

***Maintenance Function Deployment  
(MFD) for Cost-effective &  
Continuous Improvement of  
Company Business; Using Total  
Quality Maintenance (TQMain)***

***Professor Dr. Basim Al-Najjar  
Professor of Terotechnology  
Head of the Department of Terotechnology  
School of Technology and Design, Växjö University  
Building M, 351 95 Växjö, Sweden,  
[Basim.Al-Najjar@vxu.se](mailto:Basim.Al-Najjar@vxu.se)***

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Role, Characteristics and Benefits**
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- ❑ Greek *terō/tērein*; I care/watch over, take care of  
Is applied on production & service processes
- ❑ It refers to the study of the costs associated with an asset throughout its life cycle (acquisition to disposal)
- ❑ A combination of management, financial, engineering and other practices applied to processes/physical assets in pursuit of economic life cycle costs
- ❑ It covers maintenance management, man-machine-maintenance-economy interfaces, risk management, data management and databases, optimisation, CM, CBM & its impact on company's business

# ***Terotechnology at Växjö University***

- 14 persons: 4 Prof, 1 Associate Prof, 2 assistant Prof, 8 PhD students, research assistant and a couple of University teachers**
- There are two BSc programs, a Master program and a PhD program, all updated according to the Bologna Declaration**

# *Research*

- Condition-based Maintenance (CBM)**
- Risk management and modelling**
- Man-machine-economy-maintenance interactions**
- Impact of Maintenance on Production, Quality, Competence, LCC, environment, etc.**
- Maintenance of quality, Maintenance Management & Optimisation**
- Data gathering, Databases, decision support systems, decision procedures & information systems**

# Research Projects

- ❑ **DYNAMITE: Dynamic Decisions in Maintenance**
- ❑ **VARIABILITY: Value-chain integration and Risk-informed decision capability: Business models, New processes, and Integrated platforms for Performance optimization in non-hierarchical manufacturing networks**
- ❑ **Maintenance Function Deployment (MFD) for continuous enhancement of company profitability & competitiveness**
- ❑ **Tools and methods for maintaining software quality**
- ❑ **Information Systems for Selection and Implementation of a Cost-effective Maintenance**
- ❑ **Data, database and IT for managing profitable maintenance**

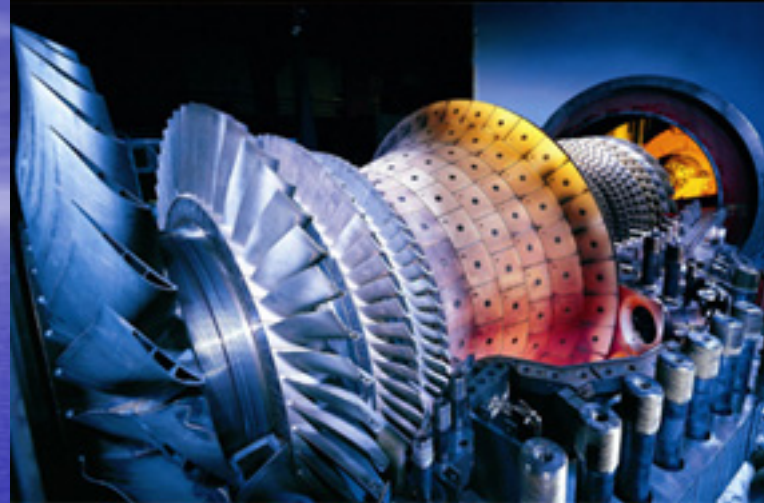
# ***International Networks***

- ***DYNAMITE: EU-IP, 6th-FP (2005-2009)***
- ***IFRIM: Int. Foundation for Research in Maintenance***
- ***EURENSEAM: European Research Network on Strategic Engineering Asset Management***
- ***INID: International Network for Industrial Diagnostic***

**ALSTOM**



**SIEMENS**



**VOLVO**



STORAENSO



JUNGBYMASKIN



SKF



Kalmar

*Make things easy*



VATTENFALL 



 VIDA



 Husqvarna



 SÖDRA

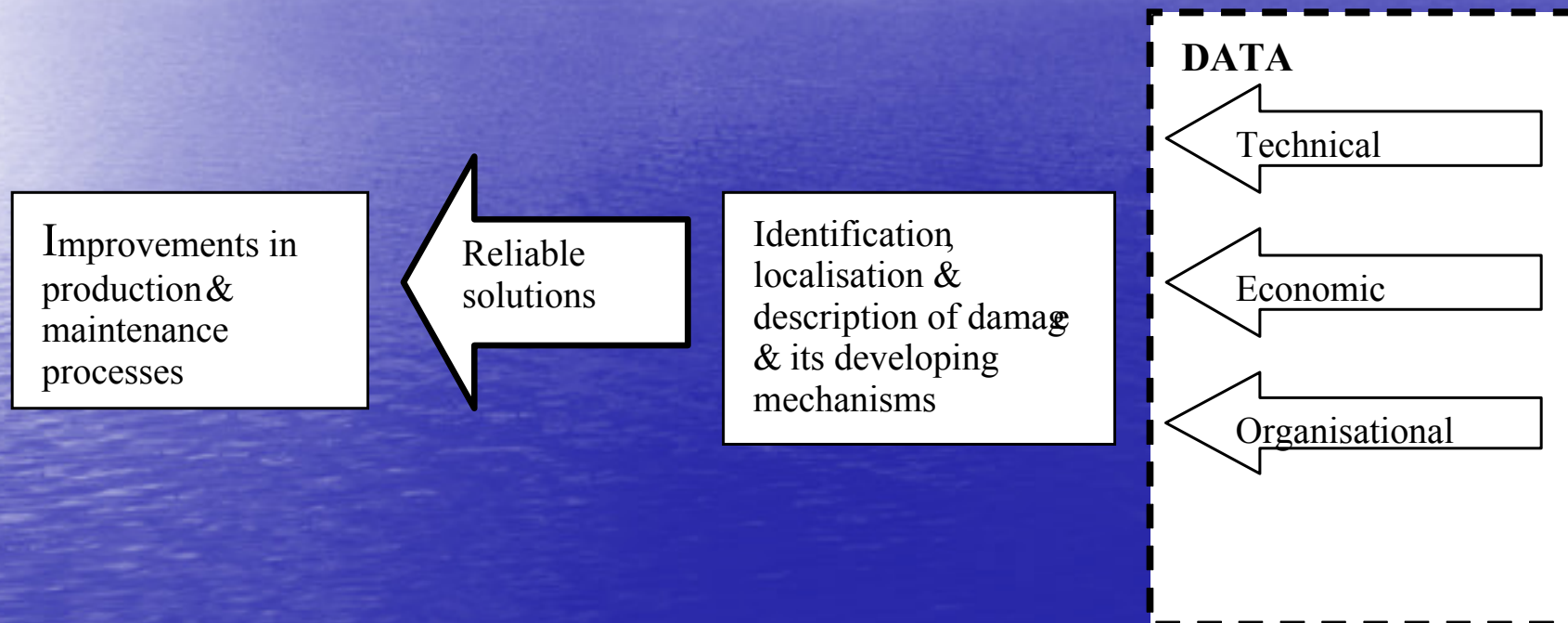


# Introduction

- ❑ Maintenance activities may cost from 15 to 40% (with an average of 28%) of the total cost of finished goods
- ❑ VBM policy provides possibilities for acquiring early indications of changes of machine-state
- ❑ These indications could be of great importance also in detecting deviations in the product quality early and before they show on quality control charts
- ❑ Cost-effectiveness is one of the criteria that should be used to select a suitable maintenance policy

- ❑ Real problems in production, quality and maintenance are complex due to the interplay between many factors**
- ❑ Databases of CM software programs are limited and in general not integrated with databases for plant other activities**
- ❑ A wide range database is required for effective diagnosis and prognosis**

# *Improvements in production and maintenance processes versus data*



# ***Maintenance as a Profit Contributor***

## ***Competitive Advantages***

- High quality production and machine**
- Competitive price**
- Delivery on time**
- Environmental friendly production and product**
- Society acceptance**

## *Deming Cycle*

- ❑ One of the essential forces driving TQM and TPM is the improvement cycle (Deming cycle), i.e.

**Plan - Do - Check - Act**

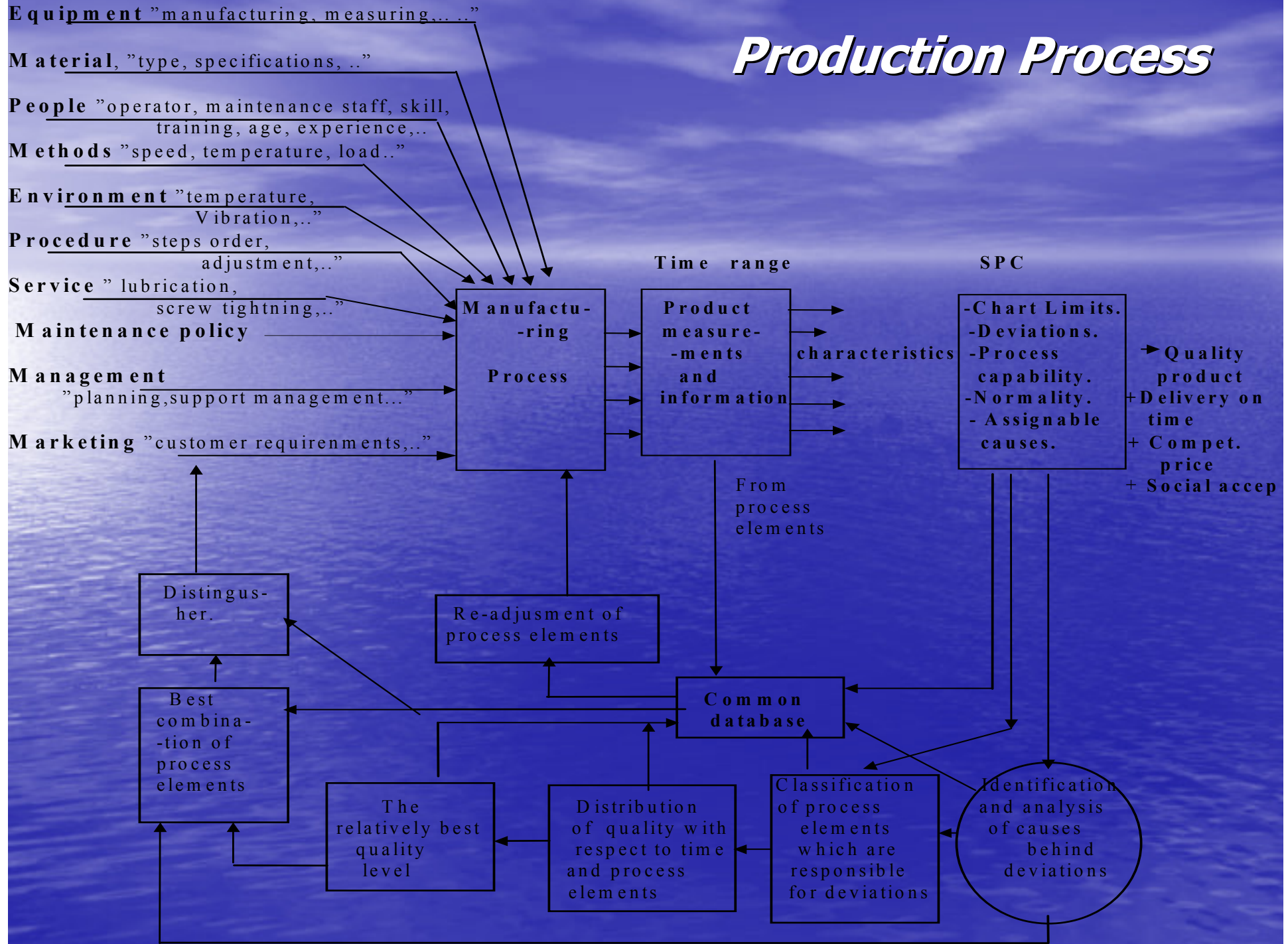
- ❑ It has been used that one should act as soon as a failure is occurred
- ❑ But, it can be used so that a maintenance action is started at an earlier stage, i.e. as soon as a significant deviation in the equipment/process condition is observed

# ***Total Quality Maintenance (TQMain)***

- It is a means to maintain and improve continuously the technical and economic effectiveness of the production process and its elements, i.e.;**

**A means to maintain the quality of the elements involved in the production process**

# Production Process



## ***TQM Main Role***

- ❑ for monitoring and controlling deviations in a process, working conditions, quality & production cost.**
- ❑ also for detecting damage causes, their developing mechanisms & potential failures for interfering (when it is possible) to “stop” or reduce machine deterioration rate before it is too late**
- ❑ All these should be performed at a continuously reducing cost per unit quality product**

# *Characteristics of TQMmain*

- ❑ **It covers a wide range of a production process and not just machinery**
- ❑ **It provides tools and methods for proactive-predictive maintenance**
- ❑ **It is planned and performed based on the needs arise due to the deviations in the quality of the elements involved in a prod. process**
- ❑ **It handles production and maintenance technical and economic problems by integrating tools and methods belong to both deterministic and probabilistic approaches**

- ❑ It advocates the use of a common database for real-time data of; machine condition, production process, product quality, working environment and competence**
- ❑ It supports selection and improvement of the most informative CM system and the most cost-effective maintenance policy**
- ❑ It provides an overall view of the state of the production process and maintenance technical & economic impact on company business**
- ❑ It provides the basis for cost-effective and continuous improvement of the production and maintenance process**



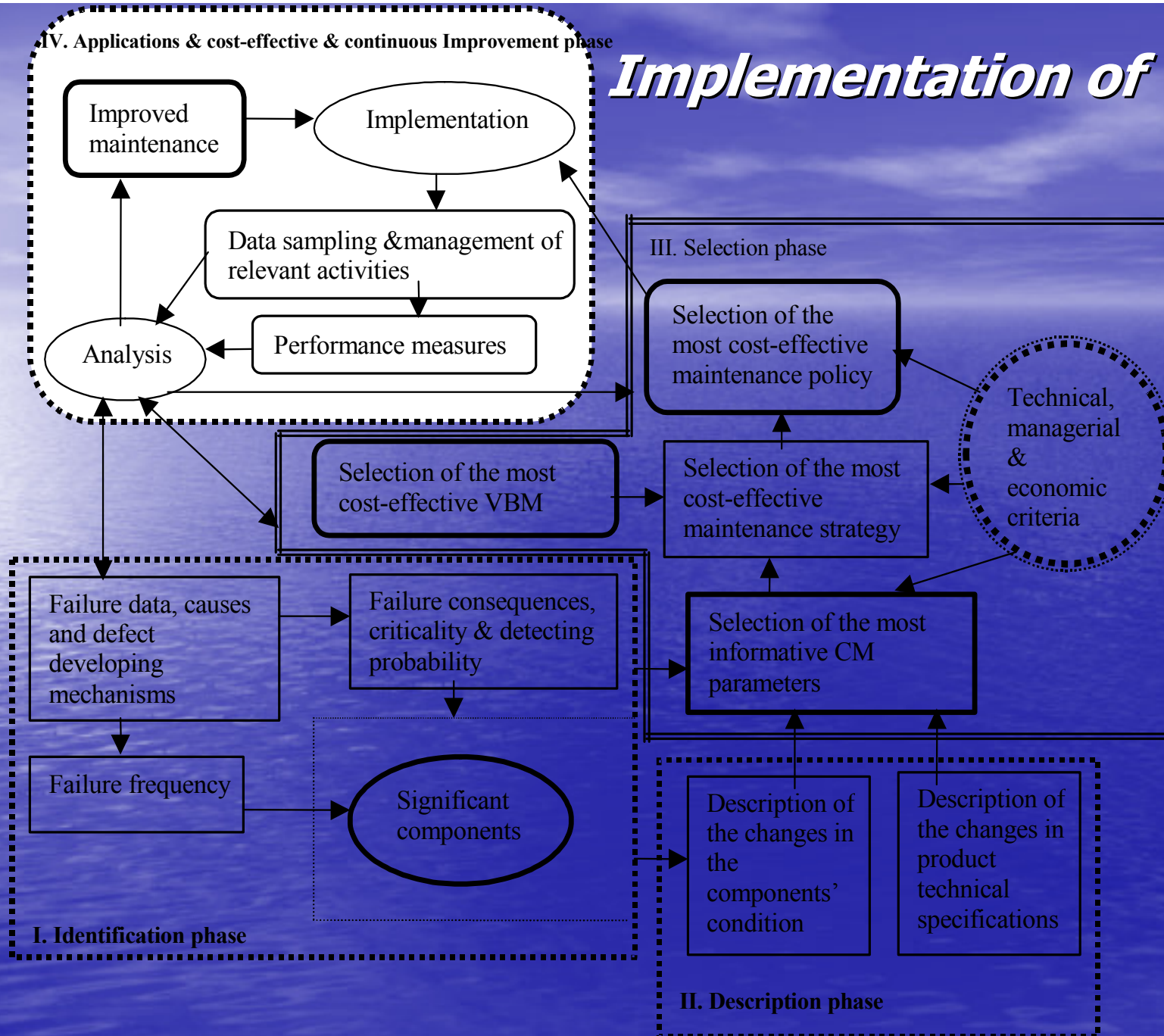
**□ The results of applying TQMain have shown a big beneficial potential**

## ***Benefits and Applicability of TQMmain***

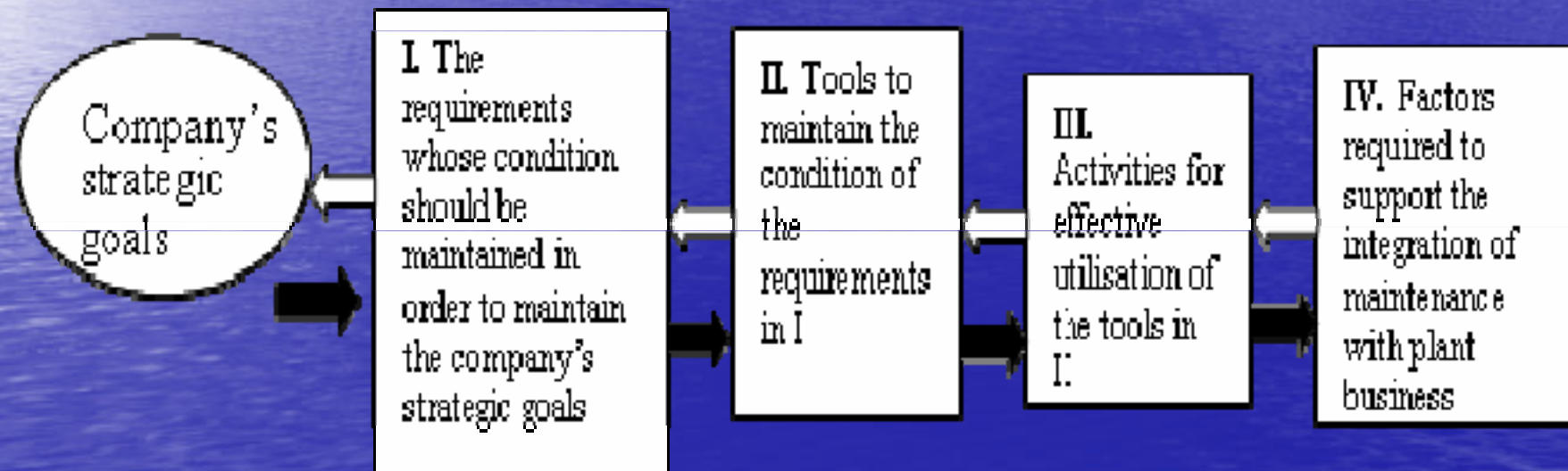
- Detecting deviations in the state of a component/ machine/process, production cost, product quality and working environment at an early stage in order to control the situation when it is possible by “stopping” or reducing the rate of the development**
- Selecting the most cost-effective maintenance strategy/policy**
- Selecting the acceptable deterioration rate to “guarantee” no sudden failure during the lead-time**

- ❑ **Detecting imminent failures and follow up their development and predicting the level of the CM parameter, e.g. vibration level**
- ❑ **Assessing the probability of failure, residual life of a component/equipment & the most cost effective opportunity for performing maintenance action**
- ❑ **Identifying damage initiation causes, developing mechanisms and failure modes with increasing diagnosis and prognosis precision by relating past measurements to the damage subsequently found and safe lead-time achieved**

# Implementation of TQMMain



# *Schematic description of the model Maintenance Function Deployment (MFD)*



# *Categories of losses w r t company strategic goals*

	<b>Category of losses according to the strategic goals</b>	<b>Losses Units</b>	<b>Share of losses</b>	<b>Comments</b>
<b>1</b>	Bad quality (Product quality)	90	9%	Losses due to internal causes, e.g. scrap, reworking, and external causes, e.g. compensations for customers, warranties, etc.
<b>2</b>	Less delivery accuracy (Delivery accuracy)	130	13%	Penalty expenses due to delivery delay
<b>3</b>	Less profit margin, which influences product price (Competitive price)	650	65%	Unnecessary production costs due to failures, short stoppages and disturbances
<b>4</b>	Negative impact of production process on the environment (Environmental-friendly production)	60	6%	Expenses for special treating of the product when its life length is terminated, e.g. batteries. Special expenses for adapting the production to the national/international legislation on environment
<b>5</b>	Worse machine condition (Machine condition)	70	7%	The losses due to losing some of the machines' value, i.e. machine life length, due to rapid deterioration compared with the case when the machines are in better condition
	<b>Total</b>	1000	100%	

Losses category (Outputs to be achieved, maintained and improved)	Target value (Max. losses)	Requirements necessary for achieving, maintaining and improving the outputs (Hows)	Production machine condition	Machine tool condition	Working environment	Production rate, e.g. m / min	Condition of the quality system	Competence of the operating and maintenance staff	Condition of the production logistics system	Importance of Whats (Total)	Priority list of the actions required for improvement
Bad quality			3%	1%	0	0	3%	2%	0	9%	Third priority (plans for deep analysis and actions may also be required)
Delivery delay			5%	1%	1%	3%	0	1%	2%	13%	Second priority (plans for deep analysis and actions may also be required)
Lost profit margin (due to failures)			30%	4%	7%	13%	0	6%	5%	65%	First priority (plans for deep analysis and actions are required)
Deviation from the Environment-friendly production			4%	0	2%	0	0	0	0	6%	
Bad machine condition			7%	0%	0%	0%	0%	0%	0%	7%	
<b>Importance of Hows (Total)</b>			<b>49%</b>	<b>6%</b>	<b>10%</b>	<b>16%</b>	<b>3%</b>	<b>9%</b>	<b>7%</b>	<b>100%</b>	

Losses category (Requirements for achieving, maintaining and improving the outputs (Whats))	Target value (Max losses)	The tools that are necessary to preserve the condition of the requirements (Hows)	Lack of or inefficient maintenance policy	Lack of or inefficient measuring and analysis system	Lack of or inefficient cost effective and continuous improvement policy	Lack of or inefficient standard and instruction for doing maintenance properly	Importance of Whats (Total)	Priority list of the actions required for improvement
Production machine condition			21,0%	8,0%	13,0%	7,0%	<b>49,0%</b>	First priority (plans for deep analysis and actions are required)
Machine tool condition			2,0%	2,0%	1,0%	1,0%	<b>6,0%</b>	
Working environment			3,0%	2,0%	3,0%	2,0%	<b>10,0%</b>	
Production rate, e.g. m/min			7,0%	4,0%	4,0%	1,0%	<b>16,0%</b>	Second priority (plans for deep analysis and actions may also be required)
Condition of the product quality system			1,5%	0,5%	0,5%	0,5%	<b>3,0%</b>	
Competence of the operating and maintenance staff			5,5%	1,5%	1,0%	1,0%	<b>9,0%</b>	
Condition of the production logistics system			3,0%	2,0%	0,5%	1,5%	<b>7,0%</b>	
<b>Importance of Hows (Total)</b>			<b>43,0%</b>	<b>20,0%</b>	<b>23,0%</b>	<b>14,0%</b>	<b>100,0%</b>	

<b>Losses category (The tools that are necessary to preserve the condition of the requirements (Whats))</b>	<b>Target value (Max losses)</b>	<b>The activities that are necessary for effective utilisation of the tools in phase two (Hows)</b>	<b>Lack of or inefficient training program to enhance the operator and maintenance staff competence</b>	<b>Lack of or inefficient technique for monitoring and adjusting production rate and working environment</b>	<b>Lack of or inefficient measures for monitoring process performance and cost-effectiveness</b>	<b>Lack of or inappropriate data and knowledge base</b>	<b>Importance of Whats (Total)</b>	<b>Priority list of the actions required for improvement</b>
Lack of or inefficient maintenance policy			26,0%	3,0%	8,0%	6,0%	43,0%	(plans for deep analysis and actions are required)
Lack of or inefficient measuring and analysis system			7,0%	3,0%	2,0%	8,0%	20,0%	Third priority (plans for deep analysis and actions may also be required)
Lack of or inefficient cost-effective and continuous improvement policy			11,0%	1,0%	2,0%	9,0%	23,0%	Second priority (plans for deep analysis and actions may also be required)
Lack of or inefficient standard and instruction for doing maintenance properly			5,0%	0,0%	0,0%	9,0%	14,0%	Fourth priority (plans for deep analysis and actions may also be required)
<b>Importance of Hows (Total)</b>			<b>49,0%</b>	<b>7,0%</b>	<b>12,0%</b>	<b>32,0%</b>	<b>100,0%</b>	

<b>Losses category (the activities that are necessary for effective utilization of the tools in pahse two (Whats))</b>	<b>Target value (Max Losses)</b>	<b>The factors required to support integrating maintenance with plant business (Hows)</b>	<b>Lack of or inefficient strategic plan for integrating maintenance with plant business</b>	<b>Lack of or insufficient risk capital for integrating maintenance with plant business</b>	<b>Lack of or unsuitable knowledge and experience in the production machines and process</b>	<b>Lack of or inefficient managerial and organisational tools</b>	<b>Lack of or insuitable criteria for selecting tools, methods and policies, e.g. for the most informative CM system, and the most cost-effective maintenance policy</b>	<b>Importance of Whats (Total)</b>	<b>Priority list of the actions required for improvement</b>
Lack of or inefficient training program to enhance the operator and maintenance staff competence			15,0%	13,0%	10,0%	11,0%	0,0%	49,0%	First priority (plans for deep analysis and actions are required)
Lack of or inefficient technique for monitoring and adjusting production rate and working environment			3,0%	2,0%	2,0%	0,0%	0,0%	7,0%	Fourth priority (plans for deep analysis and actions are required)
Lack of or inefficient measures for monitoring process performance and cost-effectiveness			4,0%	3,0%	2,0%	2,0%	1,0%	12,0%	Third priority (plans for deep analysis and actions may also be required)
Lack of or inappropriate data and know ledge base			10,0%	10,0%	3,0%	5,0%	4,0%	32,0%	Second priority (plans for deep analysis and actions are required)
<b>Importance of How's (Total)</b>			<b>32,0%</b>	<b>28,0%</b>	<b>17,0%</b>	<b>18,0%</b>	<b>5,0%</b>	<b>100,0%</b>	

# *Conclusions*

- ❑ **Detecting the deviations in the process is to control the situation at an early stage**
- ❑ **Applying cost-effective vibration-level is to replace components suffering deterioration cost-effectively**
- ❑ **Assessment of the acceptable deterioration rate is to avoid sudden failure during the lead-time**
- ❑ **At a potential failure, remaining working life & probability of failure should be assessed**
- ❑ **Applying MFD leads to identification and quantification of profit losses and their root-causes**



**✚ Applying MFD leads to identification and quantification of profit losses and their root-causes**