# MAR Plus for Material Management

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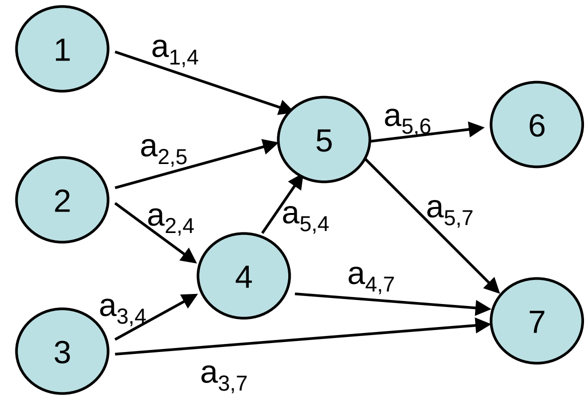
# Gozintograph




☞ Material management involves the calculation of the overall material required for various goods during the manufacturing process, considering  the requested quantities of the end product and the input-output-relationships of the single products.

☞ You can graphically illustrate the relationship between the single products by means of a **gozintograph**.

Gozintograph: (the part that) goes into (this product)

☞ The gozintograph is a vectored graph which describes the type and number of items for each product.

☞ The **circles** of the gozintograph mark the particular items. The **arrows** indicate how many units of these items are necessary to produce the subsequent product.

The indexed arrows ai,j are refered to as direct demand coefficients.

☞ The calculation of the total demand uses the **direct demand matrix**, which is directly derived from the gozintograph.

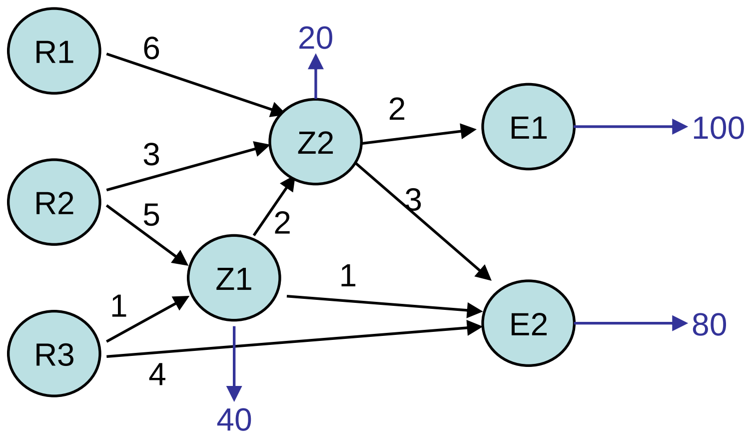
The direct demand matrix contains the gozintograph information.

# An Example

Assume that raw materials R1, R2 and R3 are required to manufacture two end products E1 and E2. In addition, the manufacturing process needs the intermediate products Z1 and Z2. Let‘s say that the following quantites are requested: 100 units of E1, 80 units of E2, 40 units of Z1 and 20 units of Z2. What is the total material demand?

Example taken from: H. Dyckhoff, Produktionstheorie, Springer 2006 (5.)

## 1 Graphical representation




The gozintograph shows the input-output correlation and the quantitative relationship between single items of the manufactoring process .

## 2 Primary demand vector

$$\{p\} = \left\{ \begin{array}{c} R1 \\ R2 \\ R3 \\ Z1 \\ Z2 \\ E1 \\ E1 \end{array} \right\} = \left\{ \begin{array}{c} 0 \\ 0 \\ 0 \\ 40 \\ 20 \\ 100 \\ 80 \end{array} \right\}$$

## Direct demand matrix

$$[D] = \begin{array}{cc} \begin{array}{ccccccc} R1 & R2 & R3 & Z1 & Z2 & E1 & E2 \end{array} & \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 6 & 0 & 0 \\ 0 & 0 & 0 & 5 & 3 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 4 \\ 0 & 0 & 0 & 0 & 2 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 2 & 3 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} & \begin{array}{c} R1 \\ R2 \\ R3 \\ Z1 \\ Z2 \\ E1 \\ E2 \end{array} \end{array}$$

The rows of [D] describe how many units of an item are in the other items.

The colums of [D] describe how many units of the other items are contained in a single item.

# Theory: Calculation of Total Material Demand

1 Given:

$$[D]=\begin{bmatrix}0&0&0&0&6&0&0\\0&0&0&5&3&0&0\\0&0&0&1&0&0&4\\0&0&0&0&2&0&1\\0&0&0&0&0&2&3\\0&0&0&0&0&0&0\\0&0&0&0&0&0&0\end{bmatrix}\Rightarrow [T]=[E]-[D]=\begin{bmatrix}1&0&0&0&-6&0&0\\0&1&0&-5&-3&0&0\\0&0&1&-1&0&0&-4\\0&0&0&1&-2&0&-1\\0&0&0&0&1&-2&-3\\0&0&0&0&0&1&0\\0&0&0&0&0&0&1\end{bmatrix}\qquad \{p\}=\begin{Bmatrix}0\\0\\0\\40\\20\\100\\80\end{Bmatrix}$$

$$[E]=\begin{bmatrix}1&0&0&0\\0&1&0&0\\0&0&...&0\\0&0&0&1\end{bmatrix}$$

Direct demand matrixv [D] $\Rightarrow$ Technology matrix [T] Primary demand vector {p}

2 **Calculation of the total material demand** by solving the **linear equation system**

$$[T]\cdot\{g\}=\{p\}:\quad \begin{bmatrix}1&0&0&0&-6&0&0\\0&1&0&-5&-3&0&0\\0&0&1&1&0&0&-4\\0&0&0&1&-2&0&-1\\0&0&0&0&1&-2&-3\\0&0&0&0&0&1&0\\0&0&0&0&0&0&1\end{bmatrix}\begin{Bmatrix}G_{R1}\\G_{R2}\\G_{R3}\\G_{Z1}\\G_{Z2}\\G_{E1}\\G_{E1}\end{Bmatrix}=\begin{Bmatrix}0\\0\\0\\40\\20\\100\\80\end{Bmatrix}$$

Determine: Total demand vector {g} $\{g\}=\begin{Bmatrix}G_{R1}\\G_{R2}\\G_{R3}\\G_{Z1}\\G_{Z2}\\G_{E1}\\G_{E2}\end{Bmatrix}$

## Solution with MAR Plus

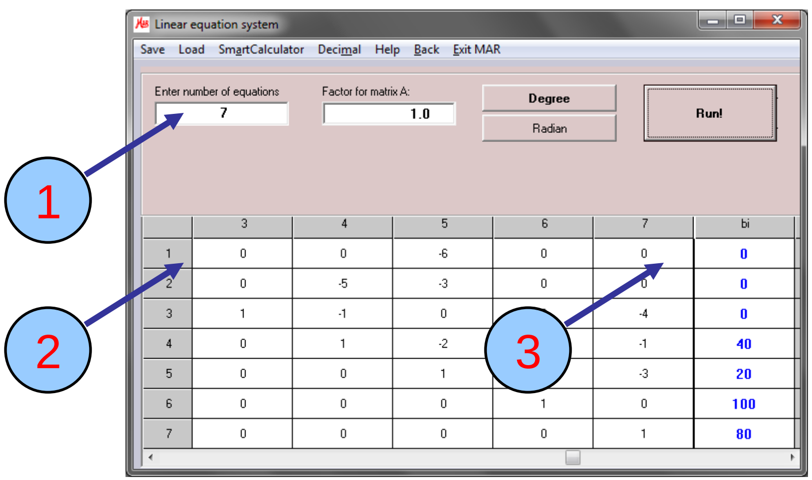
You obtain the total demand vector, which mathematically describes the cumulative material demand of the production process, by solving the linear equation system:

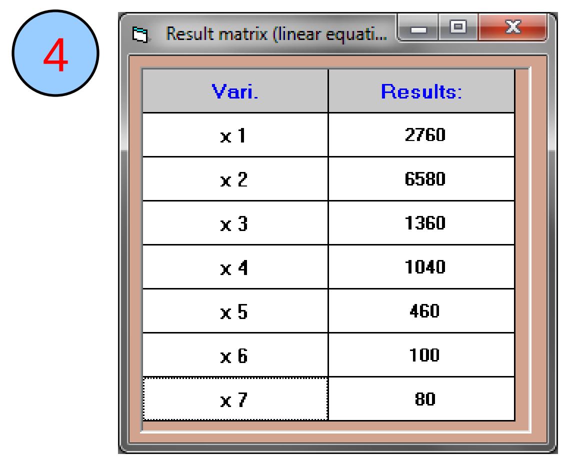
$$\begin{bmatrix} 1 & 0 & 0 & 0 & -6 & 0 & 0 \\ 0 & 1 & 0 & -5 & -3 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & -4 \\ 0 & 0 & 0 & 1 & -2 & 0 & -1 \\ 0 & 0 & 0 & 0 & 1 & -2 & -3 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} G_{R1} \\ G_{R2} \\ G_{R3} \\ G_{Z1} \\ G_{Z2} \\ G_{E1} \\ G_{E1} \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 40 \\ 20 \\ 100 \\ 80 \end{Bmatrix}$$

$$\boxed{[T]\cdot\{g\} = \{p\}}$$

Solving the linear equation system is straightforward in MAR Plus:

1. Enter the number of equations: **7**
2. Key in the technology matrix **[T]**
3. Input the primary demand vector **{p}**
4. You obtain as result the total demand vector **{g}**




$$= \begin{Bmatrix} G_{R1} \\ G_{R2} \\ G_{R3} \\ G_{Z1} \\ G_{Z2} \\ G_{E1} \\ G_{E2} \end{Bmatrix}$$