Roadmap for Manufacturing Cost Deployment

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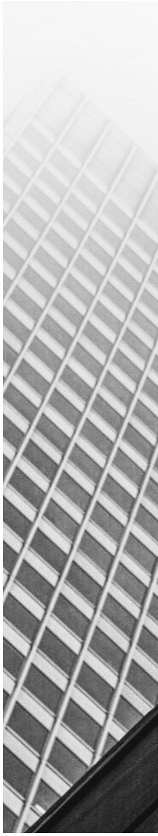


For a further elaboration on the MCD method, please see Knutsen and Høeg, 2016. This roadmap presents a compressed outline of the proposed framework.

Does your company need a decision support tool to select the improvement projects that generate the highest cost savings? Here is a compiled roadmap for how to apply the Manufacturing Cost Deployment method.

What is Manufacturing Cost Deployment?

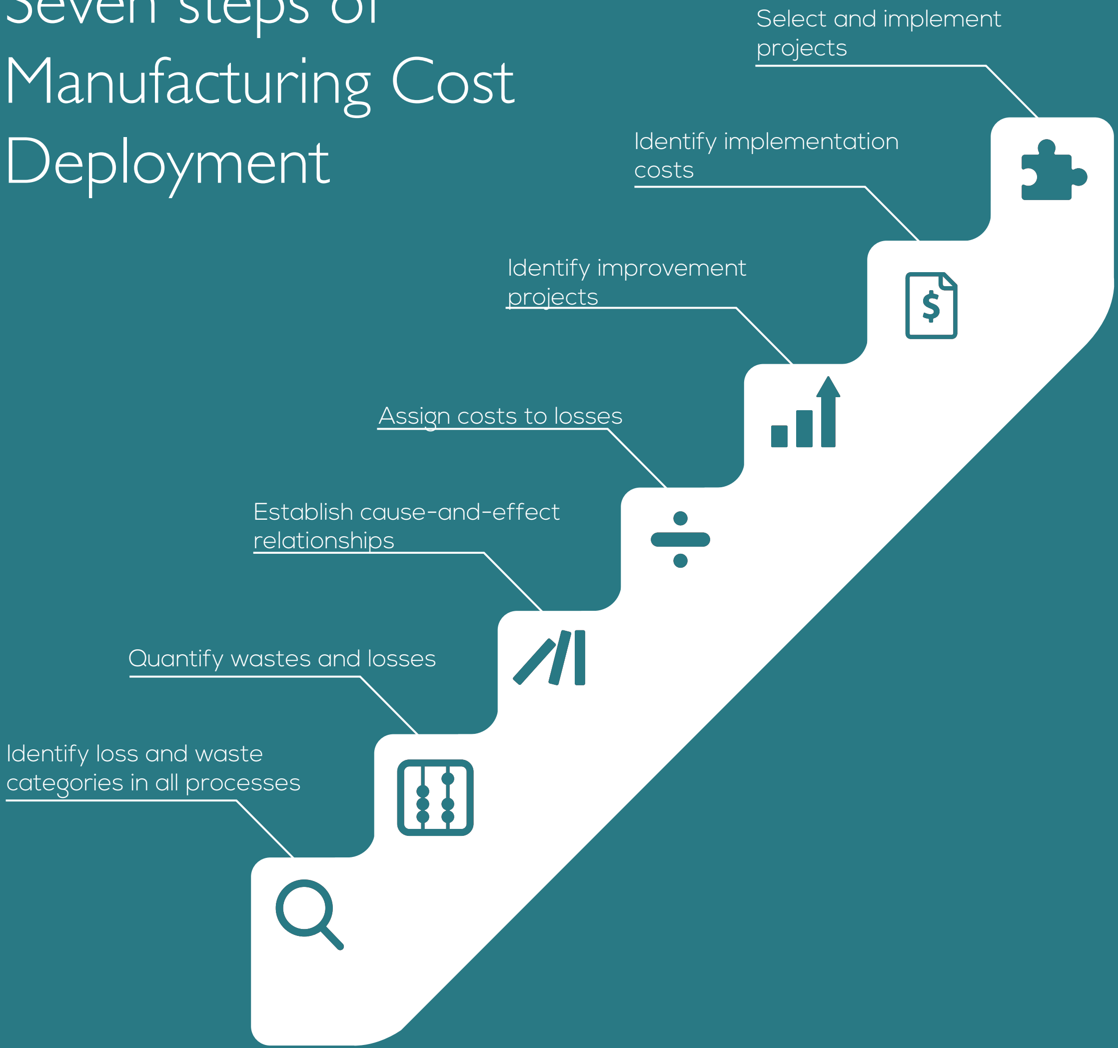
MCD was first proposed by Yamashina and Kubo (2002). It is a systematic procedure for reducing manufacturing costs. It is a seven-step method to select what improvement projects to implement. By applying the method, manufacturing companies can build cost reduction programs, targeting root causes of losses in order to implement improvement projects that deal with the causal errors in their facilities. The methodology increases the legitimacy for implementing projects that yield high investment efficiencies. Systematically selecting projects that eliminates the root problems rather than the symptoms, can contribute to long-term reduction of production costs.

Why is Manufacturing Cost Deployment such a powerful tool?

The strength of MCD is to systematically assign impact of resultant losses to their causal losses. Based on thorough root cause analysis, the total impact of causal losses can be evaluated. Systematically assigning costs to loss factors defines the total cost of each causal loss, for a defined period. Quantitatively assessing improvement projects in terms of expected loss reduction and cost of implementation, allows investment efficiencies to be evaluated This way, managers at all levels have a new way to make their improvement project proposals valid business cases.

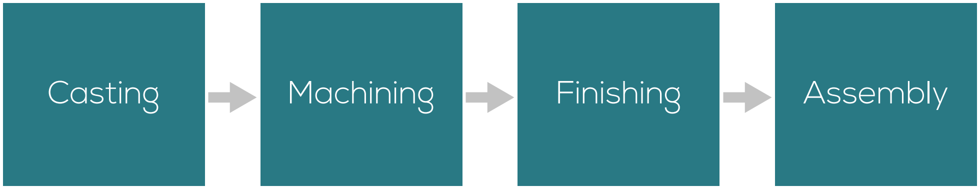
MCD can be used at all levels of the organization. For practicality, this roadmap is considering the typical department level of a manufacturing company.

Seven steps of Manufacturing Cost Deployment



Introduction to example case

Throughout this roadmap, the concepts for each step of the MCD method are illustrated with the simple example of ACME INC, a fictive company. The company has a production line with four processes: casting, machining, finishing, and assembly. The processes are coupled in series, and we disregard buffers in the example. The production line of ACME INC is illustrated below:



STEP 1.

Identify all loss and waste categories, and production processes

WHY

Obtain a deep understanding of what losses are present in the facility. Generic loss categories must be adjusted to fit the specific context. Prepares steps 2 through 4.

WHO

Department manager, technical supervisor, maintenance group, support functions, and experienced or leading operators. Continuous Improvement group should help facilitate this exercise.

PREREQUISITES

Technical insights of the production facilities. Preferably, information on the company's best available practices for similar facilities.

INFORMATION INTRODUCED IN THIS STEP

Identification and categorization of losses and processes in the facility.

DELIVERABLES

A complete list of loss categories and production processes. Categorization must be unambiguous, to allow personnel to register losses to the right category effortlessly.

PROCEDURE

> Assess all processes in the relevant facility
>> Select a set of loss and waste categories for reference
>>> Identify all relevant loss and waste types, and assign them to categories

EXAMPLE

In ACME INC, four production processes are identified: casting, machining, finishing, and assembly. In addition, eight loss categories are identified: "casting error 1," casting error 2," "machining error 1," "machining error 2," rework, scrapping, idling, and blocking. These findings are summarized in the tables below.

Loss categories	Processes
CastErr1	Casting
CastErr2	Machining
MachErr1	Finishing
MachErr2	Assembly
FinRework	
Scrapping	
Idling	
Blocking	

The layout of the production line makes idling losses relevant to the machining, finishing and assembly processes, while blocking is relevant to casting, machining and finishing.

STEP 2.

Obtain data on all losses and wastes, and assign to categories

WHY

Provide a categorized and quantified database of all losses and wastes.

WHO

Personnel with knowledge of the systems used for registering loss data, as well as how to assign this data to the defined losses and wastes categories. As multiple information systems could be used for obtaining this data, this step might require involvement of multiple persons when compiling the data.

PREREQUISITES

The list of loss categories and production processes, from Step 1. Standardized procedures, and unambiguous categories, for registering wastes and losses are essential for obtaining high-precision data.

INFORMATION INTRODUCED IN THIS STEP

Quantitative data on the losses and wastes, assigned to loss categories and production processes. Raw data is typically obtained from workers who use standardized procedures to register losses, errors and stoppages in production.

DELIVERABLES

The A matrix, which shows the total magnitude of losses and wastes, for each category and production process, for a predefined period of time.

PROCEDURE

> Decide on methods and tools for obtaining and registering loss data, as well as the duration of the period of analysis
>> Quantify and assign registered losses to categories in a spreadsheet
>>> Extract total magnitudes of each loss in process, in order to generate the A Matrix

EXAMPLE

ACME INC registers the magnitude of each loss during the period, and assigns them to the appropriate processes. The last column shows the unit of measure of each loss category.

Loss category	Casting (Process)	Machining (Process)	Finishing (Process)	Assembly (Process)	Unit
CastErr1	9				kg
CastErr2	91				kg
MachErr1		15			# occurrences
MachErr2		61			# occurrences
FinRework			29		minutes
Scrapping				53	units scrapped
Idling		60	86	88	minutes
Blocking	58	40			minutes

STEP 3.

Establish cause-and-effect relationships

WHY

Distinguish between causal and resultant losses. Assign resultant losses to causal losses, according to their interrelationships.

WHO

Department manager, technical supervisor, maintenance group, support functions, and experienced or leading operators. Continuous Improvement group should facilitate also this exercise.

PREREQUISITES

The list of loss categories and production processes from step 1, as well as data gathered in step 2. Recognized tools and procedures for determining cause-and-effect relationships.

INFORMATION INTRODUCED IN THIS STEP

Quantification of cause-and-effect relationships among losses. The quantification should be a fractional distribution of resultant losses to causal losses.

DELIVERABLES

The B matrix, which shows the causal-resultant relationships among the losses, expressed as loss magnitudes.

PROCEDURE

> Qualitatively determine fractional causal relationships between losses*
>> Generate a causal-resultant percentage matrix with these fractions as input (in %)
>>> Generate the B matrix by multiplying the values in the percentage matrix with the magnitude of the corresponding resultant losses from the A matrix

* Apply quantitatively determined relational fractions, if obtainable

EXAMPLE

In the tables corresponding to this step, we see both a causal-resultant percentage matrix, and the B matrix. The causal-resultant percentage matrix provides the assumptions made from examining the loss causality, while the B matrix is made from multiplying the factors from the causal-resultant percentage matrix with the magnitudes of the resultant losses, which is found in the A matrix.

For ACME INC, the following cause-effect relationships among the losses were identified:

- "Casting error 1" causes 50% of "machining error 1," and 100% of itself
- "Casting error 2" causes 100% of the scrapping in the assembly process
- 50% of "machining error 1" is caused by itself
- "Machining error 2" causes 100% of the rework in the finishing process, and 100% of itself
- 100% of the idling of the machining process is caused by "casting error 2"
- 100% of the idling of the finishing process is caused by "machining error 1;" however, since 50% of "machining error 1" is caused by "casting error 1," 50% of the idling of the finishing process is assigned to "casting error 1"
- 100% of the blocking of the machining process is caused by rework in the finishing process, which is caused by "machining error 2." Therefore, 100% of the blocking of the machining process is assigned to "machining error 2"
- "Machining error 2" causes 100% of the idling of the assembly process, by causing all rework in the finishing process. In addition it causes 100 of the blocking of the casting process

The table below summarizes the information above:

			Resultant									
			Casting CastErr1	Casting CastErr2	Machining MachErr1	Machining MachErr2	Finishing FinRework	Assembly Scrapping	Machining Idling	Finishing Idling	Assembly Idling	Casting Blocking	Machining Blocking
Causal	CastErr1	Casting	100 %		50 %					50 %			
	CastErr2	Casting		100 %				100 %	100 %				
	MachErr1	Machining			50 %					50 %			
	MachErr2	Machining				100 %	100 %				100 %	100 %	100 %

By multiplying the values in the table above with the magnitude of each of the resultant losses, the B matrix can be generated, as shown in the table below:

			Resultant										
			Casting CastErr1	Casting CastErr2	Machining MachErr1	Machining MachErr2	Finishing FinRework	Assembly Scrapping	Machining Idling	Finishing Idling	Assembly Idling	Casting Blocking	Machining Blocking
Causal	CastErr1	Casting	9		8					43			
	CastErr2	Casting		91				53	60				
	MachErr1	Machining			8					43			
	MachErr2	Machining				61	29				88	58	40

STEP 4.

Calculate and assign costs to losses

WHY

Express all losses in monetary terms, in order visualize the actual costs incurred by losses. The cost of resultant losses are assigned to causal losses, according to the relationships identified from step 3.

WHO

Personnel with insight in budgeting and accounting procedures should conduct this task in consultation with technical supervisor and the responsible manager.

PREREQUISITES

The list of loss categories and production processes from step 1. Thorough knowledge about budgeting and accounting procedures, as well as financial information, is required.

INFORMATION INTRODUCED IN THIS STEP

Cost rates for losses.

DELIVERABLES

The C matrix, which presents the total cost assigned to each causal loss.

PROCEDURE

> Decide on method to establish costs rates, according to company guidelines

>> Determine a cost rate for each resultant loss expressed as "cost per unit of loss". This should reflect the cost of the excess resource consumption caused by the loss

>>> Generate the C matrix by multiplying the magnitudes from the B matrix with the cost rate of the corresponding resultant losses

>>>> Summarize all costs assigned to each causal losses in order to determine the total cost of that causal loss

EXAMPLE

The table below shows the defined cost rate for each loss category in each feasible process. The values represent the cost in NOK per unit of the resultant losses.

	Process				
Loss category	Casting	Machining	Finishing	Assembly	Unit
CastErr1	599				NOK/kg
CastErr2	910				NOK/kg
MachErr1		269			NOK/occurrence
MachErr2		932			NOK/occurrence
FinRework			929		NOK/minute
Scrapping				823	NOK/unit scrapped
Idling		249	707	933	NOK/minute
Blocking	171	772			NOK/minute

By multiplying the values in the last table of step 3 with the cost rates of the resultant losses in the table above, a table that shows the cost of the losses can be generated, as shown below:

			Resultant loss										
		Process	Casting CastErr1	Casting CastErr2	Machining MachErr1	Machining MachErr2	Finishing FinRework	Assembly Scrapping	Machining Idling	Finishing Idling	Assembly Idling	Casting Blocking	Machining Blocking	Total cost
Causal loss	CastErr1	Casting	5236		2057					30456				37749
	CastErr2	Casting		82973				43551	14976					141501
	MachErr1	Machining			2057					30456				32513
	MachErr2	Machining				57016	26897				82164	9908	30685	206671

The total cost of each causal loss is calculated by summing each row, as shown in the "total cost" column.

STEP 5.

Identify improvement projects

WHY

In order to reduce losses, projects should target causal losses occurring in the processes. Project proposals are to include a quantitative assessment of the fractional proportion of a loss expected to be reduced from conducting a project.

WHO

This step should be conducted as group activities, including experienced operators and production management. Department manager, technical supervisor and supportive functions should participate in the preparation of project proposals.

PREREQUISITES

The list of occurring losses, as well as causal-resultant relationships, obtained through steps 1-3 are relevant input to this step. However, the most important is the C matrix from step 4, in order to target the causal losses generating the largest total costs.

INFORMATION INTRODUCED IN THIS STEP

Proposed improvement projects to target causal losses.

DELIVERABLES

The D matrix, which shows the expected cost savings for each proposed project, combining data from losses and associated costs, and the fractional loss reductions from each project.

PROCEDURE

> Identify improvement projects. Ideally these should target causal losses rather than resultant losses
>> Qualitatively determine the expected reduction of causal losses from implementing the improvement project, expressed as fractions of each loss to be eliminated
>>> Generate a loss-improvement percentage matrix, summarizing the assumptions above
>>>> Generate the D matrix by multiplying each entry of the loss-improvement percentage matrix with the corresponding total cost of the losses targeted, as determined with the C matrix

EXAMPLE

In the following tables, three projects are proposed, targeting the causal losses in our production line. In the first table the percentage reduction of each targeted causal loss is indicated.

	Project 1	Project 2	Project 3
CastErr1	100 %		25 %
CastErr2	100 %	50 %	
MachErr1		100 %	
MachErr2			100 %

The previous table should be read as follows:

- Project 1 targets the casting process and will eliminate all errors
- Project 2 will eliminate 50% of CastErr2 and 100% of MachErr1 (that is, 100% of machining error 1 caused by an internal error in the machining process). We see that the value of eliminating this error is worth only the equivalent of cost occurring from the internal error in the machining process, because some of the MachErr1 occurences are caused by CastErr1, and their costs are thus assigned to CastErr1.
- Project 3 will eliminate 25% of CastErr1 (and thus eliminating 12,5% of the total MachErr1 losses), and 100% of the MachErr2 losses.

In the D matrix below, the expected loss reductions are multiplied with the total cost occurring from the causal loss, as found in the C matrix. The value entries in the D matrix can therefore be read as cost reductions (per period) resulting from each project.

	Project 1	Project 2	Project 3
CastErr1	37749		9437
CastErr2	141501	70750	
MachErr1		32513	
MachErr2			206671
Total	179250	103263	216108

STEP 6.

Compile expected benefits from improvement project in terms of reduced losses, set up against costs of project

WHY

In order to evaluate the cost/benefit of a project, and thus the project investment efficiency, it is necessary to compare implementation costs with expected benefits from the project.

WHO

Facility management in collaboration with personnel from departments responsible for procurement and improvement.

PREREQUISITES

The list of potential improvement projects along with associated loss reductions, as obtained in step 5. Thus, the C and D matrices are the main inputs to do the compilation.

INFORMATION INTRODUCED IN THIS STEP

Cost of implementing the suggested improvement projects from step 5.

DELIVERABLES

The E matrix, which presents the investment efficiency associated with each project. This can be represented by the desired measure of investment efficiency, e.g. cost/benefit, ROI, Payback time, IRR etc.

PROCEDURE

> Obtain best estimates for project implementation costs
>> Determine what measures to apply for evaluating the expected economic results from the projects
>>> Determine investment efficiencies by aligning expected cost reductions and costs of project improvement, in accordance with selected measures

EXAMPLE

In the E matrix, the cost of implementation for each project is entered, and the investment efficiency is calculated. For simplicity, we have considered the Benefit/Cost ratio for each project for a single period, and remind that the numbers used for this example are purely random. To optimize the investment efficiency, the project with the highest B/C rate should be selected.

	Project 1	Project 2	Project 3
Cost of implementation	69000	138000	131000
Benefit-to-cost ratio	2,5978269	0,7482846	1,6496827

STEP 7.

Decide what projects to implement, and establish a cost reduction plan

WHY

Before projects are initiated, it is necessary to decide which of the proposed projects to implement at this point in time.

WHO

This step should be carried out as a group activity, including production management and accounting personnel.

PREREQUISITES

The list of potential improvement projects along with associated loss reductions and costs of implementation, as obtained in step 5. Also, the E matrix from step 6 is an important input to this decision process.

INFORMATION INTRODUCED IN THIS STEP

Selection of projects to undertake, and planned scheduling, based on a qualitative decision process.

DELIVERABLES

A plan for implementing the selected projects from step 6, which contains expected cost reductions for the period.

PROCEDURE

> Select projects based on investment efficiencies, in accordance with other metrics set by the company

>> Set a plan for implementation and responsibilities, as well as follow-up procedures

EXAMPLE

For our example, to optimize our cost reduction program, we would select projects from the highest return rate and descending as long as it stays above 1, depending on the funds available for improvement projects.

Concluding remarks

This roadmap was developed as part of a master's thesis at the Norwegian University of Science and Technology, Department of Industrial Economics and Technology Management, in collaboration with Norsk Hydro.
The authors have applied a design science research methodology to refine the original framework. The roadmap is a deliverable of their thesis.

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