supply even though they might be located in other countries. That is, the SSM itself does not apply the decrements for war damage, ability, etc. to the concerted programs. Any decrements to foreign concerted program output must be applied as part of the data preparation process.

As mentioned in Chapter 2, the concerted program data are listed on the U.S. supply input file. The structure of the file has been explained in Chapter 4, Section C.11. As noted there, the file has three sets of columns, one for current facilities (including planned future facilities), the second for restart concerted programs (sum of all such programs considered), and the third for new concerted programs (sum of all such programs considered). If concerted programs are not to be included, the second and third sets of columns should be filled with zeroes, but they still need to appear in the file.

The SSM adds the data to determine three different levels of U.S. supply:

- Current facilities (first set of columns only);
- Current facilities plus restarts (first set plus second set of columns); and
- Current facilities plus restarts plus new (sum of all three sets of columns).

The term “level” is frequently used in the SSM computer code to refer to these different U.S. supply amounts. The SSM performs its shortfall computation procedure three times, once for each level. A number of the output reports use the abbreviations “CF”, “CF+RES”, and “CF+RES+NEW” for the three levels. Separate reports for each level are generated for the U.S. supply and the total goals summary outputs. The goals summary, goals summary by year, foreign supply summary, and supply-to-demand reports have separate sections for each level. Of course, if concerted programs are not included, the different reports or sections will have the same values.

## C. Adjustments to the Production-to-Capacity Ratios in the First Scenario Year

### 1. Introduction

The expanded market share calculations, as described in Section A, make use of the production-to-capacity ratios. This section describes an adjustment to those ratios that should be made for the first scenario year when the first-year supply input to the SSM does not represent full capacity, but rather a “ramp-up” value somewhere between production and capacity. The adjustment should be made to the values in the production-to-capacity ratios file (input file 16) during the data preparation process before input to the SSM.

The expanded market share calculations are developed under an assumption of preferential U.S. access to unused supply capacity. In the first scenario year, it is not necessarily true that *all* the unused capacity is potentially available to the United States (or another buyer) because it takes time to ramp up to utilizing the capacity fully. Only the *available* unused capacity can be exploited for additional supply. The sections below derive a formula that takes this fact into account. The discussion applies to a combination of one specific material and one specific foreign country that produces the material.

### 2. Notation and Formula

Define the following variables (notation applies to this section only):

$c_1$  = production capacity in the first scenario year, assumed to be greater than zero<sup>30</sup>

$p_1$  = estimated production in the first scenario year<sup>31</sup>

$r$  = ramp-up time, in months; assume  $0 \leq r \leq 12$ .<sup>32</sup>

Define

$\psi = p_1/c_1$  (“raw” production-to-capacity ratio)

$\theta = r/12$

Then the entry on the production-to-capacity ratio file for this material/country combination in the first scenario year, call it  $\chi_1$ , is set to

$$\chi_1 = \psi / [\psi\theta + (1-\theta)].$$

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<sup>30</sup> If the first-year capacity is zero (which could happen if a future facility is being modeled), then the SSM sets all relevant supply quantities to zero and the production-to-capacity ratio does not operate.

<sup>31</sup> Due to inherent uncertainties in quantities of material produced, the SSM data preparation process generates an extrinsic estimate of production only for the first scenario year, not further.

<sup>32</sup> I.e., the ramp-up time is assumed to be a year or less. The extension of the adjustment procedure to handle ramp-up times longer than a year is straightforward, but is not presented here.

One might refer to  $\chi_1$  as the adjusted production-to-capacity ratio. For subsequent scenario years  $i$ , the entry in the file,  $\chi_i$ , is set to  $\psi$ , regardless of  $i$ . Thus, in the production-to-capacity ratio file, values for subsequent years equal the estimated, or raw production-to-capacity ratio that is determined via the methods described in IDA Document D-5564, but values for the first year are set to the adjusted ratio. The ramp-up time represents the amount of time needed for production facilities to build up from current production levels to full capacity. Note that if  $r=0$  (immediate ramp-up to capacity), then  $\theta=0$  and  $\chi_1 = \psi$ . Further special cases are discussed in subsection 4.

### 3. Rationale and Derivation

The U.S. Geological Survey (or other subject matter expert) furnishes historical data on material production and historical and projected data on material production capacity. The capacity value  $c_1$  is taken from the projected data, and the estimated production amount for the first scenario year,  $p_1$ , is estimated via the process described in IDA Document D-5564. The ramp-up time  $r$  is an extrinsic input, generally selected by the sponsor. For the first scenario year, the SSM supply input (on the foreign supply file),  $s_1$ , is set to reflect a ramp-up period to capacity of  $r$  months. It is a weighted average of production and capacity. In algebraic terms,

$$s_1 = p_1(r/12) + c_1(1-[r/12]).^{33}$$

The expanded market share methodology operates by separating the supply into an amount corresponding to current production ( $p_1$ ) and an amount corresponding to unused capacity ( $s_1 - p_1$ ). The quantity  $p_1$ , although it has been determined during the data preparation process and plays an important role in the computations, is not a direct input to the SSM. Rather, the SSM “re-creates” it by multiplying the entry on the foreign supply file ( $s_1$ ) by the entry on the production-to-capacity ratios file ( $\chi_1$ ). This latter entry must be set so that the product  $\chi_1 s_1$  equals the value  $p_1$  that was computed extrinsically. The desired value of  $\chi_1$  can be computed algebraically as follows. Taking the above formula for  $s_1$  and dividing both sides by  $c_1$  yields the formula

$$s_1/c_1 = (p_1/c_1)(r/12) + 1 - (r/12).$$

Making the substitutions  $\psi = p_1/c_1$  and  $\theta = r/12$  results in

$$s_1/c_1 = \psi\theta + (1 - \theta).$$

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<sup>33</sup> This formula is consistent with a step function ramp-up period, in which production remains at peacetime levels until the ramp-up time is reached, and then jumps up to full capacity. See Eleanor L. Schwartz and James S. Thomason, *The Material Supply Adjustment Process in RAMF-SM Step 2* for further information.

The parameter  $\chi_1$  needs to satisfy the equation  $\chi_1 s_1 = p_1$ . Dividing both sides by  $c_1$  yields the equivalent condition  $\chi_1 (s_1/c_1) = \psi$ . Substituting the above formula for  $s_1/c_1$  results in  $\chi_1 [\psi\theta + (1 - \theta)] = \psi$ . Dividing by the term in brackets yields

$$\chi_1 = \psi / [\psi\theta + (1 - \theta)],$$

which is the formula presented in subsection 2. One can observe that  $\chi_1$  is between  $\psi$  and 1.<sup>34</sup>

As noted earlier, during the first scenario year, it is not true that *all* of the unused capacity is potentially available to the United States because it takes time to ramp up to utilizing it fully. Only the amount  $s_1 - p_1$  can be considered as potentially available unused capacity. Setting the input production-to-capacity ratio to  $\chi_1$  ensures that the SSM computes an unused capacity value that is appropriate, given the necessity for ramp-up. The larger value for  $\chi_1$ , as compared to  $\psi$ , results in a computed estimated production value  $\chi_1 s_1$  that is closer to the supply value  $s_1$  than  $\psi s_1$  would be. The computed unused capacity value  $s_1 - \chi_1 s_1$  is correspondingly smaller.

#### 4. Special Cases

The following special cases can be noted.

- If  $r = 0$ , i.e., there is immediate ramp-up to capacity, then  $\chi_1 = \psi$ , as previously noted.
- If  $r = 12$  months, i.e., it takes a full year to ramp up to capacity, then  $\chi_1 = 1$ . This means that all the supply in the first year corresponds to peacetime production and there is no unused capacity available for preferential U.S. access.
- Most recent Requirements Report Base Cases have used a ramp-up time  $r$  of 6 months. In that case,  $\theta = 0.5$ , and the formula becomes  $\chi_1 = 2\psi / (\psi + 1)$ , a quantity between  $\psi$  and 1. Figure 2 in Chapter 4, Section C.16 illustrates this case.
- If the estimated production in the first year is zero, then  $\psi = 0$  and the formula yields  $\chi_1 = 0$ . A special case is as follows.
- If  $\psi = 0$  and  $\theta = 1$  (i.e.,  $r = 12$ ), the formula yields  $0/0$ , which is ambiguous. In this case, however,  $p_1 = s_1 = 0$ , and the resultant first-year supply amounts will be zero regardless of the value of  $\chi_1$ , so 0 is certainly a reasonable value for that input. For subsequent years  $i$ , the parameter  $\chi_i$  can be set to  $\psi$ , i.e. 0; the available unused capacity will be  $c_i$ .

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<sup>34</sup> Not necessarily strictly between.

- It is possible to use different ramp-up times for different material/country combinations if credible data can be found. In that case, the first-year adjustments would differ.

## **D. The Supply-Demand Comparison and Shortfall Calculation**

RAMF-SM Substep 2c has two parts. The first part, the computation of the material supply available, involves many inputs and assumptions. It has been discussed explicitly in Chapter 3 and many other parts of this paper have touched on it. The second part of Substep 2c, the comparison of available supply with demand, is as vital to the determination of material shortfalls as the first part, but has received less attention, discussion, and documentation. This section provides a relatively brief overview of the supply-demand comparison procedure. The discussion here applies to a combination of specific material and specific U.S. supply level (see Section B); the algorithm is performed separately for each such combination.

Stage 2 of the available material supply calculation procedure results in three types of supply:

- Domestic totally-usable supply;
- Foreign totally-usable supply;
- Civilian-usable-only supply.

There are also three tiers (kinds) of demand

- Defense demand;
- Emergency investment demand;
- Civilian demand.

These supplies and demands are all time streams (vectors) by year of the scenario. One wants to develop a method for assigning the supplies to meet the demands; the remaining unsatisfied demands become shortfalls. There are some constraints on assignment: supplies in later years cannot be assigned to meet demand in earlier years, and civilian-usable-only supply cannot be assigned to meet defense or emergency investment demand. One would like the assignments to make the resultant shortfalls as small as possible; this would mean that the supplies are used to their fullest advantage.

The problem of determining such an optimal assignment can be formulated as a transportation problem, one of the classic problems of operations research.<sup>35</sup> The algorithm

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<sup>35</sup> For information on the structure of transportation problems, see any text on mathematical programming, such as Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research*, 11<sup>th</sup> edition (New York City, NY: McGraw-Hill, 2020).

described in P-2867 found what is called an initial basic feasible solution to this transportation problem.<sup>36</sup> That solution was often optimal, but was not guaranteed to be. The transportation simplex algorithm, which is the classic algorithm for solving transportation problems, has now been implemented within the SSM.

If the scenario is  $n$  years long, the transportation problem has  $3n$  “regular” supply nodes, one for each combination of scenario year and supply type. In addition, there is a dummy supply node with an arbitrarily large amount of supply available. (The algorithm sets the available supply at the dummy supply node to the sum of all the demands.) There are  $3n$  regular demand nodes, one for each combination of scenario year and demand tier. There is also a dummy demand node. The transportation problem determines a pattern of flow (i.e., assignment) from the supply nodes to the demand nodes. The total flow from a given supply node cannot exceed the available supply from that node. The demand at each demand node must be met exactly. Demand that is not met from the regular supply nodes is met from the dummy supply node. The flow from the dummy supply node is interpreted as shortfall or stockpile; the objective is to keep it as small as possible. The dummy demand node absorbs all supplies not flowing to the regular demand nodes. Any nodes with zero supply (for example, some materials might have zero domestic supply) or zero demand are excluded from the problem.

Arcs corresponding to prohibited flows (e.g., ones where the supply year is greater than the demand year) are given a very high cost to prevent the transportation simplex algorithm from considering them. Arcs from the dummy supply node are given a high cost so that flow from them will be as small as possible. Other arcs are given a zero cost. The objective function is to minimize the total cost of the flows.

The algorithm starts by determining an initial basic feasible solution to the transportation problem. This initial procedure determines flow from the supply nodes to the demand nodes in accordance with the priority order defense demands, then emergency investment demands, then civilian demands.<sup>37</sup> The algorithm also attempts to use U.S. supply in preference to foreign, and no supply is flowed along prohibited arcs. It is interesting that in all the runs of the model performed so far, this initial basic feasible solution has the same flows as the solution determined (in a far different manner) by the legacy algorithm.

Using the standard procedures of the transportation simplex algorithm, the initial basic feasible solution is tested for optimality (i.e., minimal total flow costs); if it is not optimal, an update (resulting in a change of flows) is performed. This new flow pattern is

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<sup>36</sup> In this context, “basic” is a technical term, used in the linear algebra theory that underlies the transportation problem structure.

<sup>37</sup> The delay in establishing defense priority has been modeled via the stage 2 supply availability adjustments, which act to lessen the amounts of totally-usable supply.



then tested for optimality. If it is not optimal, the update procedure is performed again; the process continues until an optimal solution is found. In the kinds of scenarios that have been used in recent Requirements Reports (conflict at the beginning of the scenario followed by a regeneration period) the initial basic feasible solution is often optimal. However, this property is not guaranteed and might not occur frequently for other kinds of scenarios.

The “Supply Used” output file (see Chapter 5, Section B.3.d) shows the supply-to-demand assignments that were made in the optimal solution.

## **E. Goods and Services Import Reduction Factors**

The country-by-country war damage, ability, willingness, and shipping loss factors used to decrement foreign supplies of materials can also be used to decrement the imports of goods and services that are used in RAMF-SM Substep 2a. An auxiliary computer program was written to convert the decrement factors, which depend on country, to factors that depend on industry.<sup>38</sup> The projected peacetime goods and services imports (which have been generated via economic modeling) are multiplied by the corresponding factors to get reduced import amounts consistent with the emergency scenario. Goods and services demands that cannot be met via imports must then be satisfied through domestic production, causing additional demand on industry, and corresponding demand for materials.

The war damage, ability, willingness, and shipping loss factors used in the SSM can be used as is in the auxiliary program (default values of 1 are used for countries not listed in the files). There are a couple of cautionary notes.

First, the delay times (for imports delayed due to supplier country unwillingness) must be constant; they cannot depend on the country of origin, as is theoretically possible in the SSM. The auxiliary program accepts an input constant for the delay time.

Second, in the SSM, supply is considered totally unavailable from countries with a usability code of U (totally unreliable) in the Supply Usability Codes file (input file 7). There is no such analog in the auxiliary program, but goods and services imports from totally unreliable countries can be excluded by setting the war damage factors for those countries to zero. The war damage factors file used in the auxiliary program is, therefore, often slightly different from the one used in the SSM because it includes these zero settings.

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<sup>38</sup> The auxiliary program makes use of information from the Census Bureau about U.S. goods and services imports organized by industry sector and country.

## **F. Market Responses, Gross Shortfalls, and Net Shortfalls**

### **1. Introduction and Background**

In recent Requirements Reports, most SSM runs tend to occur in pairs—a “gross shortfalls” run, and a corresponding “net shortfalls” run. This section discusses the meaning of these terms and shows how to set up the runs.

These paired runs are intended to address Substep 2d of RAMF-SM, the modeling of market responses (see Appendix A). The idea is that upon noticing a material shortfall (or potential shortfall) in the course of a national emergency, the market acts in several ways to increase material supply and/or reduce material demand. These actions are to be interpreted as market responses rather than formal risk mitigation strategies by the U.S. government, which are the purview of steps 3 through 6 of RAMF-SM.

As of 2021, RAMF-SM has modeled three different market responses:

- Thrift—using less of a material in the production of goods and services;
- Substitution—using substitute material(s) for a material that might be in shortfall; and
- Extra sell—obtaining more material from certain countries.

The first two market responses act to reduce demand for materials; the third tends to increase the available supply. The market responses are implemented in RAMF-SM by adjusting certain inputs to the MDCP and the SSM. A gross shortfall run has none of the responses; the corresponding net shortfall run has all of them with the other inputs set the same as in the gross shortfall run. Comparison of the shortfall amounts in the net vs. the gross run provides an indication of the effectiveness of the market responses. Partial market response cases, which consider one or two of the market responses, are sometimes run also.

### **2. Modeling the Thrift and Substitution Responses**

Modeling of the thrift and substitution responses is done via the MDCP followed by the SSM. The reader is referred to the documentation of the MDCP in IDA Paper P-22689. Each MDCP run outputs four different files that can potentially be used as U.S. Requirements input files for the SSM (input file 10; see Chapter 4, Section C.10). The files, which are characterized by a three-letter code (see P-22689), are as follows:<sup>39</sup>

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<sup>39</sup> The name of the MDCP output file is a concatenation of an 8-character MDCP run name, the underscore character, the three-letter code, and the extension .txt. The files are tab-delimited text files that can be viewed in Excel. They are ready for input to the SSM without any further editing. The MDCP also generates corresponding notes files (same file name with extension .not) for each output file.

- “out” file—models none of the market responses; used for gross shortfall SSM runs;
- “tso” file—models both the thrift and the substitution market responses; used for net shortfall SSM runs;
- “sbo” file—models the substitution market response only;
- “tfo” file—models the thrift market response only.

The appropriate file should be used as input to the SSM.

### 3. Modeling the Extra Sell Market Response

The extra sell market response is modeled in the SSM itself. Its operation has been discussed in this paper, especially in Chapter 6, Section A. The procedure to set up the SSM to model extra sell is as follows.

- The set of countries from which extra sell is allowed is specified by the sponsor (or chosen by the user to examine variations). This set should be listed on an extra sell countries input file (input file 3; see Chapter 4, Section C.3). The file should be specified on the case file for the SSM run.
- A production-to-capacity ratio input file (input file 16; see Chapter 4, Section C.16) should be constructed and should be specified on the case file for the SSM run.
- The extra sell percentage (option 5 in the [options] section of the case file) should be set to the desired percentage *greater than zero*. Often, a value of 50 percent has been used.

Extra sell will not be modeled if the list of extra sell countries is null (contains a header line only) or if the extra sell percentage is zero.

### 4. Conclusion

By selecting the appropriate U.S. Requirements file (input file 10) and invoking or not invoking the extra sell market response, the SSM can model all the different combinations of the three market responses. For a gross shortfall run, use the MDCP “out” file and do not invoke extra sell. For the corresponding net shortfall run, use the MDCP “tso” file and do invoke extra sell.

## G. Composite Supplier Countries

For some materials, the foreign supply data from the U.S. Geological Survey, in addition to listing supply from specific countries, contain an entry marked “Other

Countries.” The total supply from the group of other countries is listed, but cannot be separated by specific country within the group.

The SSM can handle this situation by establishing a dummy composite supplier country for the material and giving it a composite country name such as Other\_<material\_name> using the name of the material in question (e.g., Other\_Unobtainium). The composite country name should be listed in the country.txt file. The “other” supply amount from the United States Geological Survey (USGS) file can be listed in the Foreign Supply input file (input file 5) on a line that starts with the material in question and the composite country name.

Every effort should be made to ascertain the component countries included in the group of other countries (the USGS usually provides them). As appropriate, values should be constructed (and listed in the corresponding input files) for the war damage, ability, willingness, shipping loss, and delay time factors for the composite supplier country by averaging the values of the component countries.

## **H. On the Separation of Ability and Willingness Factors**

This section contains some thoughts that were articulated during the period 2003-2004, when the modeling of separate degradation factors for country ability to supply material and country willingness to supply material to the U.S. was being developed.

In versions of the SSM prior to the 2005 Requirements Report study, the degradation to a country’s ability to supply and its anti-U.S. sentiment were combined into one political reliability factor. But it’s really more the trade reliability of a country, and more specifically its export reliability, than its political affinity with the U.S. that is relevant for its ability to supply materials. While the SSM’s earlier reliability construct basically assumed a world of bilateral instead of global trade relations, in reality strategic and critical materials of the sort in the National Defense Stockpile (NDS) have global markets, essentially like oil. Commodities are available on spot markets, secondary markets, and so forth.

Therefore, for the NDS planning scenarios it does not matter as much to whom an exporter sells as long as it does sell. If it sells to Country or Buyer Y and not us, we will buy from Y, or we will buy what Y would otherwise have bought from someone else. The price may be higher to us (extra transaction costs, e.g., more middlemen, higher transportation costs), but that is not the critical issue in this planning context. In this framework then, it does not matter a great deal whether a country likes to sell to the U.S. or not. However, a country’s ability to produce materials and get them to market might be affected by infrastructure problems and economic and political instabilities that could be exacerbated by the conflict scenario.

It might, however, be appropriate to impose some kind of a delay in the availability to the U.S. of a country’s strategic and critical materials ( several months for example, in

order for secondary markets to work) if that country is deemed very unlikely to want to supply any S&CMs to the U.S. in the context of the scenario. Accordingly, an estimate of the anti-U.S. sentiment of a country is useful independent of its ability to produce material.

The methodology thus uses two different sets of factors to model foreign country reliability. The first is an ability degradation factor (sometimes referred to as an infrastructure reliability factor); the second is a pro-U.S. sentiment factor, indicating willingness to supply S&CMs (and other goods and services) to the United States. (A corresponding anti-U.S.-sentiment factor is interpreted as 1 minus the pro-U.S. factor.) To obtain country reliability estimates, country experts from appropriate government agencies can be asked two separate questions, one pertaining to ability and one to willingness. Respondents can be asked to provide different values for each scenario year.

The term infrastructure reliability factors is a shorthand for all the factors that degrade a country's ability to supply materials during an emergency scenario, such as power shortages, transportation breakdowns, labor strife, civil unrest, or *indirect* effects of conflict. Direct wartime damage, e.g., bombing damage, is considered in the war damage factor rather than the ability factor.

In the previous modeling (prior to the 2005 NDS study) a combined political reliability factor represented the combined effects of infrastructure/ability degradation and anti-U.S. sentiment. To replicate the previous modeling, the ability and willingness factors can be multiplied together to generate an equivalent political reliability factor. Alternatively, the delay time ratio cutoff option can be set to zero so that all delays are infinite.

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## **Appendix A.**

### **A Precis of RAMF-SM**

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The reader is also referred to the Executive Summary of IDA Document D-5270.

The Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM) is a suite of procedures, models, and databases that can be used to assess shortfalls of strategic and critical materials and the risks of such shortfalls. It can also be used to develop and assess strategies to help reduce those risks.

RAMF-SM and its precursors have played a key role in the analyses that have supported the biennial Requirements Reports to the Congress concerning requirements for the NDS of strategic and critical non-fuel materials.<sup>40</sup> RAMF-SM, which was developed by the IDA and is discussed more fully in IDA Paper P-5190<sup>41</sup>, has six major steps:

1. Identifying (and selecting for study) materials of concern to the U.S. national security community;
2. Computing material shortfalls to assess whether there could be significant problems in a planning scenario (such as a national emergency scenario<sup>42</sup>) in meeting critical demands for materials with supplies of materials likely to be available to the United States;
3. Assessing the importance of overcoming (or the risks to the United States of not overcoming) those shortfalls by deliberate government mitigation actions;
4. Identifying various promising government mitigation options to address any important shortfalls;

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<sup>40</sup> The National Defense Stockpile was established in the World War II era and has been managed by the Department of Defense (DOD) since 1988. By law, DOD is required to submit periodic reports to Congress stating which materials, and in what amounts, the stockpile should contain. The most recent such report as of this writing is Office of the Under Secretary of Defense for Acquisition and Sustainment, *Strategic and Critical Materials 2021 Report on Stockpile Requirements* (U.S. Department of Defense, n.p., February 2021).

<sup>41</sup> James S. Thomason et al., *Analyses for the 2015 National Defense Stockpile Requirements Report to Congress on Strategic Materials*.

<sup>42</sup> Throughout this paper, the terms scenario and emergency scenario are used more-or-less synonymously.

5. Assessing and comparing the specific costs and mitigation effects of these government mitigation options, both individually and together; and
6. Identifying priorities among the materials for investments of taxpayer dollars, whether through stockpiling or other government investments, to mitigate important potential shortfalls.

Step 2 of RAMF-SM is concerned with determining shortfalls of materials in a specified planning scenario, typically a national emergency. It has four substeps.

- Substep 2a determines the U.S. demands for goods and services and the corresponding demand for outputs from U.S. industry that would occur in a certain specified national emergency. These demands are developed via economic modeling with adjustments to model the specific characteristics of the national emergency scenario.<sup>43</sup> Demands are expressed in millions of constant-year dollars.
- Substep 2b determines the demands for materials, i.e., the amounts of materials that U.S. industry needs in order to produce output that will satisfy the demands computed in Substep 2a. The demands for materials are expressed in mass units (e.g., tons) of material, and are determined from the demands for goods and services by means of material consumption information via the methodology discussed in this paper.
- Substep 2c accepts initial material supply levels and determines the available supply of materials, taking into account the characteristics of the particular national emergency scenario examined. It then compares the available supplies with the material demands from Substep 2b and computes material shortfalls. Material supplies and shortfalls are expressed in mass units of material.
- Substep 2d models three different possible actions that markets might take in response to a material shortfall. These include thrift in production (using less of a material), substitution of a non-shortfall material for a shortfall one, and seeking extra sells of material from certain countries with unused production capacity. The effects of these market responses are modeled by changing the

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<sup>43</sup> A distinction must be made between demands and industrial output. Domestic demands for goods (and services) can be met either by items produced in the United States or by imported items. Therefore, satisfying some of the demand via imports leads to less demand for output from U.S. industry. However, goods produced in the United States for export constitute an additional demand for output from U.S. industry. The calculations of Substep 2a estimate domestic demands for goods and services (defense, civilian, and emergency investment), exports, and imports. Adding net exports (i.e., exports minus imports) to the domestic demands yields the demand for output from U.S. industry, which in turn leads to demand for materials. This addition is performed as part of Substep 2b, but it could have been done in Substep 2a instead.



material demand and supply amounts in an appropriate manner and rerunning Substeps 2b and 2c.

Several mathematical models and dozens of databases, encompassing thousands of data items, support the computations of these substeps. Documentation of the major models exists.<sup>44</sup> The current paper provides updated documentation of the Stockpile Sizing Module, the major model used in Substep 2c.

The majority of analyses performed with RAMF-SM have used Steps 1 and 2 only.

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<sup>44</sup> Substep 2a utilizes several different models. Two of these are economic forecasting models from the Inter-industry Forecasting Project at the University of Maryland (INFORUM). They are named LIFT (Long-term Inter-industry Forecasting Tool) (see Douglas S. Meade, *The INFORUM LIFT Model, Technical Documentation* (College Park, MD: Inter-industry Forecasting Project, University of Maryland, November 2017, [https://www.researchgate.net/publication/266049640\\_The\\_LIFT\\_Model](https://www.researchgate.net/publication/266049640_The_LIFT_Model))) and ILIAD (Inter-industry Large-scale Integrated And Dynamic model) (see Douglas S. Meade et al., *ILIAD* (College Park, MD: Inter-industry Forecasting Project, University of Maryland, December 2011)). Substep 2a also uses a model called the FORCEMOB (Forces Mobilization Model) (Eleanor L. Schwartz et al., *Documentation of the Forces Mobilization Model (FORCEMOB), Versions 3.1 and 3.2* Vol. I: *General Description*; Eleanor L. Schwartz and James S. Thomason, Vol. II: *Data Preparation Guide*, IDA Paper P-2953 (Alexandria, VA: Institute for Defense Analyses, January 1996)). also see James S. Thomason et al., *Forces Mobilization Model (FORCEMOB): Unclassified Training Tutorial*, IDA Document D-5433 (Alexandria, VA: Institute for Defense Analyses, August 2015)), which applies scenario-specific adjustments to the output of the economic models, computes industrial requirements to build weapons, and determines emergency investment demand. Substep 2b is modeled via the Material Demand Computation Program (Eleanor L. Schwartz, *The RAMF-SM Material Demand Computation Program: Documentation and User's Guide*). Substep 2c is modeled using the Stockpile Sizing Module (Tara E. Santmire, *Stockpile Sizing Module Documentation for Version 4.4*, Vol I.: *Theoretical Foundations and User's Guide*, Vol. II: *SSM Inputs*, and Vol. III: *SSM Outputs*; also see Robert J. Atwell et al., *Generic Unclassified Stockpile Sizing Module (SSM) Training and Testing for the National Defense Stockpile (NDS) 2015*; and the current paper).

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## Appendix B. Glossary

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Ability factors	See supply ability factors.
Adjustment parameters	A set of SSM inputs that can be used to conduct quick sensitivity analyses.
Assured country list	Countries that are given a code of A (Assured) in the Supply Usability Codes input file. Dominator constraints do not apply to these countries.
Assured supply	Totally-usable available foreign supply before the Stage 2 calculations have been performed.
Assured supply usability code	An SSM input specified in the Supply Usability Codes file. Supply from countries given this code is always considered totally-usable.
Basic Information	An input file to the SSM that lists material names, units of measure, and prices.
Batch file	An input file to the SSM that lists the cases to be run and certain directory information.
Case file	An input file to the SSM that specifies the data files and other parameters to be used.
Civilian-usable-only supply	Available material supply that can be used only to satisfy civilian demands, not defense or emergency investment demands.
Concerted program	A possible future material production facility that generally involves a large investment of money, time, and labor to come to fruition. Usually applies to facilities in the U.S.
Control inputs file	A synonym for the case file
Current facilities	U.S. sources of material supply that are in current operation, or planned future facilities that have a high expectation of being operational in the scenario period.
Database subdirectory	A subdirectory of the home directory that contains all the SSM input files. The subdirectory must have the name "database."
Default parameters	A section of the case file that gives default values for certain SSM inputs. These defaults are used when the input data files do not specify values.
Defense-usable supply	A not-quite-correct term used for material supply that can satisfy defense demands. Totally-usable supply, q.v., is a better term.

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Default supply parameters	A section of the case file that specifies the supply usability code methods.
Delay time factors	A set of SSM inputs that are used to compute the length of delay it takes supply from unwilling countries to reach the United States.
Delayed defense priority	Conditions that delay or retard the use of available supply to satisfy defense demand in preference to the other tiers; the SSM features that can model such conditions.
Delayed defense usability	An option that specifies the fraction of material that is delayed due to supplier country unwillingness that can be used to satisfy defense (or emergency investment) demands.
Demand tier	A term used to specify category of demand: civilian, defense (military), or emergency investment. These categories apply to both demands for goods and services (RAMF-SM Substep 2a) and demands for materials (RAMF-SM Substep 2b). Also referred to simply as tier.
Domestic single point of failure (DSPOF)	A U.S. facility that is the sole producer of a certain material.
Domestic supply	Material supply originating in the United States.
Domestic totally-usable supply	Material supply originating in the United States that can be used to satisfy demand in any tier.
Dominator country	A foreign country that supplies a major portion of the supply of a given material. The SSM can model the effect of such concentration on the usability of the country's supply.
Expanded market share	A term encompassing extra capacity market share and extra sell.
Extra buy	See extra sell.
Extra capacity market share	An extra amount of available material resulting from preferential U.S. access to unused foreign material production capacity. Usually restricted to a small set of foreign countries.
Extra sell	An extra amount of available material resulting from preferential U.S. access to unused foreign material production capacity. Usually restricted to a small set of foreign countries.
Extra sell countries	An input file to the SSM; it contains a list of foreign countries from which extra sell is allowed.
Forces Mobilization Model (FORCEMOB)	A mathematical model that computes demands for goods and services (Substep 2a of RAMF-SM). The FORCEMOB works with the output of the LIFT and ILIAD (defined on the next page) models.
Foreign totally-usable supply	Available material supply originating in foreign countries that can be used to satisfy demand in any tier
Goal	Another term for material shortfall (shortfalls can be considered to be goal amounts for the National Defense Stockpile materials)

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Goals summary	The main output report of the SSM; shows the material shortfalls for each material, tier, and level.
Home directory	The directory from which the SSM is run; contains the executable file and the batch files.
INFORUM	The Inter-Industry Forecasting Project at the University of Maryland, a research organization that has developed the LIFT and ILIAD economic forecasting models that are used in parts of RAMF-SM.
Infrastructure reliability factors	See supply ability factors.
Inter-Industry Large-Scale Integrated and Dynamic Model (ILIAD)	An economic model developed by INFORM that is used in Substep 2a of RAMF-SM.
Level	See U.S. supply level.
Long-Term Inter-Industry Forecasting Tool (LIFT)	An economic model developed by INFORM that is used in Substep 2a of RAMF-SM.
Main directory	See home directory.
Market responses	Actions that the market might take upon noticing a material shortfall to increase supply or reduce demand. Currently, RAMF-SM Step 2 models three such responses: extra sell, substitution, and thrift.
Market share	See U.S. market share.
Material Demand Computation Program (MDCP)	A mathematical model that computes demands for materials (Substep 2b of RAMF-SM). The MDCP works with the output of the FORCEMOB; the output of the MDCP becomes input to the SSM.
Material shortfall	A situation in which the available supply of a material is insufficient to meet the demand for it.
National Defense Stockpile (NDS)	A U.S. Government stockpile of strategic and critical materials; it is maintained by the Department of Defense.
New concerted program	A concerted program that involves construction of a new production facility, or an expansion of a current facility that involves literally breaking new ground.
Options	A section of the case file that specifies a number of possible modeling options that can be invoked.
Production-to-capacity ratios	An SSM input file that contains, for each combination of material and foreign producing country, the ratio of peacetime (estimated) production to production capacity.
Pro-U.S. factors	See supply willingness factors.
Ramp-up	A situation in which a material production facility increases production from peacetime levels to full capacity.

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Reliable supply	Civilian-usable-only available foreign supply, before the Stage 2 calculations have been performed.
Reliable supply usability code	An SSM input specified in the Supply Usability Codes file. Supply from countries given this code is initially considered civilian-usable-only.
Requirements Report (RR)	A legally-mandated report about the status of materials in the National Defense Stockpile. The Department of Defense prepares the report and delivers it to Congress.
Restart concerted program	A concerted program that involves revitalizing and restarting a dormant production facility.
Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM)	A suite of procedures, models, and databases that can be used to assess the impact on national security of strategic materials.
Scenario parameters	A section of the case file that specifies the number of years in the emergency scenario and the starting year (and also two seldom-used parameters).
Shortfall material	A material that is in shortfall, i.e. has a material shortfall.
Single point of failure (SPOF)	A facility that is the sole producer of a certain material in a given country. Usually is used to refer to U.S. facilities.
SSM	See Stockpile Sizing Module.
Stage 1 calculations	The SSM's calculations of available material supply before taking into account delayed defense priority.
Stage 2 calculations	The SSM's adjustments to available material supply to model delayed defense priority.
Stockpile Batch File (SSM input file)	See batch file.
Stockpile goal	See goal.
Stockpile Sizing Module (SSM)	The mathematical model used in RAMF-SM Substep 2c, and the subject of this paper.
Strategic and critical material	A material that has important uses for national security and is not found in sufficient quantities in the United States.
Study List 1 (SL1)	A list of materials that are analyzed using the mathematical models of RAMF-SM.
Study List 2 (SL2)	A list of materials that are usually analyzed using a combination of the RAMF-SM models and detailed, specialized modeling.
Substitution	One of the market responses to material shortfalls; an attempt to use substitute materials for a material in shortfall. Has the effect of lessening demand for the shortfall material.
Supply ability factors	A set of SSM inputs that model a reduction in foreign countries' ability to supply materials. The factors encompass all the

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	conditions that could degrade a country's ability to supply materials during an emergency scenario, such as power shortages, transportation breakdowns, labor strife, civil unrest, or indirect effects of conflict.
Supply	An amount of material that is potentially available to U.S. manufacturers. The term "supply" is deliberately ambiguous; it might refer to estimated production, supply capacity, or some quantity in between.
Supply capacity	The capacity of a certain country to supply a certain material; might be considerably greater than its peacetime production level.
Supply reliability factors	See supply ability factors.
Supply shipping loss factors	A set of SSM inputs that model losses to foreign material supply due to attacks in transit.
Supply usability codes	A categorization that models the tiers of demand that certain kinds of supply can satisfy. The Supply Usability Codes input file to the SSM contains initial values for these codes: Assured, Reliable, or Unreliable, q.v.
Supply usability code methods	A set of SSM inputs that can model the tiers of demand that supply from certain countries can satisfy, and possibly the amounts of supply available. They are often used to model the effects of dominator countries.
Supply war damage factors	A set of SSM inputs that model the effect of direct wartime damage, e.g., bombing damage, on a country's ability to supply materials.
Supply willingness factors	A set of SSM inputs that model foreign countries' willingness to supply materials to the United States. These factors explicitly apply to pro-U.S. sentiment and orientation.
Thrift	One of the market responses to material shortfalls; an attempt to use a material more efficiently in the production of goods and services. Has the effect of lessening demand for the material.
Tier	A term used to specify category of demand: civilian, defense (military), or emergency investment. These categories apply to both demands for goods and services (RAMF-SM Substep 2a) and demands for materials (RAMF-SM Substep 2b). Also referred to as demand tier.
Totally-usable supply	Available material supply that can be used to satisfy material demand in any tier.
U.S. Imports	An optional input file to the SSM that lists imports of materials.
U.S. market share	The fraction of foreign material supply that the U.S. can obtain after the other supply decrement and delay factors have been applied. Initial values are input to the SSM on the U.S. Market Share file, but expanded market share values can then be applied.
U.S. Requirements	An SSM input file that specifies the material demands, organized by material, demand tier, and scenario year.

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U.S. supply level	The SSM performs its shortfall calculations separately for three different U.S. supply levels: 1) current facilities only; 2) current facilities plus restart concerted programs; 3) current facilities plus restart and new concerted programs.
United States Geological Survey (USGS)	An agency of the U.S. Government that provides much of the material-related data used in the Requirements Report analyses.
Unreliable supply	Foreign material supply that cannot be used at all.
Unreliable supply usability code	An SSM input used in the Supply Usability Codes file. Supply from countries given this code is excluded from consideration.
War damage factors	See supply war damage factors.
Year	The emergency scenario is generally several years long. The number of years and starting year are input on the case file. Most SSM input and output quantities vary by year.

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# Appendix C. Illustrations

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## Appendix E. Abbreviations

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A	Assured supply usability code
.cas	Case file (SSM input file)
CF	Current facilities
CF+RES	Current facilities plus restart concerted programs
CF+RES+NEW	Current facilities plus restart and new concerted programs
CIA	Central Intelligence Agency
DLA-SM	Defense Logistics Agency Office of Strategic Materials
DOD	Department of Defense
DSPOF	Domestic single point of failure
FORCEMOB	Forces Mobilization Model
GDP	Gross domestic product
IDA	Institute for Defense Analyses
ILIAD	Inter-Industry Large-Scale Integrated and Dynamic Model
INFORUM	Inter-Industry Forecasting Project at the University of Maryland
.lgb	Log batch file (SSM output file)
LIFT	Long-Term Inter-Industry Forecasting Tool
MDCP	Material Demand Computation Program
NDS	National Defense Stockpile
.not	Note file
_out	Main output file of the MDCP
R	Reliable supply usability code
RAMF-SM	Risk Assessment and Mitigation Framework for Strategic Materials
.rpt	Report (suffix for many SSM output files)
RR	Requirements Report
S&CM	Strategic and critical material
.sbf	Stockpile Batch File (SSM input file)
_sbo	Substitution only (output file of the MDCP)
SL1	Study List 1
SL2	Study List 2
SPOF	Single point of failure
SSM	Stockpile Sizing Module
_tfo	Thrift only (output file of the MDCP)
_tso	Thrift and substitution output (output file of the MDCP)
.txt	Text file

U  
U.S.C.  
USGS

Unreliable supply usability code  
United States Code  
United States Geological Survey

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188		
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1. REPORT DATE (DD-MM-YY) XX-04-2022		2. REPORT TYPE Final		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE <i>The RAMF-SM Stockpile Sizing Module: Updated Documentation and User's Guide</i>			5a. CONTRACT NO.		
			5b. GRANT NO.		
			5c. PROGRAM ELEMENT NO(S).		
6. AUTHOR(S) Eleanor L. Schwartz James S. Thomason			5d. PROJECT NO.		
			5e. TASK NO. DE-6-4333		
			5f. WORK UNIT NO.		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute for Defense Analyses 730 East Glebe Road Alexandria, VA 22305			8. PERFORMING ORGANIZATION REPORT NO. IDA Paper P-22696 Log: H 21-000208		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Strategic Materials Office, Defense Logistics Agency 8725 John J. Kingman Rd. #2545, Fort Belvoir, VA 22060			10. SPONSOR'S / MONITOR'S ACRONYM(S) DLA		
			11. SPONSOR'S / MONITOR'S REPORT NO(S).		
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This paper provides updated documentation of the Stockpile Sizing Module (SSM), a mathematical model, with associated computer program, that constitutes a key portion of the Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM). Developed by the Institute for Defense Analyses, RAMF-SM has played a key role in the analyses that have supported the Reports to the Congress from the Department of Defense concerning requirements for the National Defense Stockpile of strategic and critical non-fuel materials (S&CMs). The SSM estimates shortfalls of S&CMs that might occur in a national emergency scenario. This paper focuses on training a user to set up runs of the SSM computer program and to interpret its output. Detailed descriptions of the model's inputs and outputs are provided, along with discussion of the underlying methodology.					
15. SUBJECT TERMS strategic materials, critical materials, National Defense Stockpile, Defense Logistics Agency, material requirements, material shortfalls, mathematical modeling, methodology, computer program documentation					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT U	18. NO. OF PAGES 106	19a. NAME OF RESPONSIBLE PERSON Thomas Rasmussen
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (Include Area Code) 571-757-5478

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