Weapon-Specific Strategic Material Estimation Process (WSSMEP)

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Weapon-Specific Strategic Material Estimation Process (WSSMEP)
Executive Summary

This annotated briefing and associated Microsoft Excel file demonstrate the practical operation and theoretical basis of the Weapon-Specific Strategic Material Estimation Process (WSSMEP). A previous version of this briefing was presented to Defense Logistics Agency (DLA) representatives in July 2014. It is intended as a high-level overview. Some data inputs to WSSMEP are proprietary or classified, but the model itself is not.

WSSMEP is a modeling tool used to estimate the demand for the strategic and critical materials (S&CM) associated with production of a particular U.S. weapons system. For example, WSSMEP can be used to estimate the amount of tungsten required by the industrial base to build an M-1 tank. The algorithms and calculations of WSSMEP have long been used as a part of the Risk Assessment and Mitigation Framework – Strategic Materials (RAMF-SM), an analytical process used to determine, among other things, what materials in what quantities should be considered for inclusion in the National Defense Stockpile (NDS). WSSMEP has also been used to support Congressionally mandated reports about, for example, the dependence of major U.S. weapons systems on rare earth elements.

In the logic of WSSMEP, a weapon can be thought of as the sum of industrial output from each economic sector needed to produce it. For example, the production of a tank places demand on the metallurgical sector, the electronics sector, and so forth. The Production Process Matrix (PPM) defines U.S. weapons systems in terms of their required output from each of 360 economic sectors. Importantly, this matrix measures the economic output needed for the production of a weapon, not just the weapon itself, meaning that it includes tool and die, building maintenance, and so forth. The economic sectors come from the Interindustry Large-scale Integrated and Dynamic (ILIAD) model, an input/output model of the U.S. economy run by the Interindustry Forecasting Project at the University of Maryland (INFORUM).

The PPM itself is the product of the Defense Translator and the Leontief Inverse Matrix. The Defense Translator is a set of vectors, each of which corresponds to a U.S. weapon. The vector components specify percentages of system purchase price that go to companies in a particular economic sector. Because these values are percentages, they should sum to 1. Defense Translators are
determined by the Office of the Secretary of Defense (OSD), Cost Assessment and Performance Evaluation (CAPE). The Leontief Inverse Matrix (developed by Nobel Prize-winning economist Wassily Leontief (1906–1999)) is a measure of economic requirements by industry. In other words, how much input from other economic sectors is required to produce a fixed amount of output in another industry? It is computed using INFORUM data. Multiplying the Defense Translator and Leontief Inverse Matrix results in the PPM, which measures economic output needed in each industry to produce a particular weapon.

Each economic sector also requires a certain amount of materials to produce a fixed amount of output. For example, the automobile industry requires X quantity of iron to produce Y amount of output. The Material Consumption Ratios (MCRs) define the quantities of material needed to produce $1 billion of output in each economic sector. MCRs are computed from data provided by the U.S. Geological Survey (USGS), the Department of Commerce (DOC), and industry subject matter experts (SMEs). A separate MCR is developed for each combination of material of interest and industry sector.

Multiplying a weapon’s PPM vector by the appropriate MCR vector results in the material quantities needed to produce $1-billion worth of a weapon. Multiplying by the weapon unit price and dividing by unit conversion factors result in the material quantities needed to produce one unit of the weapon. To summarize the mathematical operations used in WSSMEP:

\[
\text{Material Required} = \frac{(\text{Weapon Price} \times \text{PPM} \times \text{MCR})}{\text{Unit Conversion Factors}}.
\]

Since WSSMEP essentially consists of vector algebra operations, it can be—and has been—programmed in a variety of computing languages. This annotated briefing is intended to be used in conjunction with a Microsoft Excel implementation of WSSMEP. It uses entirely notional data to avoid classification restrictions but otherwise reproduces the operations described in this document and used in production versions of WSSMEP. This approach should allow users to understand and experiment with WSSMEP. Step-by-step instructions for entering data and running the Excel model are contained in the main body of this document.
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Weapon-Specific Strategic Material Estimation Process (WSSMEP)
Weapon-Specific Strategic Material Estimation Process (WSSMEP)

December 2, 2014

Robert J. Atwell Jr.
Eleanor L. Schwartz
Thomas J. Wallace
James S. Thomason, Project Leader
An earlier version of this briefing was presented to Defense Logistics Agency (DLA) representatives at the Institute for Defense Analyses (IDA) facilities on July 31, 2014. It has since been updated with additional information and annotations.
The Weapon-Specific Strategic Material Estimation Process (WSSMEP) allows questions such as the following to be answered:

- How much beryllium is needed to produce an F-35?
- How many different rare earth materials are needed to produce an Arleigh Burke destroyer?
- What is the dollar cost of strategic and critical materials in the production of an M1A2 tank?
1. Introduction

The questions in this slide can be encountered in several different contexts:

- Analysis supporting the National Defense Stockpile (NDS) Requirements Report (RR) relies on estimation of material shortfalls, which are partially attributable to U.S. weapon casualties and expenditures in a given combat scenario. The loss of platforms and munitions requires the production of replacements, which increases demand for strategic and critical materials (S&CM) and possibly increases material shortfalls. Thus, an accurate estimation of the material requirements associated with the production of a particular weapon plays a key role in determining overall U.S. material demand, possible shortfalls, and mitigation strategies. The Weapon-Specific Strategic Material Estimation Process (WSSMEP) is a tool for making such estimates.

- Congress has periodically shown interest in the S&CM demand associated with weapons production. For example, in the National Defense Authorization Act for Fiscal Year 2011, Congress required the Secretary of Defense to submit a report on supply and demand for rare earth materials in defense applications. IDA assisted in the production of this report and used WSSMEP to assess the role of rare earth materials in prominent U.S. weapons systems. See Thomason et al. (2011).
WSSMEP is a model for estimating the quantities of strategic and critical materials needed to build specific weapon systems. It is part of the material demand estimation process used in preparing the National Defense Stockpile (NDS) Requirements Report (RR) and has been used for many years.

WSSMEP can be run as a stand-alone Excel model. This briefing uses such a stand-alone version (available on compact disc (CD) and designed to be used in conjunction with this presentation) to better illustrate the model’s logic.

- IDA Research Staff Member Eleanor Schwartz is the original developer of WSSMEP (both the embedded and the stand-alone Excel versions).
- IDA Research Associate Tom Wallace created a non-proprietary version based on Schwartz’s original model.

Some data inputs to WSSMEP are proprietary, but the model itself is not. This presentation and the associated Excel file use entirely notional data, which should facilitate user understanding of the modeling logic without creating the need for extra data security procedures.

More detailed reference documents are listed at the end of this briefing.
2. Background

The stand-alone, non-proprietary model of WSSMEP was provided to DLA representatives on July 31, 2014.
A weapon can be thought of as the sum of the industrial output from each economic sector needed to produce it. For example, the production of a tank places demand on the metallurgical sector, the electronics sector, and so forth. The Production Process Matrix (PPM) defines U.S. weapons systems in terms of their required output from each of 360 economic sectors. Importantly, this matrix measures the economic output needed for producing a weapon, not just the weapon itself, meaning that it includes tool and die, building maintenance, and so forth.

Each sector requires a certain amount of materials to produce a fixed amount of output. For example, the auto industry requires X quantity of iron to produce Y amount of output. The Material Consumption Ratio (MCR) defines the quantity of material needed to produce $1 billion of output in each of the Interindustry Large-scale Integrated and Dynamic Model’s (ILIAD) 360 economic sectors. A separate MCR is developed for each combination of material of interest and industry sector.

ILIAD is an input/output model of the U.S. economy run by the Interindustry Forecasting Project at the University of Maryland (INFORUM) and widely used by the Bureau of Economic Analysis (BEA).

Multiplying a weapon’s PPM vector by the appropriate MCR vector results in the material quantities needed to produce $1-billion worth of a weapon. Multiplying by the weapon unit price and dividing by unit conversion factors result in the material quantities needed to produce one unit of the weapon:

\[
\text{Materials Required} = \frac{(\text{Weapon Price} \times (\text{PPM} \times \text{MCR}))/\text{Unit Conversion Factors}}{}
\]
3. Conceptual Overview

This slide introduces key WSSMEP concepts in a general fashion. More detailed treatment is given in later slides.
The following sections will walk through the operation of the WSSMEP model, including
- Required data inputs,
- Internal model calculations,
- Data sources, and
- Sources for more detailed documentation material.

The Excel file Final_WSSMEP_For_DLA_No_PI.xlsx is the version that will be examined in this document.
4. WSSMEP Operation

The Excel file is on a compact disc (CD) associated with this briefing and is available from the IDA Control and Distribution Department. IDA provided the Excel file to the DLA on July 31, 2014. The version of WSSMEP examined in this document, as is implied by its filename, contains no classified or proprietary information and uses notional data.
Step 1: Weapon Data

- First, the user must define the weapons to be studied (a maximum of seven). The user inputs the following values to the “Weapon Data” sheet:
  - Weapon reference numbers
    - Used as shorthand reference for keeping track of different weapons
  - Weapon names
  - Per-unit weapons cost
    - Procurement cost. Before entering costs into WSSMEP, the user should deflate them to a common base year using factors from the Department of Defense (DOD) Comptroller’s Office Green Book. This cost usually is in thousands of dollars.

User declares weapons to study

<table>
<thead>
<tr>
<th>Weapon Reference Number</th>
<th>Weapon Name</th>
<th>Per-Unit Cost in Thousands of Constant Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MiG-31</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>2</td>
<td>T-90</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>3</td>
<td>SS-N-25</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>4</td>
<td>Ka-52</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>5</td>
<td>BMP-3</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>6</td>
<td>BM-30</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>7</td>
<td>SA-21</td>
<td>$10,000.00</td>
</tr>
</tbody>
</table>

Each WSSMEP sheet requiring user input is labeled as such.
A. Required Data Inputs

1. Weapons To Be Studied

   The “Weapon Reference Number” shown in this slide is a generalization. In practice, IDA uses Major End Item (MEI) and Major Equipment Type (MET) numerical codes. The generalized name is accurate, however, in the sense that MEI and MET are simply reference numbers for weapons systems in larger databases and do not carry much informational content on their own.
Step 2: Material Data (1 of 2)

- Second, the user must enter data on which materials to include in the WSSMEP analysis. The user inputs the following values into the “Material Data” sheet (see table on next slide):
  - Material
    - Shorthand name
  - Long name
    - Full name of material
  - Units
    - Standard unit of measurement for material
  - Price
    - Defense Logistics Agency (DLA) per-unit price for material
  - Goal and Cost
    - Only used if a legally mandated quantity of material must be bought
  - Conversion Factor for Short Tons
    - Used to convert disparate units into a single, comparable unit (short tons). These cells are auto populated via a VLOOKUP formula that compares the “Units” column to a conversion table and generates the appropriate conversion factor.
2. **Materials To Include in the WSSMEP Analysis**
   The sponsor typically determines what materials will be studied.
User has declared materials to study (units, price, and so forth).

<table>
<thead>
<tr>
<th>Material</th>
<th>Long Name</th>
<th>Units</th>
<th>Price</th>
<th>Goal</th>
<th>Cost</th>
<th>Conversion Factor for Short Tons</th>
<th>Short Tons</th>
<th>Metric Tons</th>
<th>Short Tons Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMINUM_LITH</td>
<td>Aluminum Lithium Alloys</td>
<td>Metric Tons</td>
<td>$10,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td>Short Tons</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ALUMINUM_OXIDE</td>
<td>Aluminum Oxide</td>
<td>Short Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Short Dry Tons</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ANTHUNDER</td>
<td>Anthrapy</td>
<td>Short Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Short Tons Pb</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BERYL</td>
<td>Beryllium</td>
<td>Short Tons</td>
<td>$10,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Short Tons Ni</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BERYLLUM_COPPER</td>
<td>Beryllium Copper</td>
<td>Short Tons</td>
<td>$10,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Short Tons V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BERYLLUM_METAL</td>
<td>Beryllium Metal</td>
<td>Short Tons</td>
<td>$10,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Metric Tons</td>
<td>1.102315</td>
<td></td>
</tr>
<tr>
<td>BISMUTH</td>
<td>Bismuth</td>
<td>Pounds</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>0.0005</td>
<td>Metric Tons Br</td>
<td>1.102315</td>
<td></td>
</tr>
<tr>
<td>BORON</td>
<td>Boron</td>
<td>MT Oxide</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td>Long Tons</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td>CERIUM</td>
<td>Cerium</td>
<td>MT Oxide</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td>Pounds</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>CHROMIUM_FER</td>
<td>Chromium Ferro</td>
<td>Short Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Pounds Co</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>CHROMIUM_METAL</td>
<td>Chromium Metal</td>
<td>Short Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Pounds Co</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>COBALT</td>
<td>Cobalt</td>
<td>Pounds Co</td>
<td>$18,000.00</td>
<td>0</td>
<td>0</td>
<td>0.0005</td>
<td>PoundsTa</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>COLUMBNIUM</td>
<td>Columbium</td>
<td>Pounds Co</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>0.0005</td>
<td>Pounds</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>CSM</td>
<td>CSN - Ceria</td>
<td>Metric Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td>Kilograms</td>
<td>1.102315</td>
<td></td>
</tr>
<tr>
<td>DYSPROSII</td>
<td>Dysprosium</td>
<td>MT Oxide</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td>MT Oxide</td>
<td>1.102315</td>
<td></td>
</tr>
<tr>
<td>EURANIUM</td>
<td>Europium</td>
<td>MT Oxide</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td>Troy Oz</td>
<td>3.420707</td>
<td></td>
</tr>
<tr>
<td>FLUORITE</td>
<td>Fluorite</td>
<td>Short Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLUORIDE</td>
<td>Fluoride</td>
<td>Short Tons</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GADODIUM</td>
<td>Gadolium</td>
<td>MT Oxide</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GALLOPH</td>
<td>Gallium</td>
<td>Kilograms</td>
<td>$16,000.00</td>
<td>0</td>
<td>0</td>
<td>1.102315</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This slide shows that the user has declared the materials that will be studied, including units, price, and so forth.
Step 3: Production Process Matrix (PPM) (1 of 2)

- The user then inputs the PPM, which requires additional methodological explanation. The PPM is the product of the Defense Translator and the Leontief Inverse Matrix.

  - The Defense Translator is a set of vectors, each of which correspond to a weapon. The vector components specify percentages of system purchase price that go to companies in a particular economic sector. Because these values are percentages, they should sum to 1. Defense Translators are determined by the Office of the Secretary of Defense (OSD), Cost Assessment and Performance Evaluation (CAPE). The many zero values correspond to sectors that do not contribute to the production of a particular weapon.

  - The Leontief Inverse Matrix is a measure of economic requirements by industry. In other words, how much input from other economic sectors is required to produce a fixed amount of output in a particular economic sector. It is based on INFORUM data. It is computed by subtracting the “A” matrix (direct coefficients) from the “identity” matrix (a matrix with 1 in the diagonal and 0 in all other fields) and taking the inverse.

- Multiplying the Defense Translator and Leontief Inverse Matrix results in the PPM, which measures the amount of economic output needed in each industry to produce a particular weapon. WSSMEP does not perform this calculation. The calculation to derive the PPM must be performed beforehand, allowing the user to input the PPM into WSSMEP.
3. **The Production Process Matrix (PPM)**

The third step in the data entry process is inputting the PPM.
In this example, there are 7 weapons × 360 economic sectors, which equals 2,520 values for the user to input.
This example shows 7 weapons and 360 economic sectors, which means that the user has to input 2,520 values. All of the values in this slide are notional.
Step 4: Material Consumption Ratio (MCR)

- Next, the user inputs the MCR
  - The MCR equals the amount of given material (by mass) required to produce $1 billion of output in given economic sector.
  - MCRs are computed from consumption and economic information. Sources include proprietary company data, the United States Geological Survey (USGS), the Department of Commerce (DOC), and subject matter expert (SME) interviews.
  - Material demand encompasses all aspects of production, not just the weapon itself.

In this example, user has declared, among other things, that Sector 113 requires 5,289 metric tons of aluminum lithium alloy to produce $1 billion of output.
4. **The Material Consumption Ratio (MCR)**

The fourth step in the data entry process is inputting the MCRs. Not all materials have MCRs. The demand for some materials—mostly proprietary ones that have strongly articulated defense demands—is calculated using a different methodology. These materials cannot be assessed using WSSMEP.

As with the PPM, MCRs encompass all aspects of production, not just the weapon itself. These aspects of production include tool and die, building maintenance, and so forth. Some consumers of WSSMEP analysis are interested in the material content of the weapon alone, often referred to as “flyaway” material demand. WSSMEP does not natively support such analysis. Separating the weapon from its production would require sector-by-sector data on the ratio of “flyaway” industrial production and material demand to “production” industrial production and material demand. As far as the authors know, such data do not exist.
Step 5: Calculations

- When the user has input all of the necessary data, WSSMEP automatically calculates material requirements on the “Calculations” sheet. No user input is required to execute the operations.
- The slides on the following pages detail the operations step by step.
B. Internal Model Calculations

After all of the necessary data have been input, WSSMEP automatically calculates material requirements. The operations are executed without additional user input.
Operation 1

- Excel automatically pulls the input data from the “Input MCR sheet” and recreates these data on the “Calculations” sheet.

### Values

<table>
<thead>
<tr>
<th>MCRs</th>
</tr>
</thead>
<tbody>
<tr>
<td>IJAD Sector</td>
</tr>
<tr>
<td>113</td>
</tr>
</tbody>
</table>

### Formulas

- MCRs

```
=Input MCR!$A2
=Input MCR!$B2
=Input MCR!$C2
```
Slides 12–16 detail the operations step by step.
Operation 2

- Excel also automatically retrieves relevant PPM values by searching the “Input PPM” sheet for a particular weapon/sector combination.
  - This is an array formula. If the user modifies it, he/she must press CTRL + SHIFT + ENTER to reexecute.

Values

```
<table>
<thead>
<tr>
<th>Weapon Ref #</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weapon Name</td>
<td>MiG-31</td>
</tr>
<tr>
<td>IUIAD Sector</td>
<td>113</td>
</tr>
</tbody>
</table>
```

Formulas

```
Weapon Ref #  ="Input Weapon Data"!SA$2
Weapon Name    =VLOOKUP(F54,"Input Weapon Data"!SA$2:SC$8,2)
IUIAD Sector   =A7 =INDEX("Input PPM"!SA$2:SC$2633, MATCH(1,"Input PPM"!SA$2:SA$2633="SFS4"),"Input PPM"!S8$2:S8$2633="SE7")!0,3)
```
Excel then multiplies the MCR vector by the relevant PPM vector.
   - This sum represents the amount of material required by a specific economic sector to produce $1$-billion worth of the weapon.

### Values

<table>
<thead>
<tr>
<th>MCR x RELEVANT PPM VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weapon Ref #</td>
</tr>
<tr>
<td>113 ALMNM_LITH</td>
</tr>
<tr>
<td>33 ALMNM_LITH</td>
</tr>
</tbody>
</table>

### Formulas

- Weapon Ref #: `=Input Weapon Data!'A$2`  
- Weapon Name: `=VLOOKUP(P$4,'Input Weapon Data!'A$2:$C$8,2)`  
- Sector: `=A7`  
- Material: `=B7`  
- Total: `=$C7*$F7`
Excel compiles material requirements for the entire weapon by summing across all economic sectors. This sum represents the amount of material required across all sectors to produce $1-billion worth of the weapon.

### Values

<table>
<thead>
<tr>
<th>Weapon Ref #</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weapon Name</td>
<td>MiG-31</td>
<td>T-90</td>
<td>SS-N-25</td>
</tr>
<tr>
<td>Material</td>
<td>ALMNM_LITH</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.7326000</td>
<td>0.6627000</td>
<td>0.4866000</td>
</tr>
</tbody>
</table>

### Formulas

```
=SUMIFS($85$7:$85$10000,$87$7:$87$10000,$85$7:$85$10000)
```
Lastly, Excel multiplies by the unit price of the weapon and conducts unit conversion to derive a per-unit material requirement.

### Values

<table>
<thead>
<tr>
<th>Weapon Ref #</th>
<th>1</th>
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<tbody>
<tr>
<td>Weapon Name</td>
<td>MIG-31</td>
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<tr>
<td>Material</td>
<td>Number of units of material per weapon</td>
</tr>
<tr>
<td>ALMNM_LITH</td>
<td>0.0073260</td>
</tr>
<tr>
<td>ALMNM_OXIDE</td>
<td>0.0057020</td>
</tr>
<tr>
<td>ANTIMONY</td>
<td>0.0073860</td>
</tr>
<tr>
<td>BERYL</td>
<td>0.0076500</td>
</tr>
</tbody>
</table>

### Formulas

\[
\text{Weapon Ref #} = \text{Input Weapon Data}!SA$2
\]
\[
\text{Weapon Name} = VLOOKUP(AH4, \text{Input Weapon Data}!SA$2:$C$8,2)
\]
\[
\text{Material} = \text{Number of units of material per weapon}
\]
\[
\text{Material} = Y7 \times \text{Input Weapon Data}!SC$2/(10^{-6})
\]
The “Results Summary” sheet shows material requirements for one unit of the weapon, expressed either in the mass unit associated with the particular material, short tons (for ease of comparison), and material cost.

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Long Name</th>
<th>Units</th>
<th>Amount in Units</th>
<th>Amount in Short Tons</th>
<th>Amount in Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMN_LITH</td>
<td>Aluminum Lithium Alloys</td>
<td>Metric Tons</td>
<td>0.0073260</td>
<td>0.0080755</td>
<td>7.326000</td>
</tr>
<tr>
<td>ALUMN_OXIDE</td>
<td>Aluminum Oxide Fused Crude</td>
<td>Short Tons</td>
<td>0.0057020</td>
<td>0.0057020</td>
<td>5.702000</td>
</tr>
<tr>
<td>ANTIMONY</td>
<td>Antimony</td>
<td>Short Tons</td>
<td>0.0073860</td>
<td>0.0073890</td>
<td>7.386000</td>
</tr>
<tr>
<td>BERYL</td>
<td>Beryl Ore</td>
<td>Short Tons</td>
<td>0.0076500</td>
<td>0.0076500</td>
<td>7.650000</td>
</tr>
<tr>
<td>BERYLLUM_COPPER</td>
<td>Beryllium Copper Master Alloy</td>
<td>Short Tons</td>
<td>0.0100220</td>
<td>0.0100280</td>
<td>10.028000</td>
</tr>
<tr>
<td>BERYLLUM_Metal</td>
<td>Beryllium Metal</td>
<td>Short Tons</td>
<td>0.0013900</td>
<td>0.0013900</td>
<td>1.390000</td>
</tr>
<tr>
<td>BISMUTH</td>
<td>Bismuth</td>
<td>Pounds</td>
<td>0.0081700</td>
<td>0.0080001</td>
<td>8.170000</td>
</tr>
<tr>
<td>BORON</td>
<td>Boron</td>
<td>MT Oxide</td>
<td>0.0062610</td>
<td>0.0062616</td>
<td>6.261000</td>
</tr>
<tr>
<td>CERIUM</td>
<td>Cerium</td>
<td>MT Oxide</td>
<td>0.0047700</td>
<td>0.0047800</td>
<td>4.770000</td>
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<tr>
<td>CHROMIUM_FER</td>
<td>Chromium Ferro (Ferrochromium)</td>
<td>Short Tons</td>
<td>0.0037720</td>
<td>0.0037720</td>
<td>3.772000</td>
</tr>
<tr>
<td>CHROMIUM_Metal</td>
<td>Chromium Metal</td>
<td>Short Tons</td>
<td>0.0039440</td>
<td>0.0039440</td>
<td>3.944000</td>
</tr>
<tr>
<td>COBALT</td>
<td>Cobalt</td>
<td>Pounds</td>
<td>0.0108990</td>
<td>0.0108990</td>
<td>10.899000</td>
</tr>
<tr>
<td>COLUMBIUM</td>
<td>Columbium</td>
<td>Pounds</td>
<td>0.0004770</td>
<td>0.0000002</td>
<td>0.477000</td>
</tr>
</tbody>
</table>
C. **Data Sources**

All data are automatically referenced from other sheets. No user input is required.
WSSMEP Notes

- WSSMEP can be run for any weapon that has a Defense Translator vector and uses materials that have MCRs. However, because not all weapons have Defense Translator vectors and not all materials have MCRs, a not-insignificant portion of the U.S. arsenal cannot be analyzed with WSSMEP.
- WSSMEP is dynamic. It must be updated in response to new materials, new Defense Translators, new MCRs, and so forth.
- WSSMEP is conceptually simple and can be—and, in fact, has been—programmed in formats other than Excel.
WSSMEP can be run for any weapon that has a Defense Translator vector and uses materials that have MCRs. It is dynamic and must be updated to reflect new processes, and it can be run in formats other than Microsoft Excel. For example, some components of WSSMEP are found in the Forces Mobilization Model (FORCEMOB), which is programmed in Fortran.
WSSMEP is one method for determining material requirements, but it is not the sole or even primary way of doing so. Consider the following points (items 1–7):

1. The calculation of material requirements and shortfalls has three main stages:
   a. Step A, in which required U.S. economic production during a national emergency is calculated;
   b. Step B, in which material requirements implied by this production are computed;
   c. Step C, in which these material requirements are compared against U.S. and foreign supplies to identify shortfalls.

2. WSSMEP, which calculates the industrial production levels needed for a particular weapon and the material requirements thereof, thus spans Steps A and B.

3. Material requirements analysis must take into account “base” defense, “conflict” defense, essential civilian, and emergency investment needs. Base defense refers to normal Future Years Defense Plan (FYDP)-level spending, while conflict defense refers to the need to regenerate specific forces lost or expended in the conflict scenario.
6. WSSMEP vs. Other Methods for Material Requirements

WSSMEP is one method for determining material requirements, but it is not the sole or even primary way of doing so, as discussed in slides 20 and 21.
4. WSSMEP, which is narrowly focused on per-unit weapons requirements, does not support the analysis of base defense, essential civilian, or emergency investment needs. WSSMEP is not designed, for example, to assess the material requirements from base force maintenance and operations or from domestic automobile production.

5. For these reasons, the Forces Mobilization Model (FORCEMOB) also is used to calculate production and material requirements for analysis supporting NDS RRs. Like WSSMEP, FORCEMOB uses PPMs and weapon costs to calculate production requirements for Major End Items (MEIs) lost in a conflict scenario. However, FORCEMOB takes into account base defense, civilian, and investment demands not modeled in WSSMEP, all of which require extensive preprocessing and modeling. FORCEMOB aggregates the weapon-specific production estimates into these broader tiers of demand and outputs aggregated production estimates. These estimates then are used to derive material requirements in a separate step.

6. A main value proposition of WSSMEP is less labor than the aforementioned “normal” method of calculating material requirements. WSSMEP’s narrow focus on per-unit weapon requirements means, for example, that no ILIAD or Long-term Interindustry Forecasting Tool (LIFT) runs are required and that a separate step is not needed for computing material requirements based on industrial production levels.
7. As such, WSSMEP can be thought of as reporting the results of a subset of FORCEMOB and the “normal” material demand computation. It isolates the impact of weapons production on S&CM requirements, rather than rolling it up into broad tiers of demand. In this sense, WSSMEP is useful to explicitly report weapon-specific results within RAMF-SM. It also is useful in other circumstances. Periodically, Congress and/or the sponsor have shown interest in the material requirements of key weapons systems. WSSMEP (which focuses on single weapons) may be better suited to calculate this than the normal process (which focuses on aggregate categories of demand).
Further Reference

WSSMEP


Defense Translators

Material Consumption Ratios
7. Further Reference

This slide provides sources for more detailed documentation material.
Appendix A
References

Appendix B

Bibliography


## Appendix C
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEA</td>
<td>Bureau of Economic Analysis</td>
</tr>
<tr>
<td>CAPE</td>
<td>Cost Assessment and Performance Evaluation</td>
</tr>
<tr>
<td>CD</td>
<td>compact disc</td>
</tr>
<tr>
<td>DLA</td>
<td>Defense Logistics Agency</td>
</tr>
<tr>
<td>DOC</td>
<td>Department of Commerce</td>
</tr>
<tr>
<td>DOD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>FORCEMOB</td>
<td>Forces Mobilization Model</td>
</tr>
<tr>
<td>FYDP</td>
<td>Future Years Defense Plan</td>
</tr>
<tr>
<td>IDA</td>
<td>Institute for Defense Analyses</td>
</tr>
<tr>
<td>ILIAD</td>
<td>Interindustry Large-scale Integrated and Dynamic Model</td>
</tr>
<tr>
<td>INFORUM</td>
<td>Interindustry Forecasting Project at the University of Maryland</td>
</tr>
<tr>
<td>LIFT</td>
<td>Long-term Interindustry Forecasting Tool</td>
</tr>
<tr>
<td>MCR</td>
<td>material consumption ratio</td>
</tr>
<tr>
<td>MEI</td>
<td>Major End Item</td>
</tr>
<tr>
<td>MET</td>
<td>Major Equipment Type</td>
</tr>
<tr>
<td>NDS</td>
<td>National Defense Stockpile</td>
</tr>
<tr>
<td>OSD</td>
<td>Office of the Secretary of Defense</td>
</tr>
</tbody>
</table>
The Weapon-Specific Strategic Material Estimation Process (WSSMEP) is a modeling tool used to estimate the demand for strategic and critical materials generated by production of a U.S. weapons system. This annotated briefing is intended to train a new user on operation of WSSMEP. It is intended to be used in conjunction with a training version of WSSMEP available on CD from IDA Control and Distribution.