

**PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)**

University of Siegen, Department of Mechanical Engineering
Chair for International Project Management

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Contents of Lecture

Introduction	
1	Theoretical Background Methodology, Systems Theory, Projects and Processes, Project Management
2	Project Definition Project Objectives, Project Stakeholders
3	Project Structure Definitions; Developing WBS, Organisation, and other Structures, Relational Project Structure
4	Project Scheduling Project Networks; Project Network Calculations; Other Scheduling Tools
5	Resource Planning Definitions; Resource Demand; Resource Constrained Project Scheduling
6	Project Control Project Cost Management; Project Cash Flow; Project Progress and Earned Value Concept; Project Monitoring and Reporting
7	Project Management Software Project Management Systems; Project Data Warehouse and Workflow

10-2006 2 PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

There have been immense undertakings throughout the history of the mankind.



The A3XX Project



Taipei 101



Sheikh Zayed



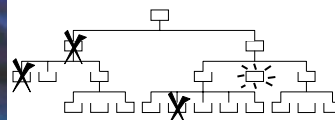
The Euro

Today, project management ideas are used on many occasions other than high technology endeavours.

ERP system introduction



Organisational changes



Globalisation of companies



Apart from great international undertakings, projects can be found:

- in all kinds of organisations
- in all functional units an organisation may have.

Branches of Industries applying Project Management

- Building and construction industry
- Software engineering
- Shipbuilding
- Aerospace and defence technology
- Automotive industry
- Process plant engineering and construction
- Telecommunications
- Research and science
- Social sector and politics
- Entertainment industry
- ...

Functional Units Applying Project Management

- New product development
- Engineering and design
- Production
- Procurement
- Sales and marketing
- Management and organisation

Project Characteristics:

- Activity
- Unique
- Temporary

“A project is a temporary endeavour undertaken in order to create a unique product or service.”

PMI BoK, 2002

Introduction

Project Management Associations

- PMI (Project Management Institute)
 - <http://www.pmi.org/>
- IPMA (International Project Management Association)
 - <http://www.ipma.ch/>
- GPM (Deutsche Gesellschaft für Projektmanagement e.V.)
 - <http://www.gpm-ipma.de/>
- APM – Association for Project Management
 - <http://www.apm.org.uk/>

Body of Knowledge

PMBOK Guide ®, 2000
(PMI – Project Management Institute)
Body of Knowledge, 2000
(APM – Association for Project Management)
IPMA Competence Baseline (ICB), 1999
(IPMA – International Project Management Association)
Projektmanagement-Kanon der Gesellschaft für
Projektmanagement, 2002
(GPM - Gesellschaft für Projektmanagement)



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Introduction

- 1 Theoretical Background**
Methodology, Systems Theory, Projects and Processes, Project Management
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Project Networks; Project Network Calculations; Other Scheduling Tools
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1 Theoretical Background

Methodology

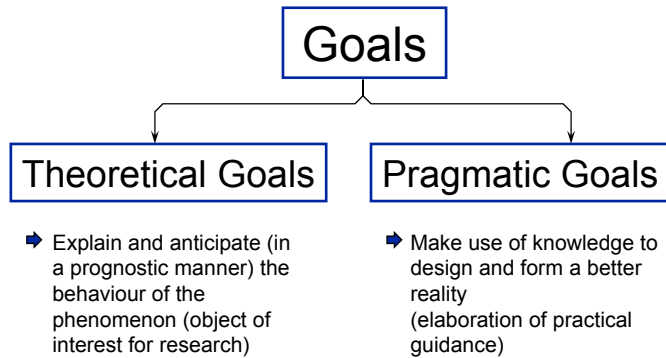
Research Methods

As an analogue to general objectives of the theory of research work

the Project Management I lecture aims at two objectives:

- theoretical goals and
- pragmatic goals

with major focus on pragmatic goals.



1 Theoretical Background

Methodology

Research Methods

The research process comprises a set of activities, allocable to a three classes

Terminological - descriptive

- Creation of terminology
- Application of the terminology to describe the research phenomenon (object)

Empirical - inductive

- Investigation of visible or recognisable relations and interdependencies (even by questionnaire)
- Formulation of hypotheses by generalising of single events

Analytical - deductive

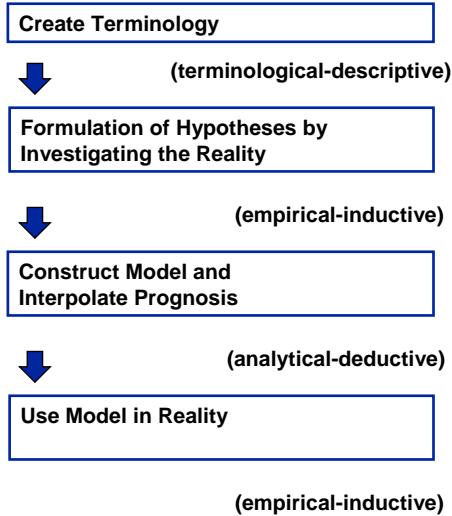
- Construct and analyse models based on existing general rules



Research Methods

This is a successful procedure.

It looks simple, but the research process always implicates heuristic complex steps, we are not able to describe analytically.



Research Methods

Create a Model

- ➡ **To reduce complexity:**
 - Isolating abstraction: only essential features (or variables) will be taken into consideration
 - "ceteris paribus"-approach (one-thing-at-a-time approach): one variable only will be altered by a constant value of the other variables
 - correlation type approach: Only the interdependencies will be considered, without reference to the cause

- ➡ **To manage dynamic impact:**
 - Static picture: Actual situation, some variables are to be constant (e.g. variables to define the goals)
 - statistics type approach: Use of statistic mean or median, to reduce full range of possible values

- ➡ **To cope with numerous possible configurations of the system**
 - Defining archetypes
 - Set limits to the range of values for validity of results



1 Theoretical Background

Methodology

"to analyse" means "to divide something into its elements"

System Engineering or System Analysis: breaking down the system into sub-systems and elements, which interfere with each other.

- **Principle of Hierarchical Structuring**
divide the system and its environment, as in reality there are no boundaries (somewhere in infinity).
- **Principle of Black box**
one does not have to know the internal processes inside this box, only **input and output** are important.
conceive systems consisting of sub-systems without having to analyse the internal structures of these sub-systems

Detailed analysis of the sub-system can be postponed to a later planning phase, when the variety of possible solutions have already been reduced.



1 Theoretical Background

Systems Theory

Basic terms in system theory

Created by Ludwig von Bertalanffy the general system theory is a theory about representations i.e. models rather than the systems themselves. A scientific effort to identify structural, behavioural and developmental features common to particular classes of organisms.

A system is a set of elements standing in interrelations.

A system comprises

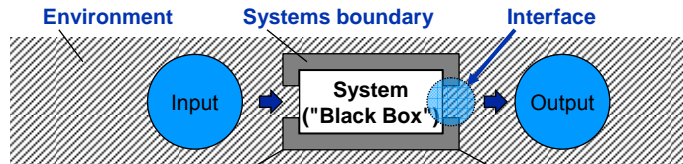
- **a goal:** goal orientation and function (purpose, effect)
- **complexity:** structure and processes (set-up, relations, and links in between the elements including attributes and properties)
- **an environment:** at least one input and one output (processes of information, material flow, flow of energy) i.e. the system is open, there are interfaces etc.
- **dynamics:** an actual status, changing status throughout project life cycle



1 Theoretical Background

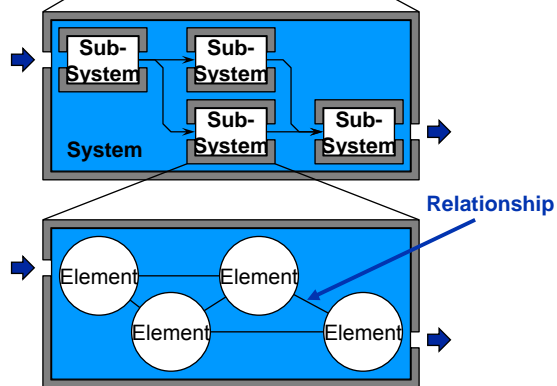
Systems Theory

Systems definition



Systems boundaries are to be defined (agreed upon), as in reality there are no boundaries (somewhere in infinity)

All parts of the systems are to be defined as sub-systems and elements and interfere with each other.



10-2006

17

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METHODS AND INSTRUMENTS (PM I)

1 Theoretical Background

Systems Theory

System goals are descriptions of future states, important aspects, and behaviour of a system.

They are derived from effects an anticipated system in operation is designed for.

System goals

- should not contain any predefined solutions: to enlarge the search space for new solutions
- should describe system's capabilities at operational level (qualitative)
- should be unambiguous
- should be well defined.

There are technological, economical, and /or sociological goals describing the capabilities of the system (object).



10-2006

18

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METHODS AND INSTRUMENTS (PM I)

Systems Theory

The project as a system

Project measures to manage project system

Goal oriented: define project goals and constraints
define project stakeholders
define conflicting and complementary issues
define measures to resolve conflicts

Complex: reduce complexity by structuring
elaborate useful structures
establish project organisation

Open: define boundaries
define interfaces (technological, organisational etc)

Dynamic: establish permanent project control
establish risk management
establish change management
establish configuration management



Systems Theory



PMI Project Management Institute's definition of a project:

“Organizations perform work. Work generally involves either operations or projects. Operations and projects share many characteristics; for example, they are:

- Performed by people
- Constrained by limited resources
- Planned, executed and controlled.

Operations and projects differ primarily in that the operations are ongoing and repetitive while projects are temporary and unique.”

“A project is a temporary endeavour undertaken in order to create a unique product or service.”

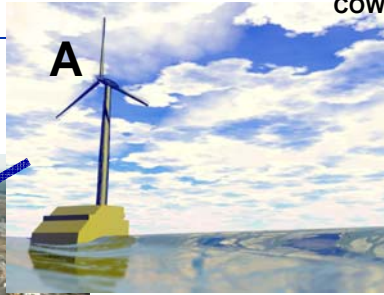
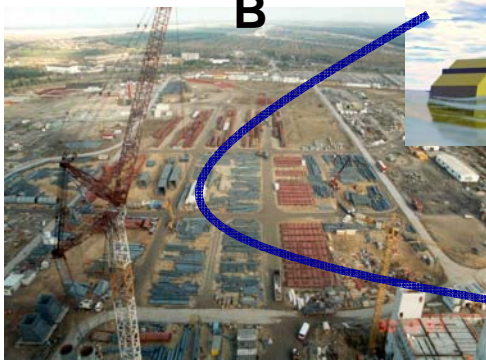


1 Theoretical Background

Project and Process

COWWECS

Project example: Power station



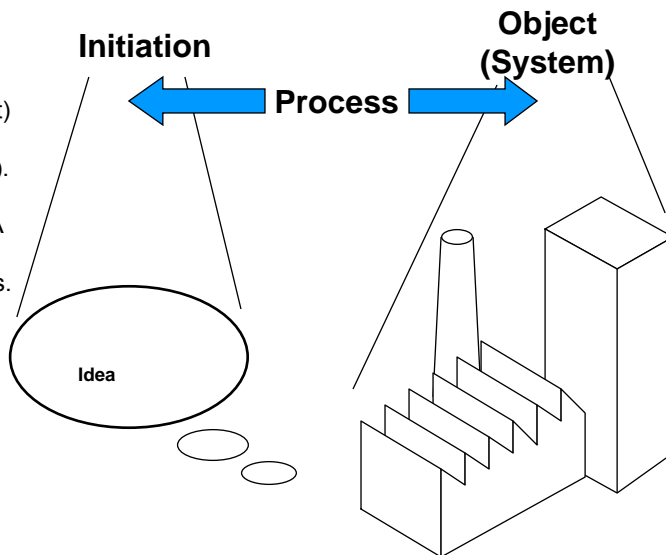
1 Theoretical Background

Project and Process

A project initiated at a status A (commencement) and finished at a status B (completion).

The difference between A and B comprises a (problem solving) process.

This process has to be managed and controlled,

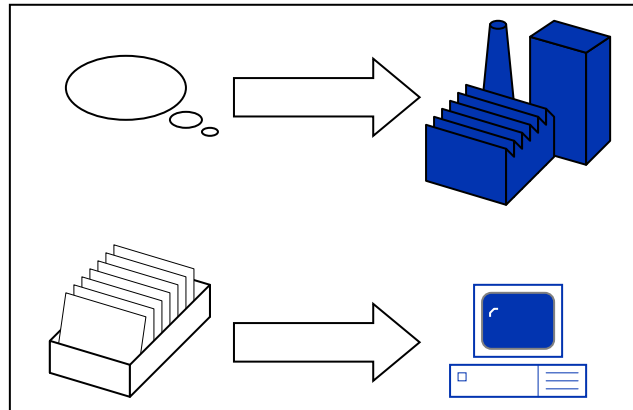
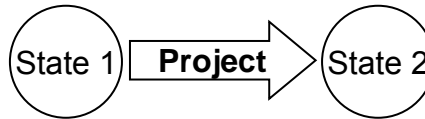


1 Theoretical Background

A project is a transformation process

Project and Process

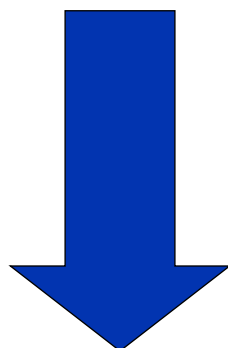
Projects always aim at realising a permanent change of the system in which they are run.



1 Theoretical Background

Project Management

Begin: Idea



End: Success

Defining Goals

Structuring

Scheduling

Resource

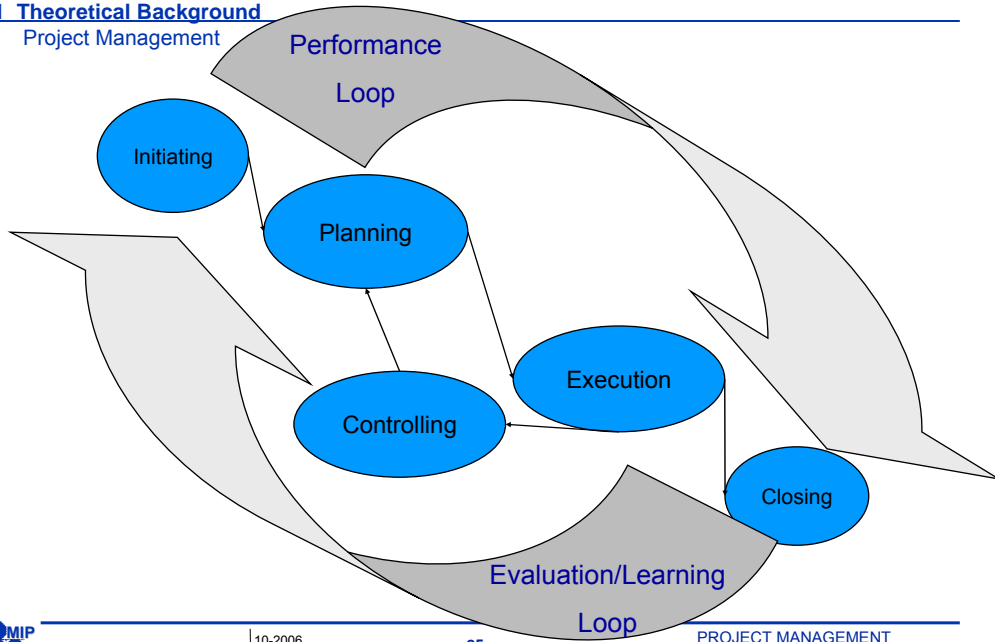
Control

Act



1 Theoretical Background

Project Management

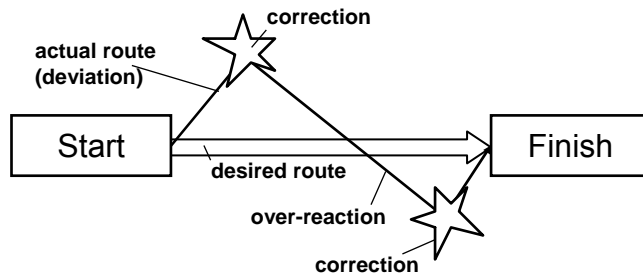


1 Theoretical Background

Project Management

Managing projects

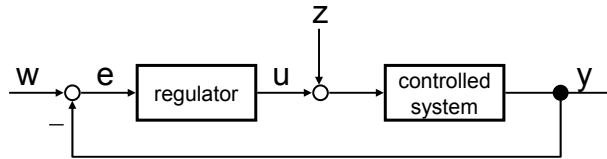
Managing projects has been compared to driving a car. Like a car driver the project manager has to detect and correct deviations from the planned course as early as possible



1 Theoretical Background

Project Management

- The role of the project manager is quite similar to that of the regulator.



legend

w = reference variable (or: w = const. = desired value), setpoint

y = controlled variable

e = w - y = error variable

u = manipulated variable

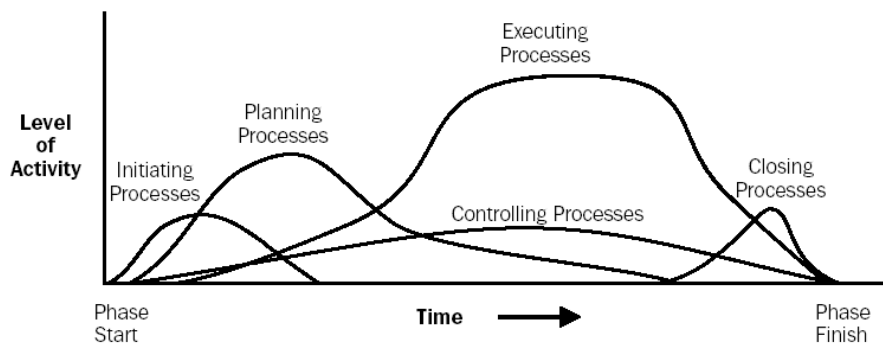
z = disturbance variable

1 Theoretical Background

Project Management

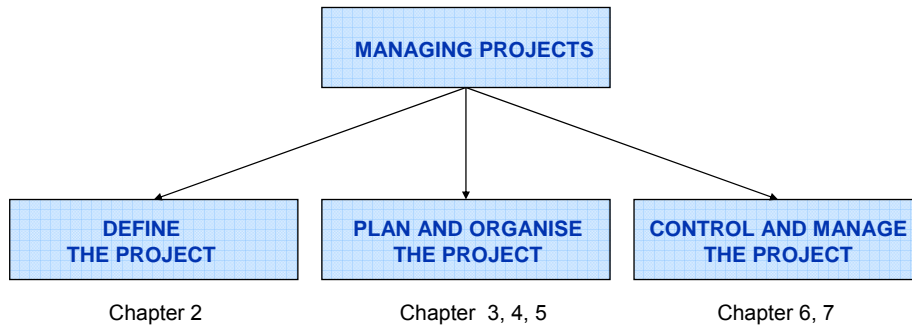
Project Management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements"

Project Management Life Cycle



1 Theoretical Background

Project Management



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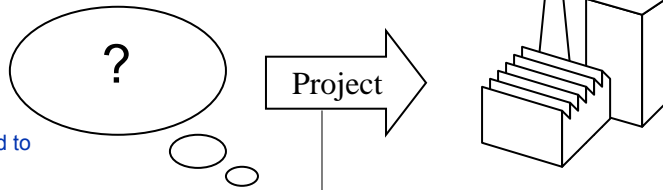


2 Project Definition

Project Objectives

Dimensions of Project Management

The essence of project management can be reduced to a set of simple questions.



What is the object?
What has to be done in order to complete the job?
Who will do this?
Where will it be done?
What is needed to do it?
When will it start?
When will it finish?



2 Project Definition

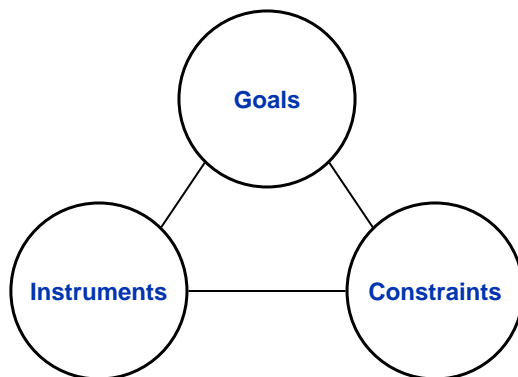
Project Objectives

Projects and Processes

System theory and Project boundaries:

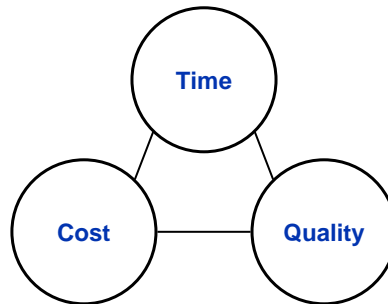
Goals, instruments and constraints

To achieve the project goals, the project manager uses a given set of instruments. Whether these instruments are sufficient depends on the constraints.



Time, cost and quality are sometimes called the "magic triangle" of project management.

Stick to the project schedule
Meet the final delivery date



Stay within the project's budget

Meet the system specification
(This means more than only quality!)

Project goals are results (system goals) to be proved and demonstrated under observance (compliance) of process goals (constraints) such as time, budget, resources available etc.

The purpose of defining project goals

- to define objectives to be controlled (quantitative units, to know how to measure)
- to define objectives to specify the end result (to know what to do)
- to define objectives to motivate people
- to define objectives to make the right decisions on alternative solutions

Goals impeding or restricting solutions are considered as **constraints** and not as goals.

2 Project Definition

Project Objectives

PMBok (pg 15 The Project Management Context)

Project stakeholders are individuals and organizations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or successful project completion.

The project management team must identify the stakeholders, determine what their needs and expectations are, and then manage and influence those expectations to ensure a successful project.

Stakeholder identification is often especially difficult.

For example, is an assembly line worker whose future employment depends on the outcome of a new product design project is a stakeholder?



2 Project Definition

Project Objectives

Key stakeholders on every project include:

Internal stakeholders

- Project manager—the individual responsible for managing the project.
- CEO or president of the company
- Head of
 - engineering department
 - manufacturing department
 - procurement department
 - financing department

.I.



2 Project Definition

Project Objectives

Key stakeholders on every project include cont'd:

External stakeholders

- Customer—the individual or organization who will use the project product.
There may be multiple layers of customers. For example, the customers for a new pharmaceutical product may include the doctors who prescribe it, the patients who take it, and the insurers who pay for it.
- Sponsor—the individual or group within the performing organization who provides the financial resources, in cash or in kind, for the project.
- Owners engineer.
- Authorities.



2 Project Definition

Project Objectives

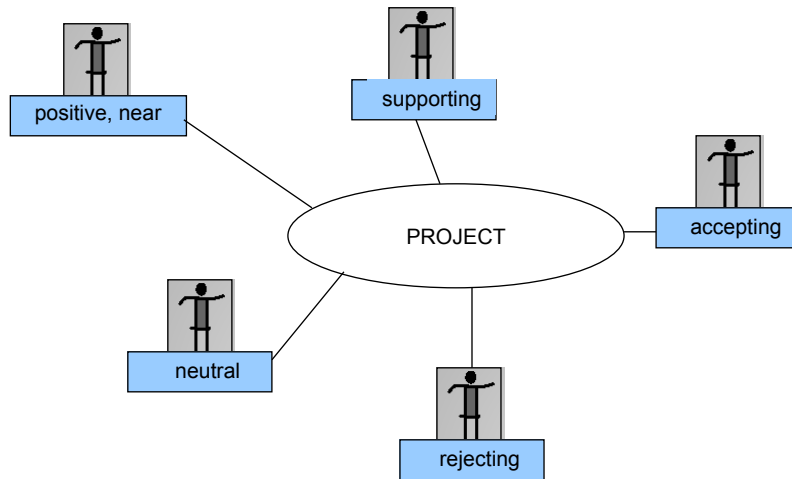
In defining project stakeholders always ask

- Who is the client ?
- Who will benefit from the project ?
- What are the existing conflicts ?
- What are the positive and negative impacts of the project ?
- Who cooperates with whom ?



2 Project Definition

Project Objectives



10-2006

39

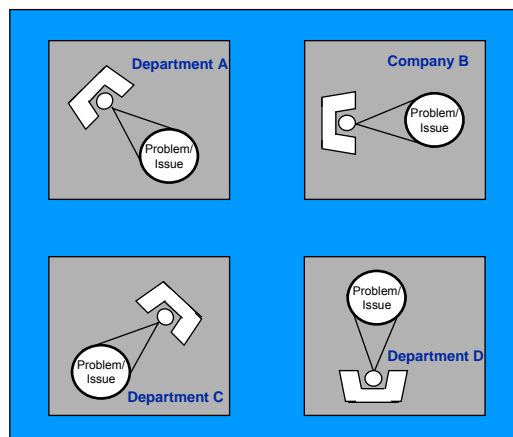
PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

2 Project Definition

Project Objectives

View at the project

Four departments
four different views



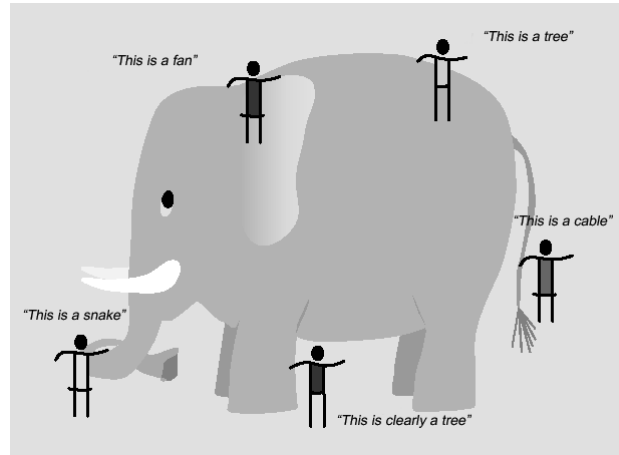
10-2006

40

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

2 Project Definition

Project Objectives



10-2006

41

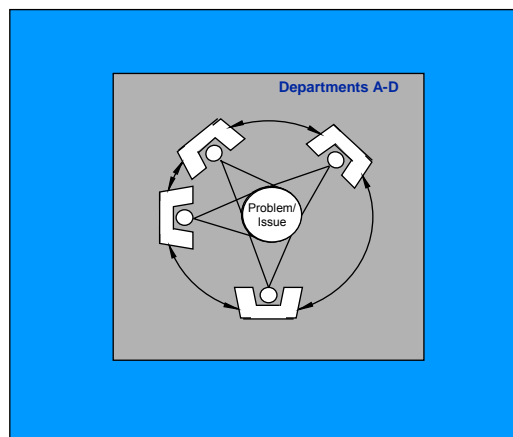
PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

2 Project Definition

Project Objectives

View at the project

Four departments
one common view



10-2006

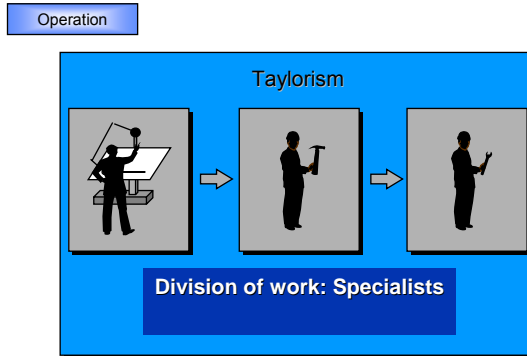
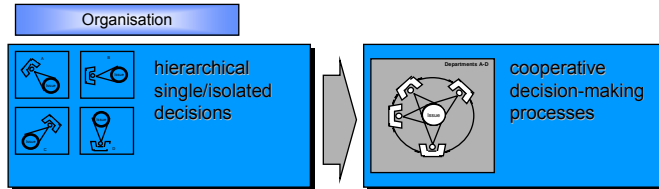
42

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

2 Project Definition

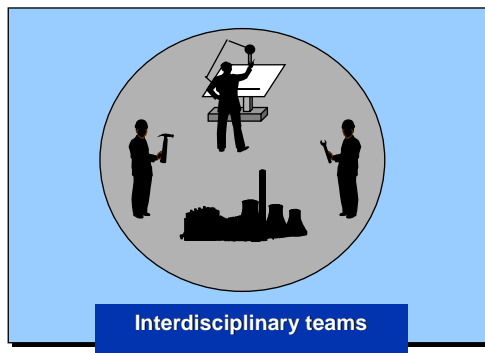
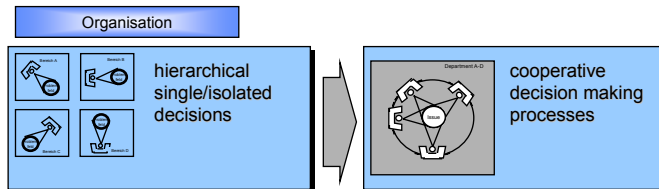
Project Objectives

Hierarchy causes time consuming decision making process



2 Project Definition

Project Objectives

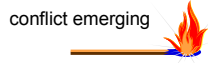
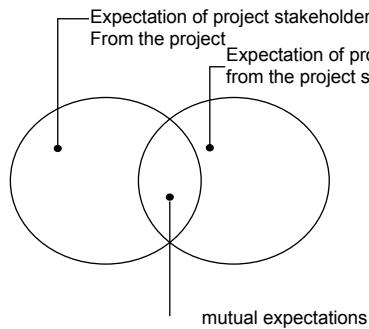




2 Project Definition

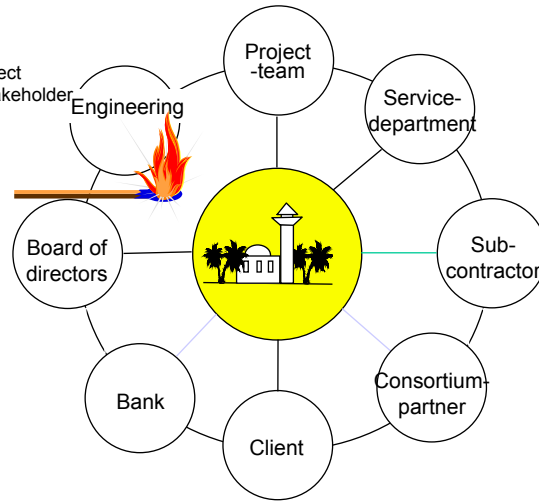
Analysis of project environment

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Project Objectives



Neutral 
without any friction and
conflict 



10-2006

45

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

Contents of Lecture

Introduction

- 1 **Theoretical Background**
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- 2 **Project Definition**
Project Objectives, Project Stakeholders
- 3 **Project Structure**
Introduction, Developing WBS, Organisation, and other Structures, Relational Project Structure
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Project Networks; Project Network Calculations; Other Scheduling Tools
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Definitions; Resource Demand; Resource Constrained Project Scheduling
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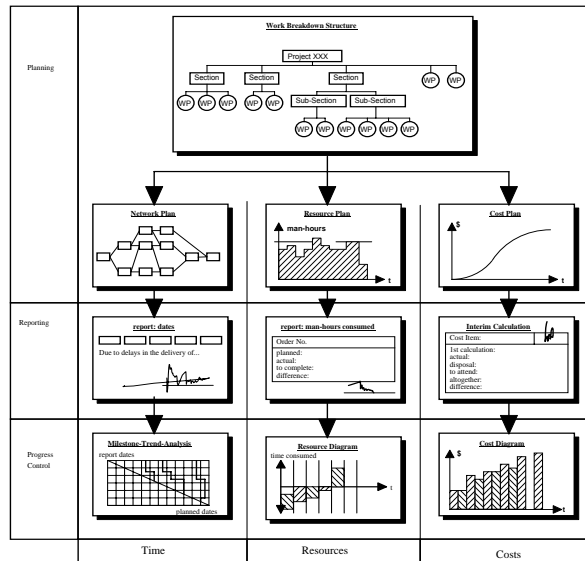


10-2006

46

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

The figure shows the logical interdependencies of the project structure, schedule, resource and cost plans within the control circuit of project management.



- the aim of project structuring is to **avoid chaos**.
- A clear structure of project activities is a great help to **make the project transparent**.
- Project structuring is the **most important activity in project planning**, because scheduling, resource planning and cost planning depend on the description of what has to be done during the project.
- The "classical" tool : "**work breakdown structure (WBS)**" (sometimes also called "division of work — DOW").
 - Basis for planning schedule, resources and costs
 - Backbone during the project execution phase (as coding, project reporting, progress evaluation and documentation refer to the WBS)

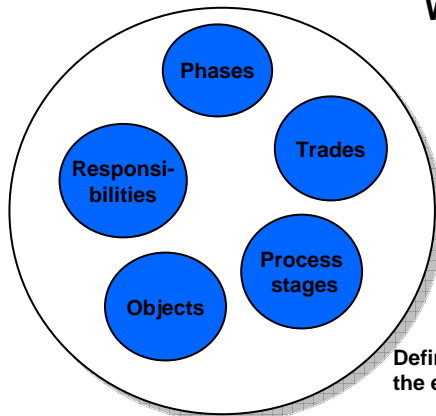


A system's breakdown into subsystems and elements

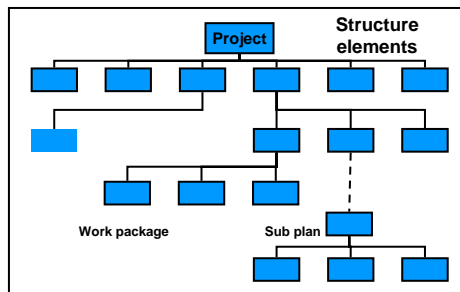
Purpose:

- define work packages, scheduling, progress monitoring
- identification of project items
- cost allocation and cost control
- resource allocation and management
- material take off - bill of material, piece list
- structure of quotation
- contract management
- logistics, delivery list
- design numbering system
- maintenance
- administration (customs, letter of credit)
- labelling and coding, packing list
- permanent and temporary import list (customs)
-

Traditional Structuring



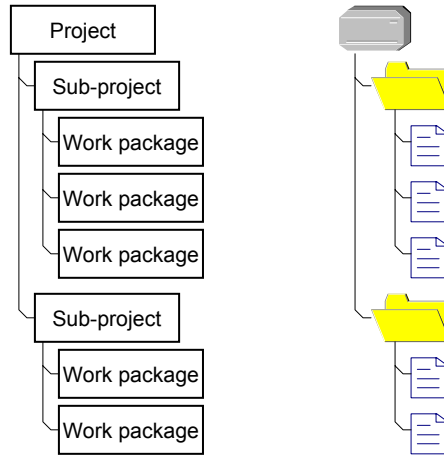
Work Breakdown Structure



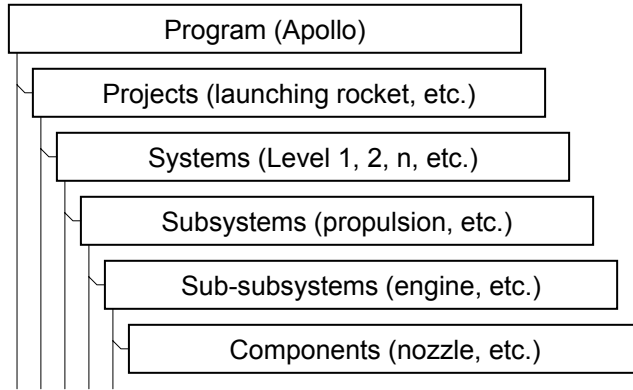
Definition: "totality of the essential relationships between the elements of a project"

In the literature, the WBS is defined as a complete, hierarchically, structured representation of all work packages.

Like in the directory structure of a computer drive, the WBS contains elements that can be subdivided and other elements that cannot be subdivided.



Level	Description
1	Programme
2	Project
3	Subproject
4	Task
5	Subtask
6	Work Package

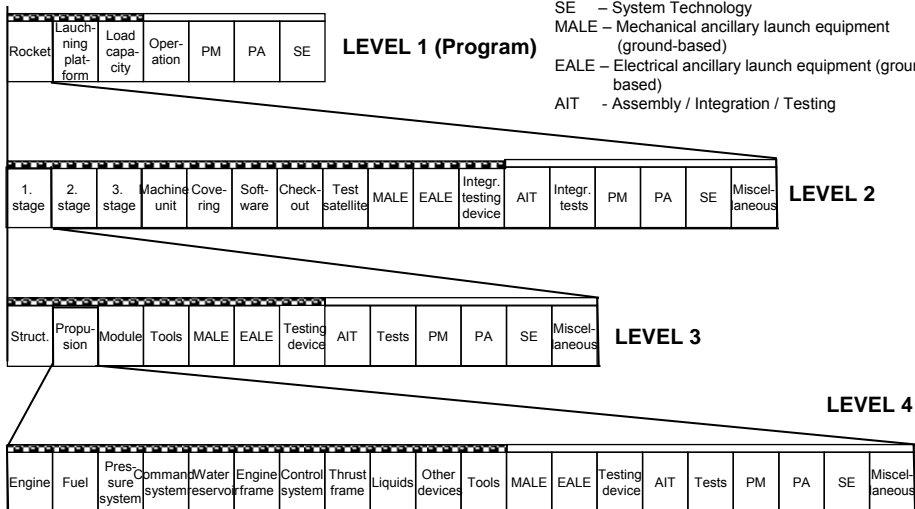


Source: MADAUSS 1994, pg.197



Abbreviations:

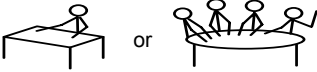


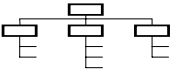
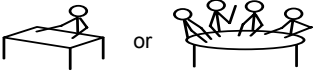
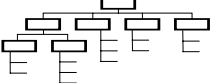
- PM – Project Management
- PA – Product Assurance
- SE – System Technology
- MALE – Mechanical ancillary launch equipment (ground-based)
- EALE – Electrical ancillary launch equipment (ground-based)
- AIT – Assembly / Integration / Testing



Source: MADAUSS, 1994, p. 198



3 Project Structure
Developing WBS

1st step definition of structuring task																	
2nd step choice of structuring method	top-down  or  bottom-up																
3rd step preliminary WBS																	
4th step definition of work packages																	
5th step compatibility check	<table border="1" data-bbox="749 663 885 756"> <tr><td>A</td><td>B</td><td>C</td><td></td></tr> <tr><td></td><td>c</td><td>nc</td><td>A</td></tr> <tr><td></td><td></td><td>c</td><td>B</td></tr> <tr><td></td><td></td><td></td><td>C</td></tr> </table> <p>c = compatible nc = not compatible</p>	A	B	C			c	nc	A			c	B				C
A	B	C															
	c	nc	A														
		c	B														
			C														
6th step approval of final WBS																	



3 Project Structure
Developing WBS

PROJECT STRUCTURE EXAMPLE

KKS Kraftwerkskennzeichnungssystem
Power Station Designation System
Developed by ABB

Requirements

- Determination of all installations and subsystems
- An open system (reserve codes) for future developments in engineering
- Generally applicable for classification of installations and subsystems; all individual circuits and arrangements must be clearly identifiable
- Independent designation of various systems must be possible
- Ease of recognition ensured by clarity and an acceptable length for the designation
- Each item designation must unique in one structure



The KKS consists of three types of designation:

- The **process-related designation** identifies installations and equipment according to their assigned task in the power plant process;
- The **point of installation designation** identifies the points of installation within an installation unit (e.g. cubicles, consoles, panels)
- The **location designation** identifies the rooms and floors, or other installation sites, for installations and equipment in building structures

A uniform designation structure, with a maximum of four breakdown levels, was created for all three types; the units referred to becoming smaller from left to right.

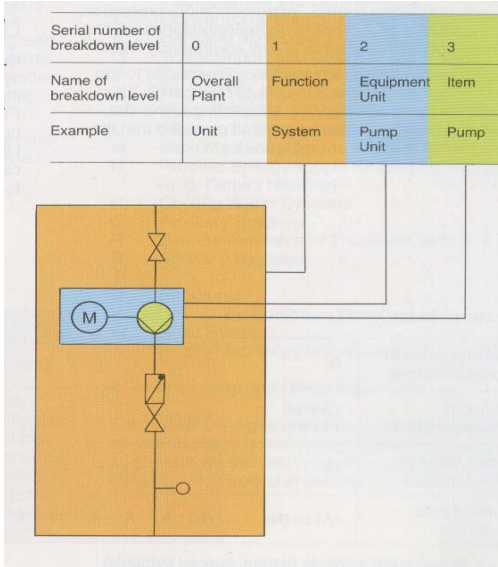


Serial number of breakdown level	0	1	2	3
Name of breakdown level	Overall Plant	Function	Equipment Unit	Item
Example	Unit	System	Pump Unit	Pump



3 Project Structure

Developing WBS



3 Project Structure

Developing WBS

Function key main groups

- A** Grid and Distribution Systems
- B** Power Transmission and Auxiliary Power Supply
- C** Instrumentation and Control Equipment
- D** Instrumentation and Control Equipment
- E** Conventional Fuel Supply and Residue Disposal
- F** Handling of Nuclear Equipment

- G** Water Supply and Disposal
- H** Conventional Heat Generation
- J** Nuclear Heat Generation
- K** Nuclear Auxiliary Systems
- L** Steam-, Water- and Gas-Cycles
- M** Main Machine Sets
- N** Process Energy supply for External Users (e. g. District Heating)



3 Project Structure
Developing WBS

Function key
main groups

P	Cooling Water Systems
Q	Auxiliary Systems
R	Gas Generation and Treatment Systems
S	Ancillary Systems
U	Structures
W	Solar Systems
X	Heavy Machinery (not main machine sets)
Z	Workshop and Office Equipment

Equipment unit code –
Main group

A	Mechanical equipment
B	Mechanical equipment
C	Direct measuring circuits
D	Closed loop control
E	Analog and binary signal conditioning
F	Indirect measuring circuits
G	Electrical equipment
H	Subassemblies of main and heavy machinery
J	Nuclear assemblies



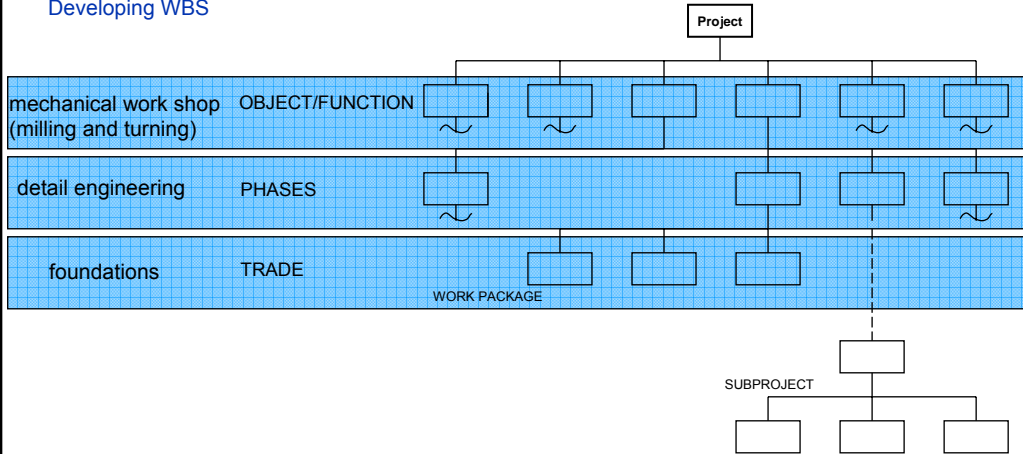
3 Project Structure
Developing WBS

Item code – Main group

K	Mechanical components
M	Mechanical components
Q	Instrumentation and control components (non-electrical)
—	Electrical components
X	Signal origin *)
Y	Signal application *)
Z	Gated signals *)



3 Project Structure
Developing WBS



3 Project Structure
Developing WBS

Work Package

Work Package (WP): last step in project structuring

The intention is no longer to define a sensible order, but to **formulate what shall be done**.

It is absolutely necessary to describe somewhere what is meant by this heading. In particular,
- all deliveries (machines, equipment, spare parts etc.)

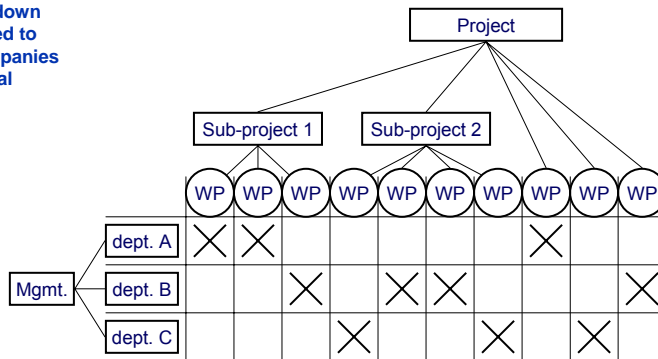
- all performances (engineering, assembly, ...)
have to be mentioned and specified.

Description	
Dates	early dates late dates float
	target dates fixed dates

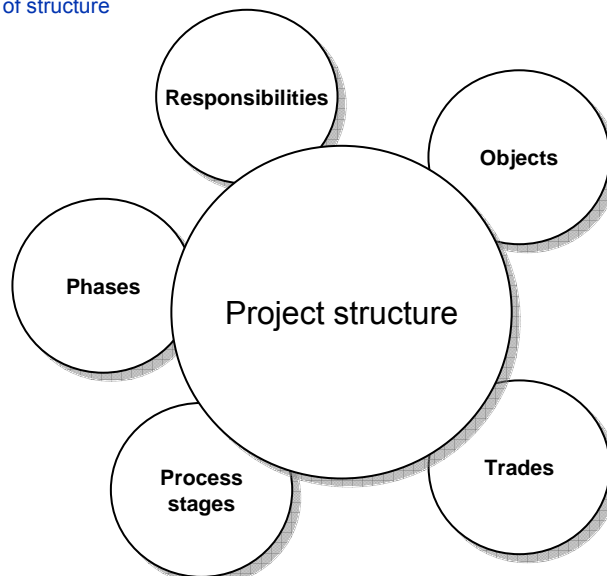
1	INVESTMENT STAGE
2	RESPONSIBILITY
3	PHASE
4	TRADE
5	OBJECT
6	APPROVAL MARKER
7	SITE OF EXECUTION
8	# ID
9



Tasks from the Work Breakdown Structure (WBS) are allocated to people, departments or companies from the OBS (Organisational Breakdown Structure)



Dimension of structure

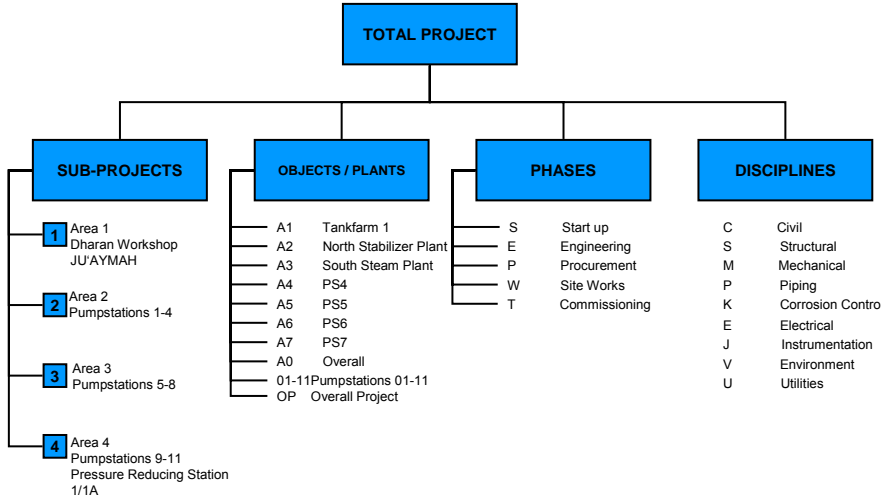


3 Project Structure

Increase Export Capacity Project

Dimension of structure

Major Mechanical Works and Plants Project Structure Level 1/2

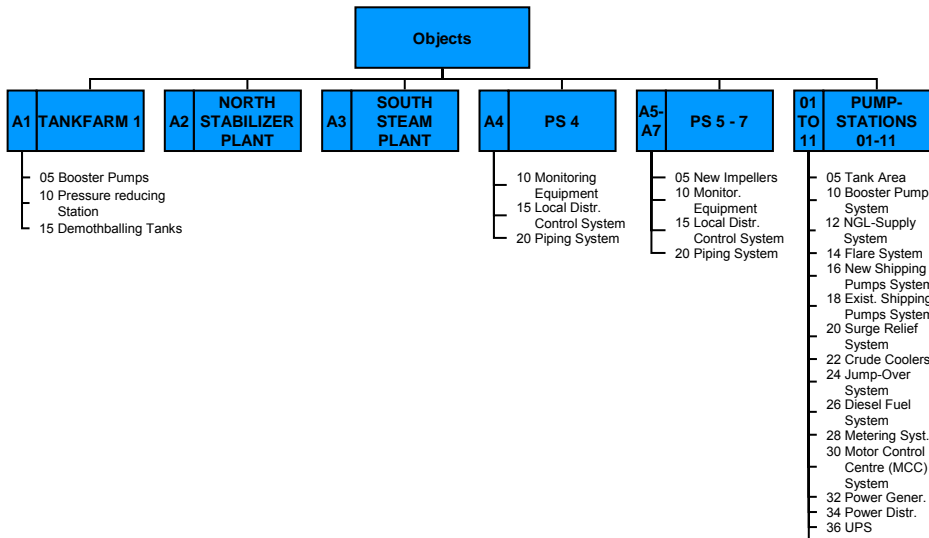


3 Project Structure

Increase Export Capacity Project

Dimension of structure

Major Mechanical Works and Plants Project Structure Level 1/2

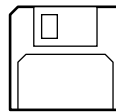
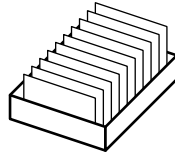


Relational project structure

Relational project structuring

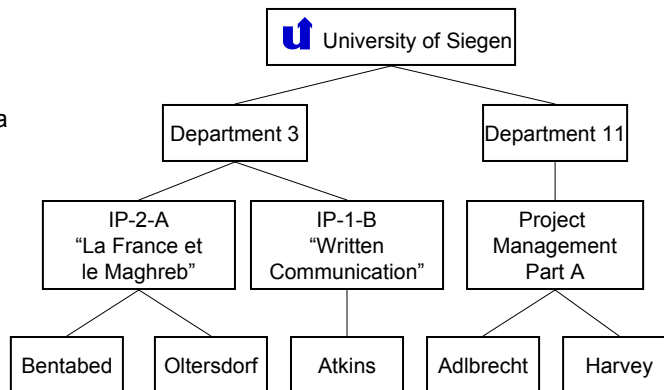
Theory

•A database is a collection of data memorised systematically for a special purpose.



Relational project structure

•The hierarchical Database Model arranges the data in a tree structure.



3 Project Structure

Relational Database Model

Relational project structure

•The relational database model is based on tables and relations.

personnel #	name	address
P001	Adlbrecht	...
P002	Waegner	...
P003	Bentabed	...
P004	Mirault	...
P005	Mothershaw	...
P006	Oltersdorf	...
P007	Harvey	...

table "IPEM teachers"

course ID	course title	SS/WS	timetable	room
C001	FIPW-1	WS	FRI 08-10	A337
C002	FIPW-2	SS	FRI 08-10	A337
C003	PM-A	WS	FRI 08-10	A342
C004	PM-B	SS	WE 08-10	A337
C005	PM-C	WS	THU 04-06	A342
C006	FRE 1	WS	FRI 10-12	A337
C007	ENG 2	WS	FRI 08-10	A337
C008	FR 2	SS	FRI 08-10	A337
C009	CAPM	WS	THU 10-12	A337

table "IPEM courses"

course ID	personnel #
C001	P001
C001	P002
C002	P001
C002	P002
C003	P001
C004	P001
C006	P004

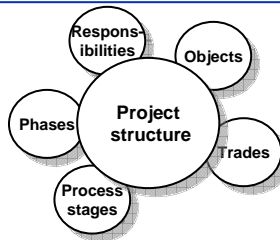
allocation of teachers to courses



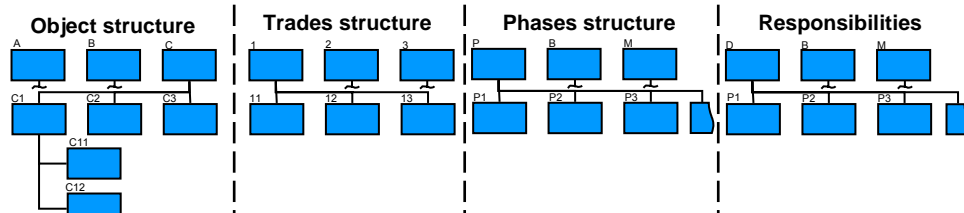
3 Project Structure

Dimensions of the Project Structure - relational

Relational project structure



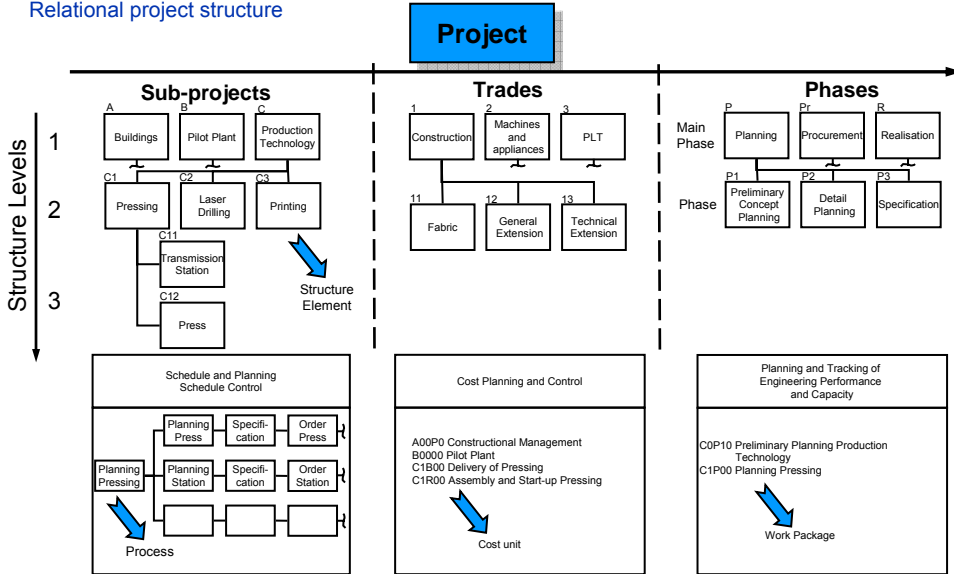
Project structures



3 Project Structure

Dimensions of the Project Structure - Model

Relational project structure



10-2006

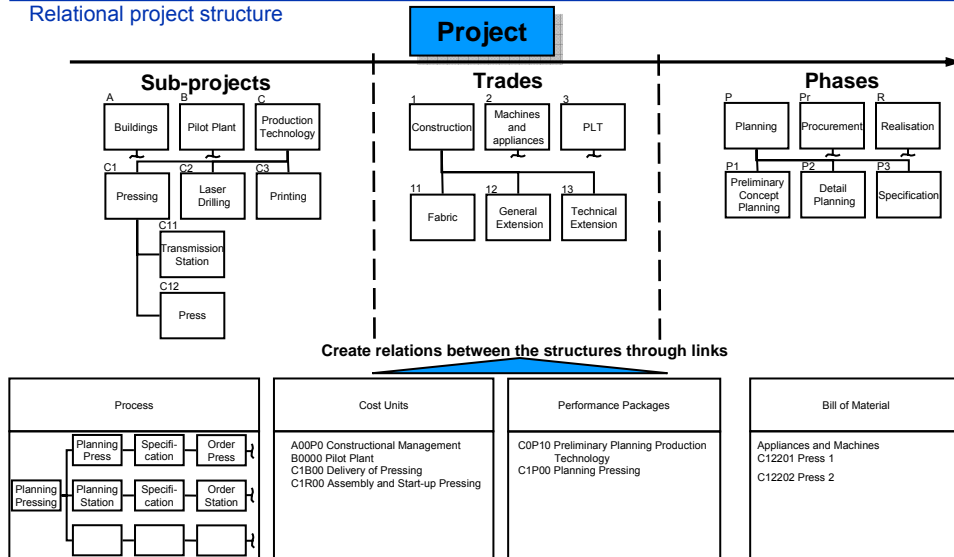
73

PROJECT MANAGEMENT METHODS AND INSTRUMENTS (PM I)

3 Project Structure

Dimensions of the Project Structure - Model

Relational project structure



10-2006

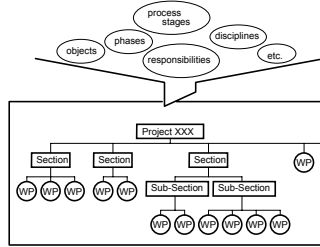
74

PROJECT MANAGEMENT METHODS AND INSTRUMENTS (PM I)

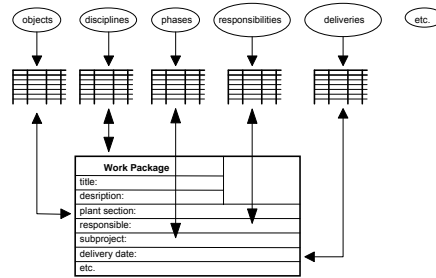
3 Project Structure

Relational Project Structuring vs. Structuring by WBS

Relational project structure



Relational Project Structuring means that there is a relational database to store the data of the project. This is a solution to many problems faced when setting up a WBS.



3 Project Structure

Relational Project Structuring and Reporting

Relational project structure

label „deliveries“

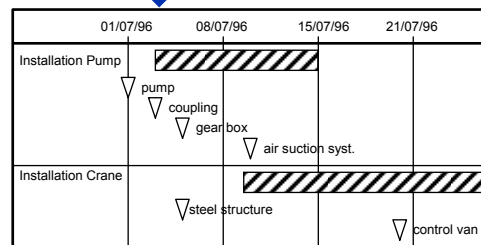
del_ID	title	del_date
M.101	pump	01/07/01
M.201	coupling	03/07/01
M.204	gear box	05/07/01
M.206	air suction syst.	10/07/01
M.401	steel structure	05/07/01
M.031	control van	12/07/01

label allocation „deliveries“ to activities

del_ID	act_ID
M.101	W0712M01
M.201	W0712M01
M.204	W0712M01
M.206	W0712M01
M.401	W0712M02
M.031	W0712M02

label „activities“

act_ID	title	start	finish
W0712M01	installation pump	03/07/01	15/07/01
W0712M02	installation crane	10/07/01	20/07/01

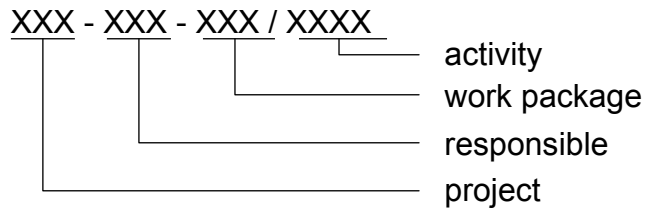


•Relational Project Structuring permits easy aggregation of data memorised in different files in one report.



Relational project structure

•Using relational project structures it is possible to generate "talking" codes automatically. Those codes can contain much more information than only WBS levels.



Filters:

- XXX - XXX - 1442 / XXX : all activities of WP 1442
- XXX - SKF - 1442 / XXX: all activities of WP 1442, of which company SKF is responsible
- XXX - SKF - XXX / XXX: all activities under SKF responsibility in the whole project



Contents of Lecture

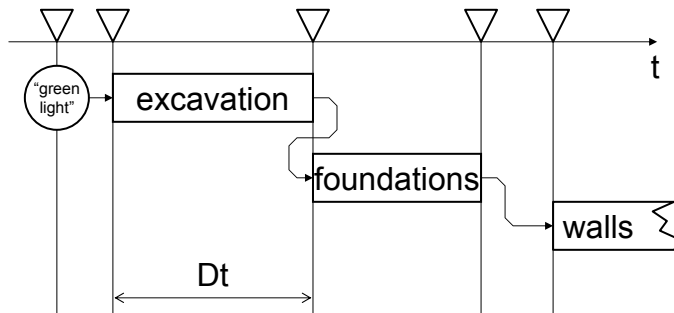
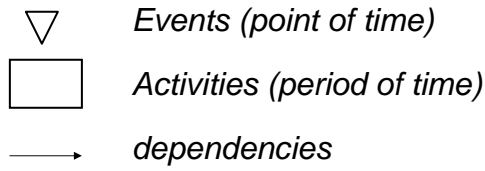
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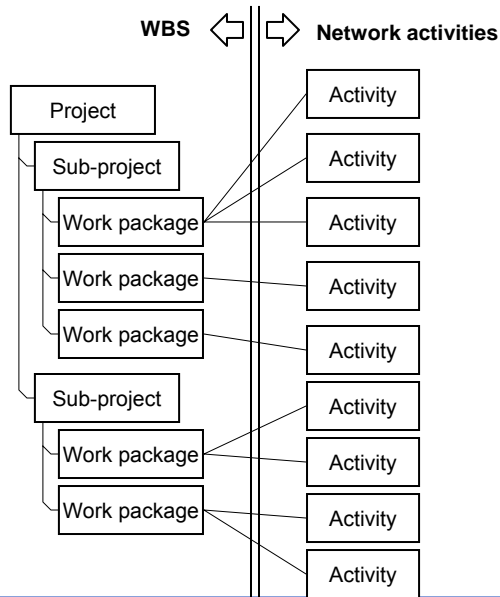


Project network

Activities, Events and their dependencies form the "logic" of a project.

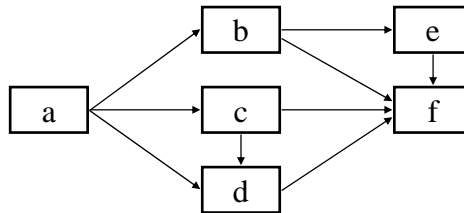
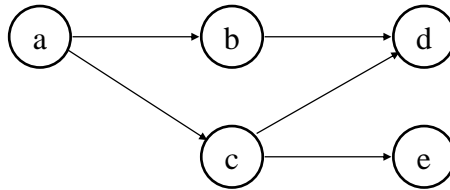


Project network



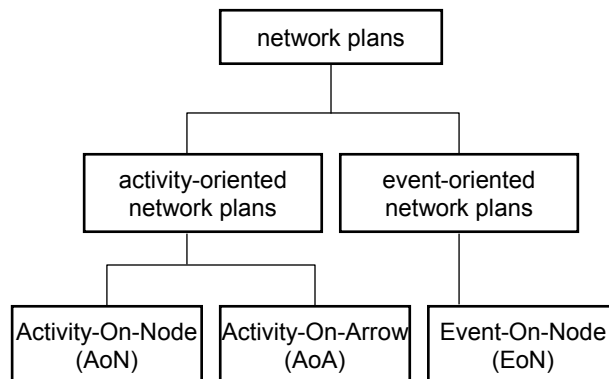
Project network

A graph consists of a set of elements and a set of relationships between the elements of the first set. The elements are depicted as the nodes of a network, the relationships as lines or arrows ("directed graphs").

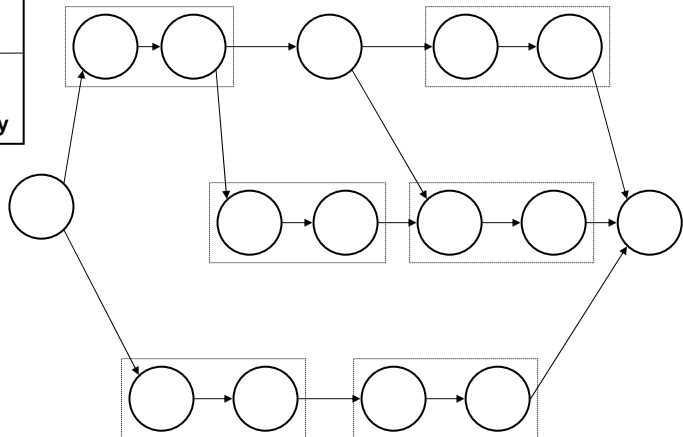


Project network

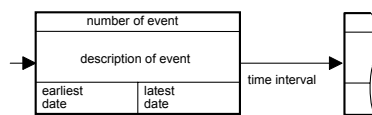
There are different types of network plans used in project management.



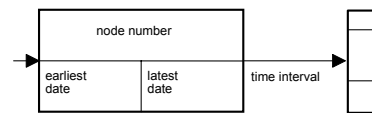
Graph	Time	Network Logic
Node	Point in Time	Event
Arrow	Period of Time	Activity Dependency



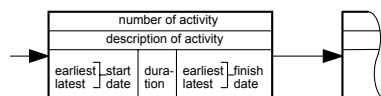
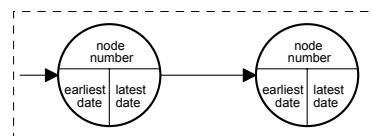
The way how to draw the different types of network diagrams is prescribed by norms (e.g. DIN 69900). In practice however, the information to be included is selected according to the purpose the network is used for.



EoN



AoA

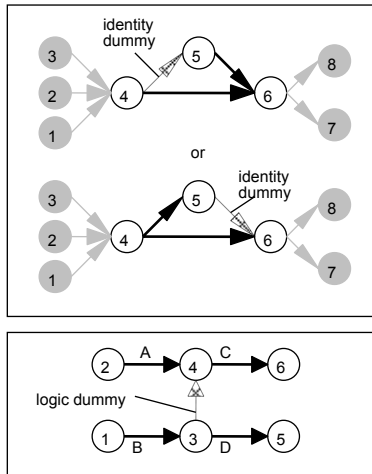


AoN



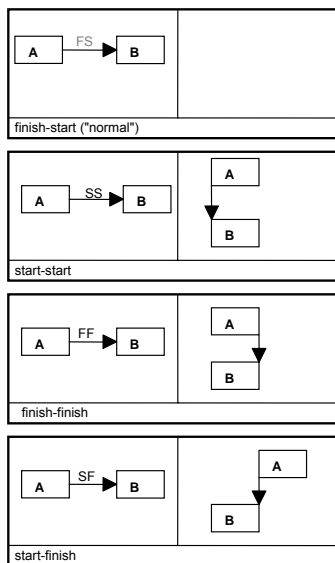
Project network

Dummy activities are used in AoA networks in order to represent parallel activities and complex dependencies.



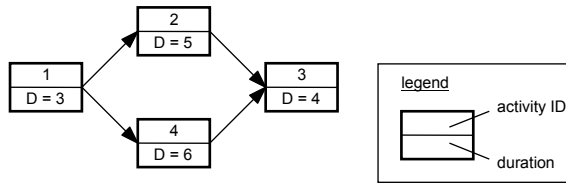
Project network

In AoN networks, a dependency may link the start or the finish of the predecessor and the successor. Thus, there are four possible dependency types.



Project network

The necessity of a forward and a backward pass is demonstrated using a small example.



	0	1	2	3	4	5	6	7	8	9	10	11	12	13
activity 1														
activity 2														
activity 3														
activity 4														

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
activity 1														
activity 2														
activity 3														
activity 4														

To be completed during lecture !



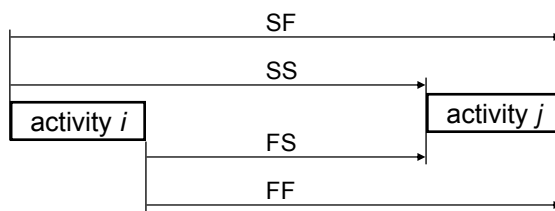
Project network

Relationships:

- FS: Finish-to-Start
- SS: Start-to-Start
- FF: Finish-to-Finish
- SF: Start-to-Finish
- Z: Lag

Activities:

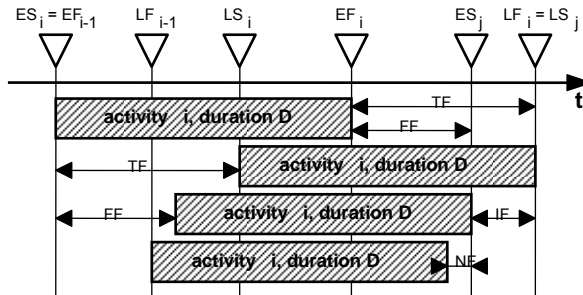
- ES: Early Start
- LS: Late Start
- EF: Early Finish
- LF: Late Finish
- D : Duration
- i: preceding activity
- j: succeeding activity



type	forward pass	backward pass
FS:	$ES_j = \max(EF_i + Z_{ij})$ $EF_j = ES_j + D_j$	$LF_i = \min(LS_j - Z_{ij})$ $LS_i = LF_i - D_i$
SS:	$ES_j = \max(ES_i + Z_{ij})$ $EF_j = ES_j + D_j$	$LS_i = \min(LS_j - Z_{ij})$ $LF_i = LS_i + D_i$
FF:	$EF_j = \max(EF_i + Z_{ij})$ $ES_j = EF_j - D_j$	$LF_i = \min(LF_j - Z_{ij})$ $LS_i = LF_i - D_i$
SF:	$EF_j = \max(ES_i + Z_{ij})$ $ES_j = EF_j + D_j$	$LS_i = \min(LF_j - Z_{ij})$ $LF_i = LS_i + D_i$



TF: Total Float
 FF: Free Float
 IF: Interference
 Float
 NF: Independent
 Float



$$TF_i = LS_i - ES_i = LF_i - EF_i$$

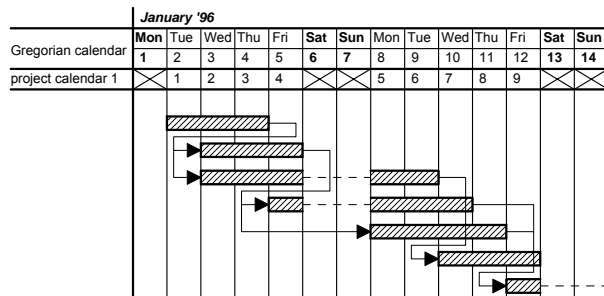
$$FF_i = \min(ES_j - EF_i)$$

$$IF_i = TF_i - FF_i$$

$$NF_i = ES_j - (LF_{i-1} + D)$$

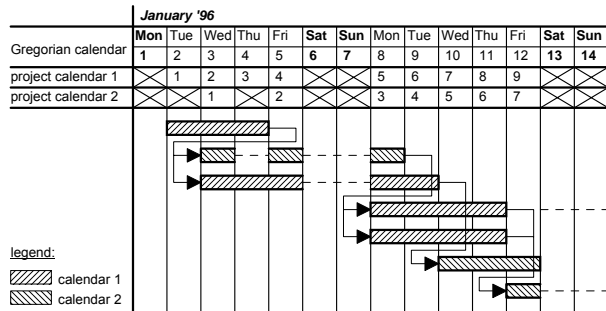


The system time units used for the forward and backward pass have to be transformed into calendar dates.



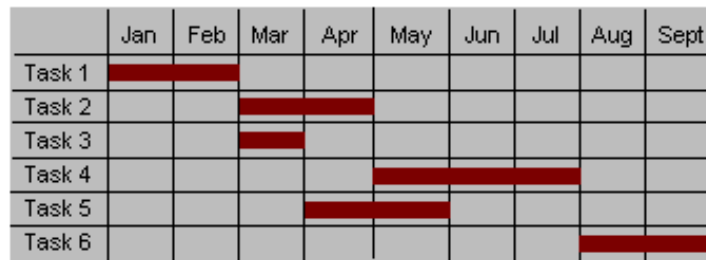
Project network

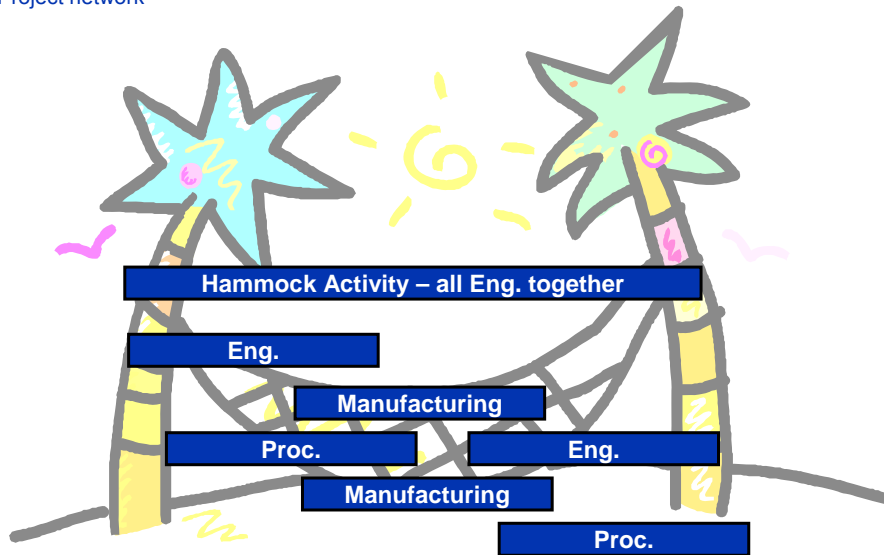
In case we work with more than one calendar, the forward and backward pass become more complicated because it is necessary to coordinate the two calendars.



Project network

- Milestone charts
- Invented by Harvey Gantt in 1916





Methods used for deterministic processes

Methods used for stochastic processes

Deterministic

- CPM Critical Path Method: activity on arrow
- PERT Program Evaluation and Review Technique
event on node with three point estimates of activity duration
optimistic, pessimistic, and most-likely
- MPM Metra Potential Methode activity on node

Stochastic

- GERT Graphical Evaluation and Review Technique



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5 Resource Planning

Resource

Definitions

Definition: "A resource is any factor except time required or consumed in order to accomplish an activity".
the "4 M"

- * Man
- * Machine
- * Material
- * Money *

This means that everything you need in order to execute an activity, a work package or a project in a certain time, is a resource.

* Money, however, is to be considered as a special type of resource and will not be treated here but in a separate chapter ("cost planning").



Definitions

A resource is characterised by its capacity

Capacity: the work that can perform during a given time (or, if we change the point of view, it is the time needed for carrying out a certain work).

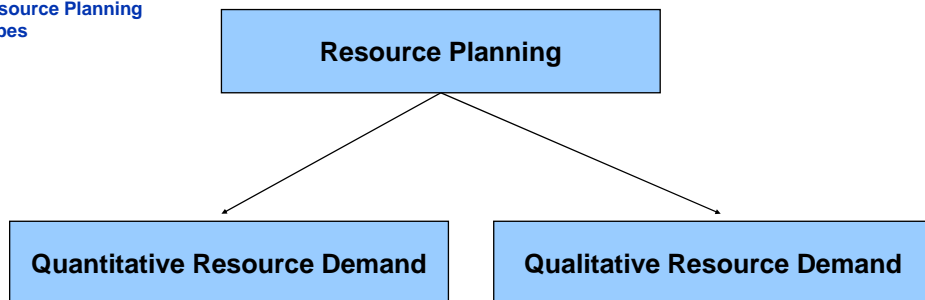
For example, you can indicate how many cu.m or tons of earth an excavator can dig during a time of one hour.

The capacity of a resource is determined by two parameters:
The number of resource units used
The time of resource usage.



Definitions

Resource Planning Types



Calculation of capacity in terms of resource-time (examples: man-hour, machine-hour)



5 Resource Planning

Definitions

Resource Planning Qualitative

Qualitative Resource Demand

- * What qualification do the people working on this task have?
- * Does the work have to be done by a team? If so, is the team already existing (as a department or as a fixed team within the company)?
- * Which machines, materials and aids have to be used?
- * Do these resources have to be used continuously from the beginning to the start of the activity or is it a discontinuous need?



5 Resource Planning

Definitions

Managing Resource

The purpose of **resource planning** is to find out, which **resources you need** at all for the **execution of an activity** (quality of the resources) and which amount of each resource (quantity of the resources).

But also the **optimisation of resource allocation** according to time, costs or load as well as resource balancing between several activities or even several projects ("multiproject management") belong to resource planning.

note: Resource planning also has to be done constantly in the regular production process of a production facility, e. g. a work shop, in order to find out whether an order can be finished within a certain time or if all machines and workers will be busy with other orders until that date.



5 Resource Planning

Definitions

RCPS

Resource Constrained Project Scheduling

Given:

- a set of activities
- a set of resources
- a set of restrictions (constraints)
- a set of goals (optimisation criteria)

Task: to allocate the resources to the activities in a way such that

- the restrictions are met
- the goals are fulfilled

Restrictions:

- precedence restrictions (logic)
- target dates
- resource availability per time unit
- total resource availability
- splitting of resources (dividing into portions)
- single-mode/multi-mode (priority rules)
- budgets

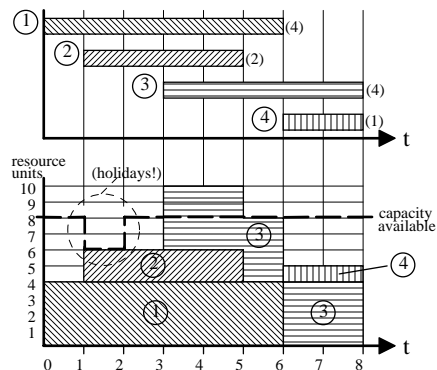


5 Resource Planning

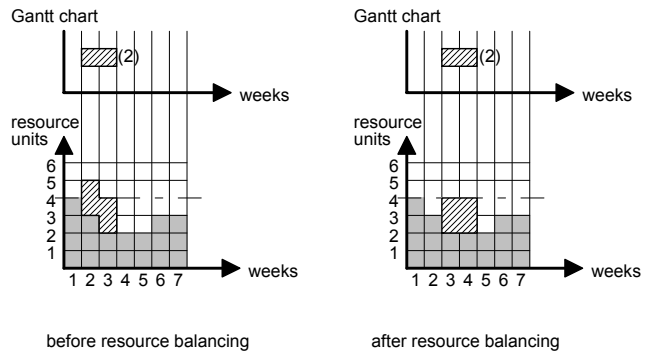
Resource demand

Determination of the Resource Demand — Solution

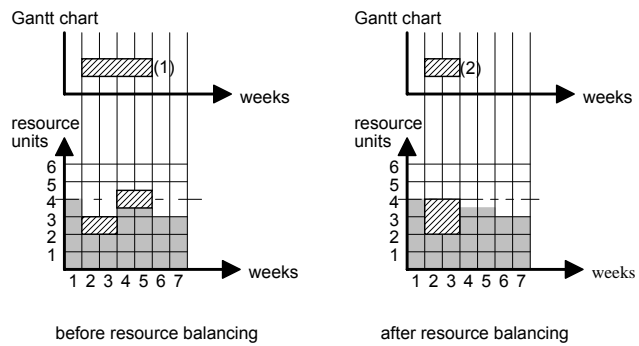
activity no.	start	finish	capacity demand
①	0	6	4
②	1	5	2
③	3	8	4
④	6	8	1



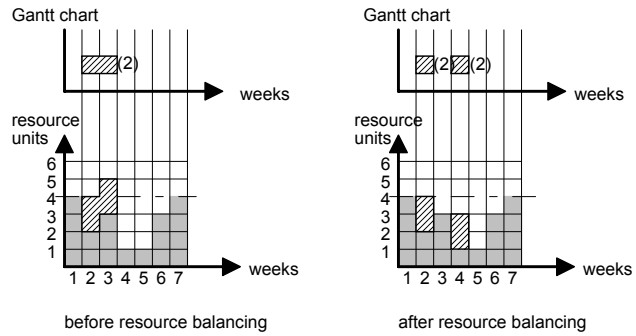
Resource constrained scheduling



Resource constrained scheduling

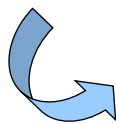


Resource constrained scheduling

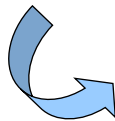


Resource constrained scheduling

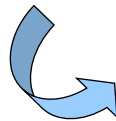
First diagram of the resource demand. All activities start at their earliest start date.



Resource balancing by moving activities.



Resource balancing by compressing and expanding activities.



Resource balancing by changing resource allocation and compressing the critical activities as well.



At any point in time we determine the set of activities that can be scheduled. This set is sorted by priority rules and activities are scheduled in that order accordingly.

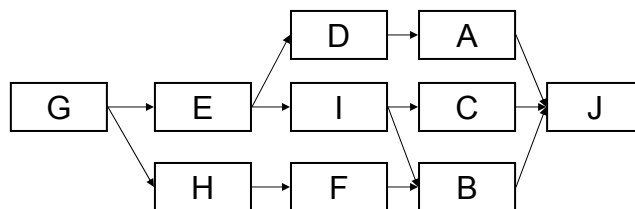
In case of a resource conflict: The next activity from the list is calculated (while in serial scheduling the same activity is used for calculation at a later point in time).

Static procedures: network and priorities are calculated once at the beginning.

Dynamic procedures: network is recalculated after an activity has been scheduled. Priorities are recalculated as well.



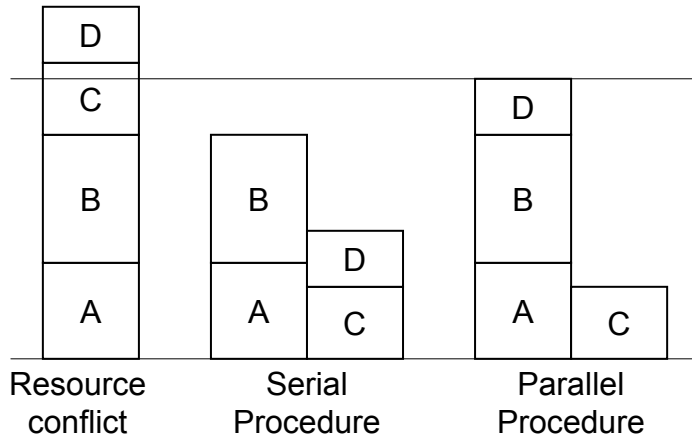
Activities are numbered in such a way that if activities are sorted by number, then no activity will appear before any of its predecessors.



1	G	6	F
2	E	7	A
3	H	8	C
4	D	9	B
5	I	10	J



At any point in time we determine the set of activities that can be scheduled. This set is sorted by a priority rule and activities are scheduled in that order. In case of a resource conflict: The next activity from the list is calculated (while in serial scheduling the same activity is calculated at a later point in time).



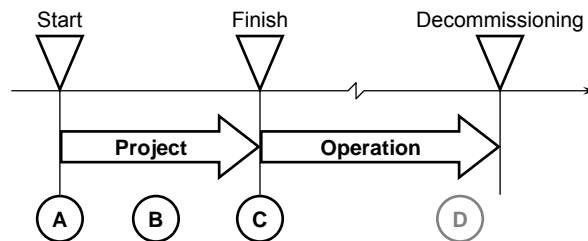
Contents of Lecture

Introduction

- 1 **Theoretical Background**
Methodology, Systems Theory, Projects and Processes, Project Management
- 2 **Project Definition**
Project Objectives, Project Stakeholders
- 3 **Project Structure**
Introduction, Developing WBS, Organisation, and other Structures, Relational Project Structure
- 4 **Project Scheduling**
Project Networks; Project Network Calculations; Other Scheduling Tools
- 5 **Resource Planning**
Definitions; Resource Demand; Resource Constrained Project Scheduling
- 6 **Project Control**
Project Cost Management; Project Cash Flow; Project Progress and Earned Value Concept; Project Monitoring and Reporting
- 7 **Project Management Software**
Project Management Systems; Project Data Warehouse and Workflow



Project costs are considered throughout the entire project life cycle. This implies that there are different points of view and different questions to be answered in project costing.



- A** before / at project start:
initial calculation, preliminary estimate
- B** during project execution:
intermediate calculation / (project) cost control
- C** at / after project end:
historic cost calculation / final investment cost analysis
- D** including operational and decommissioning costs:
life cycle costing

Costs: the monetary equivalent of the values, which are consumed in order to produce goods or services

Cost Type: what (i.e. material, personal, etc.)

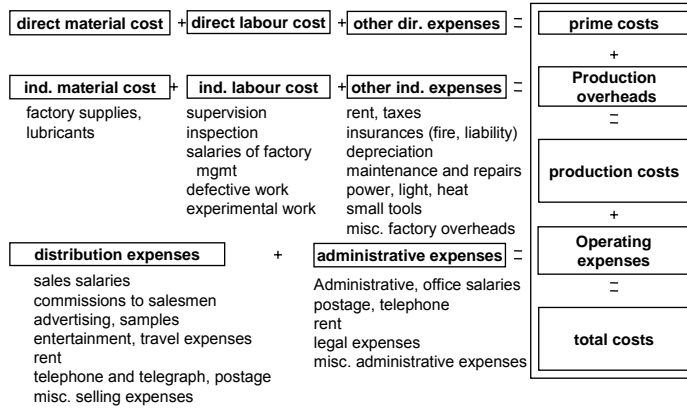
Cost Centre: Where (i.e. sales department, procurement, etc)

Cost Unit: for what (i.e. product x, order y, etc.)

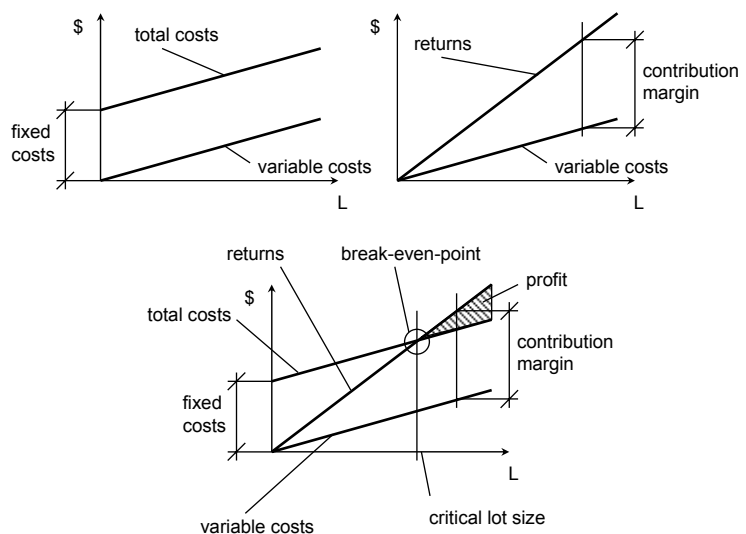
Variable Costs: proportional to the amount produced (e. g. material and labour costs)

Fixed Costs: constant costs, which do not depend on the amount produced (e. g. heating and lighting of the workshop)

The methods of absorption of costs: try to allocate all costs to their cost unit



In marginal costing only the variable costs are charged to their cost unit. Fixed costs are summed up separately. A "contribution margin" is added to the variable costs to cover the fixed costs.



6 Project Control

Project Cost Management

Cost estimation

- Parametric model
- Detail unit cost model
- Resource profile model
- Bill of quantities model

Bottom-up method (work package)

- personnel (qualification)
- machinery, equipment, auxiliaries, tools
- material
- subcontracts and supplies
- travel expenses
- other cost (licencies, consulting, rent)
- shipment, transport
- custom duties, fees

- overhead
- provisions for risk (contingencies)
- n.a.



10-2006

115

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

6 Project Control

Project Cost Management

Cost Estimation

1. Judgement Methods

- experienced experts
- Determined by "feeling" based on analogies ("A nuclear power station costs about 5 billion €.")
- These estimates are often very realistic!

2. Parametric Methods (Top-Down Methods)

- costs may be directly proportional to the weight, volume or other physical quantity of a product. simple equations
- use statistical information or mathematical models.
- general problem: get information about the unit price mentioned in the equation ("how expensive is 1km of road, what does 1kg of drilling machine cost?").
- literature providing such data (e. g. VDMA, "Statistisches Handbuch", published every year). But one cannot really rely on this information, because often the figures found there are not true for your own company.



10-2006

116

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

3. Detailed Methods (Bottom-Up Methods)

- If very **much knowledge** about the project is available → **detailed estimate** is possible (i.e. formulation of work packages completed, schedule finished, technical specifications written)
- collaboration of an engineer and a person with a qualification in commerce
 - engineer - amount of material needed and the personnel demands
 - businessman - multiply these figures with the hourly rates and costing rates of the company.



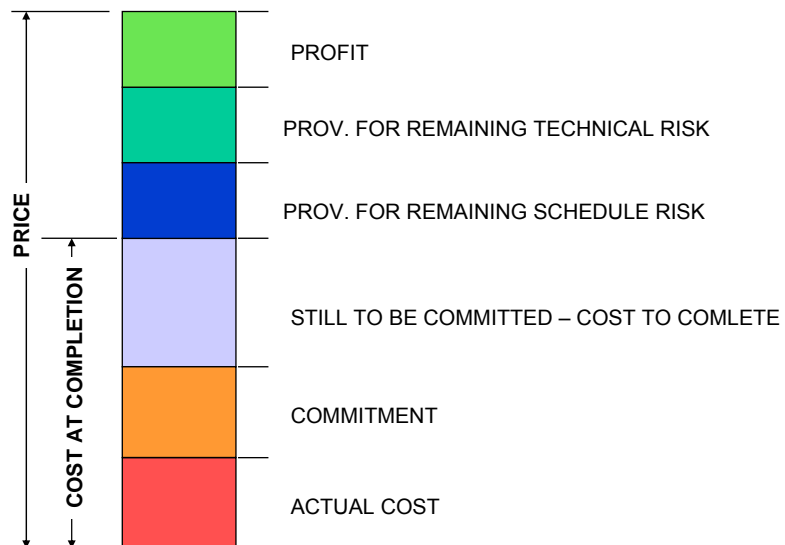
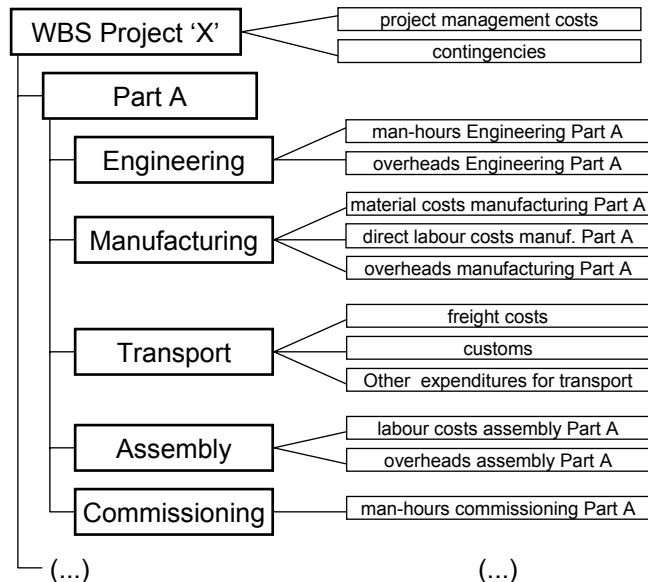
Top-Down vs. Bottom-Up

Bottom-up Method: starts at the bottom of the work breakdown structure, where the project is sub-divided into its smallest units

Top-Down Method : regard the object as a whole.

Both methods can be used together. For example, a detailed estimate can be used in order to confirm a parametric estimate.

The WBS is the back bone for a detailed cost analysis.

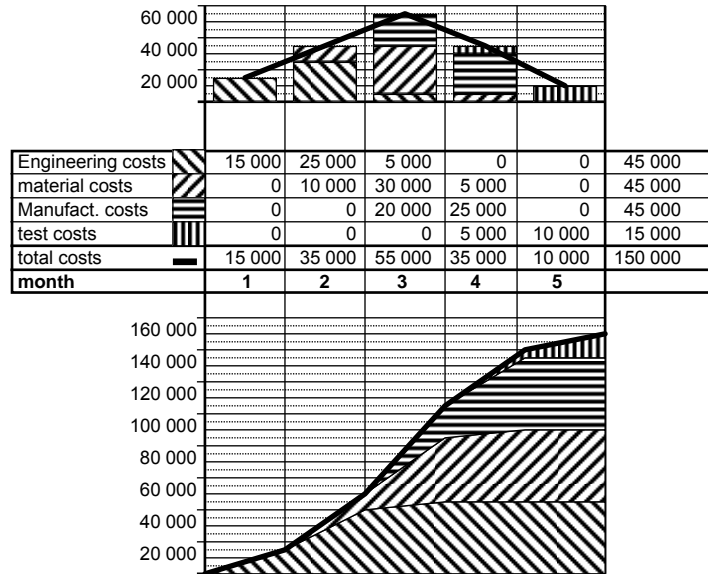


6 Project Control

Cost Schedule

Project Cost Management

Together with the WBS and the project schedule, a cost estimate can be used to show when which costs will arise for the project. The cost behaviour curve shows the costs incurred for each month, the cost increase curve shows the total cost for the entire project accumulated until that month. The cost increase curve often has the form of an "S".



10-2006

121

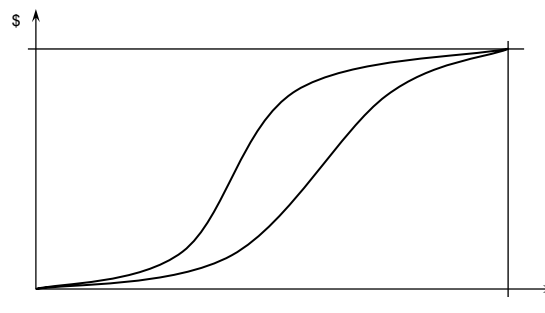
PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

6 Project Control

Project Cost Curves with Earliest and Latest Dates

Project Cost Management

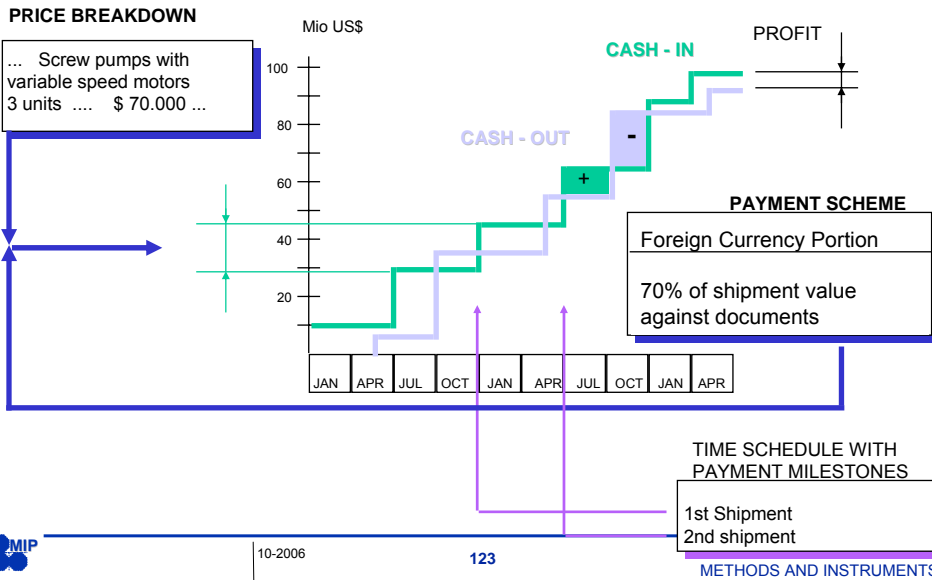
Depending on the start and finish dates of the project activities, the cost increase curve can have different shapes. This can have an influence on project scheduling: for project financing, it is better to start late!



10-2006

122

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)



PRICE BREAKDOWN

Bill of Quantities and Schedule of Prices

	Units	US\$	RIALS
Section 4			
ItemNo			
4.1	Screw pumps 3	70,000	15,000,000
4.2	Level Control 3	4,000	27,000,000
4.3	Syst. Contr. panel	110,000	12,000,000
...			
4.12	Spare Parts	55,000	
...	Civil Works		
4.16	Erection Works	500,000	53,000,000
...			
4.21	Provide for painting		6,000,000
...			

PAYMENT SCHEME

Local Currency Portion (RIALS)

Foreign Currency Portion (US\$)

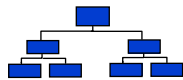
% out of US\$ Contract Value

- 10% advance payment drawn from L/C against presentation of an advanced payment guarantee of the same value
- 70% for delivery of the permanent plant against the following documents (part shipment is allowed)
 - certificate of origin
 - commercial invoice
 - Bill of Lading or FCR (forwarders certificate of receipt)
 - ...
- 10% after mechanical completion
- 10% after initial handing over of the plant against 5% bank guarantee valid for 12 months

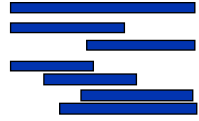


No Performance Measurement Method !

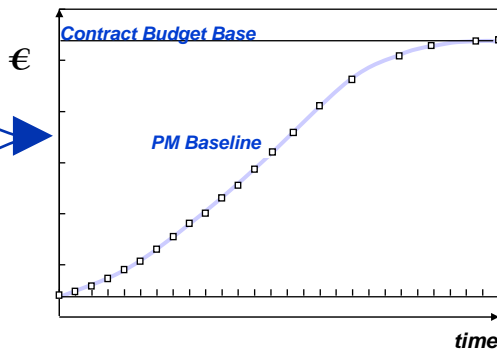
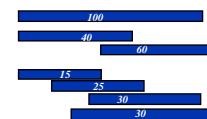
1. Define the Work



2. Schedule the Work



3. Allocate Budgets

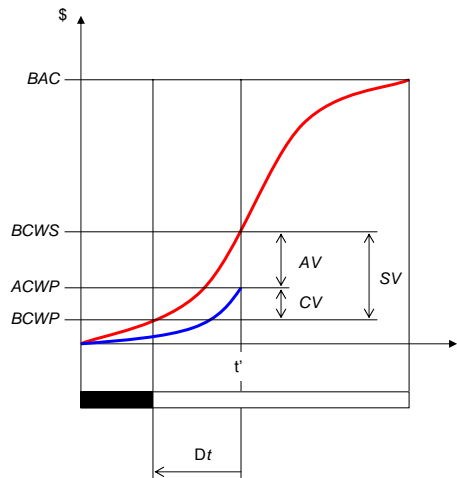


6 Project Control

Earned Value

Project Progress and Earned Value Concept

The Earned Value Analysis compares the cost development to the work progress. By this integrated approach it can detect cost overruns very early.



(see next page for definitions)



6 Project Control

Earned Value Analysis: Terminology

Project Progress and Earned Value Concept

BAC = Budgeted Cost at Completion
BCWS = Budgeted Cost of Work Scheduled
ACWP = Actual Cost of Work Performed
BCWP = Budgeted Cost of Work Performed
(= Earned Value EV)
AV = Accounting Variance = $BCWS - ACWP$
CV = Cost Variance = $BCWP - ACWP$
(negativ value means budget overrun)
CPI = Cost Performance Index = $BCWP/ACWP$
EAC = Estimate At Completion*)
VAC = Variance At Completion = $BAC - EAC$

PD = Project Duration
SV = Schedule Variance = $BCWP - BCWS$
(negativ value means behind schedule)
SPI = Schedule Performance Index = $BCWP/BCWS$
EPD = Estimated Project Duration = PD/SPI

*) frequently used Formulas for EAC
 $EAC = BAC / CPI$
 $EAC = ACWP + (BAC - BCWP)$
 $EAC = ACWP + PF * (BAC - BCWP)$
(PF = estimated "Performance Factor")



6 Project Control

Cost Follow-Up and Work Progress

Project Progress and Earned Value Concept

To estimate the remaining costs to project completion one can compare the actual costs to the actual work progress.

$$1) D = B - C$$

$$2) B = E + F$$

$$3) C = G + H$$

$$4) F = I + J$$

$$5) K = \frac{G}{B}$$

$$6) M = \frac{K}{L}$$

$$7) H = (B - G) \times M$$

desired value		actual value	deviation
(A)	(B)	(C)	(D) ¹⁾
cost account	budget	predicted total costs	predicted final deviation

(E)	(F)	(B) ²⁾	(G)	(H)	(C) ³⁾
original budget	changes	current budget	actual costs	remaining costs	predicted total costs

(I)	(J)	(F) ⁴⁾	(K) ⁵⁾	(L)	(M) ⁶⁾	(H) ⁷⁾
approved changes	changes to approve	total changes	actual % budget	actual % work progress	efficiency	remaining costs



6 Project Control

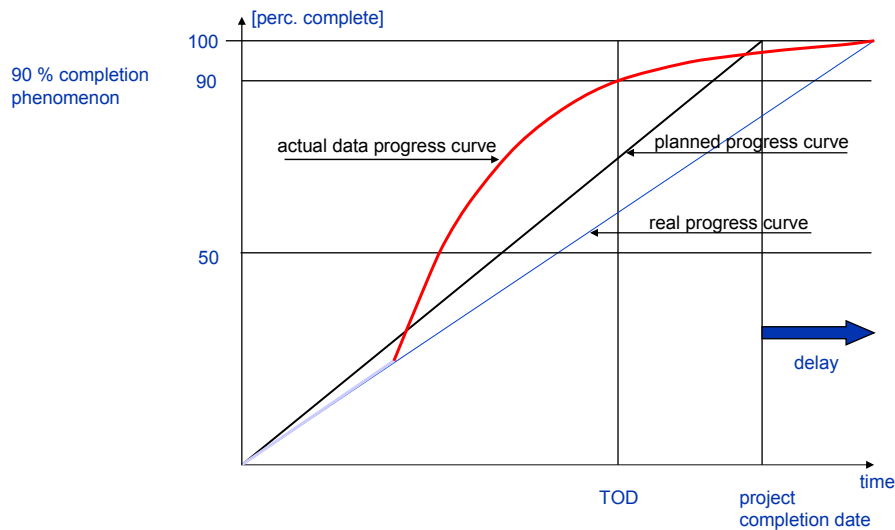
Project Progress and Earned Value Concept

• Milestone rating technique	0/100%	100% of "work to be performed" is reported as earned at completion of the task.
• Fixed percentage method (x/y%-Method)	50/50%	50% of "work to be performed" is reported as earned at initiation of task, 50% at completion of task.
• Proportionality rating		
• Apportioned effort	15/85 %	15% of "work to be performed" is reported as earned at initiation of task, 85% at completion of task.
• Level of effort		
% Complete		A cumulative percentage of the total work planned - which is currently completed - is reported as earned . The actual effort expended to date as a percentage of actual and anticipate work to be expended.



6 Project Control

Project Progress and Earned Value Concept



Source M. Burghardt (1)
10-2006

131

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

6 Project Control

Project Monitoring and Reporting

Report Types

	standard report ("status report")	completion report	special report	public relations report
task	checking the progress of activities and of the whole project	report about the completion of an important activity, a sub-project of the project itself	in case of prob- lems or on special request	information of the public, motivation of project personnel
reporting period	project team: weekly; project management: monthly	no regular reporting period	no regular reporting period	3 months; on special events (milestones)
receiver of report	project management, top management, or client	project management, top management, or client	project management, eventually even top management	internal and/or public information authorities



10-2006

132

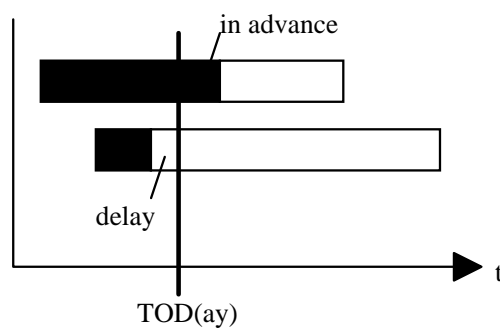
PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

dimensions for project monitoring

- ✓ technology and performance (do the results of the work correspond to the specifications?)
- ✓ dates (are milestones and completion dates kept?)
- ✓ costs (will the project's budget not be overrun?)
- ✓ resources (will there be any bottlenecks?)

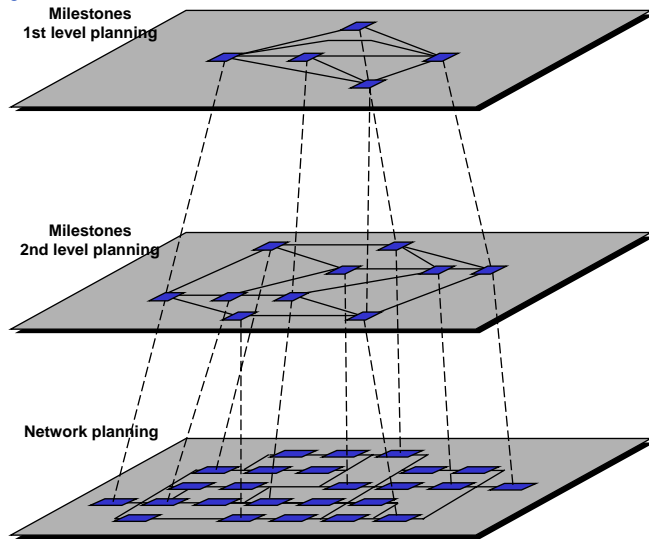
criteria for the success

- ✓ "technically brilliant"
- ✓ "on time" and
- ✓ "on budget".



Project Monitoring and Reporting

Scheduling and Reporting



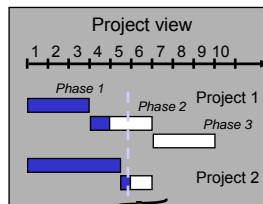
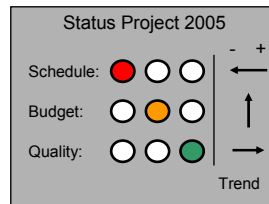
Project Monitoring and Reporting

USE
of Information by CEO, Client, Director of department, PM ...

TYPE
of Information such as cost, schedule, resources ..

FORMAT
of information such as select, sort, aggregate ...

DEFINE AND PRODUCE REPORTS (list, graphic)



HAMMOCKS



6 Project Control
Project Monitoring and Reporting

To select data means:

Show specific data only i.e.

show engineering activities only
or
show activities of procurement department only
or
show no activities but milestones only

To sort data means:

Show all data but

show activity data according to their early start
or
show activity data according to their total float
or
show activities according to their project structure
e.g. WBS structure

To aggregate data means:

Show overview only for a group of data i.e.

show all engineering activities as one bar only
or
show all manufacturing costs as one figure only

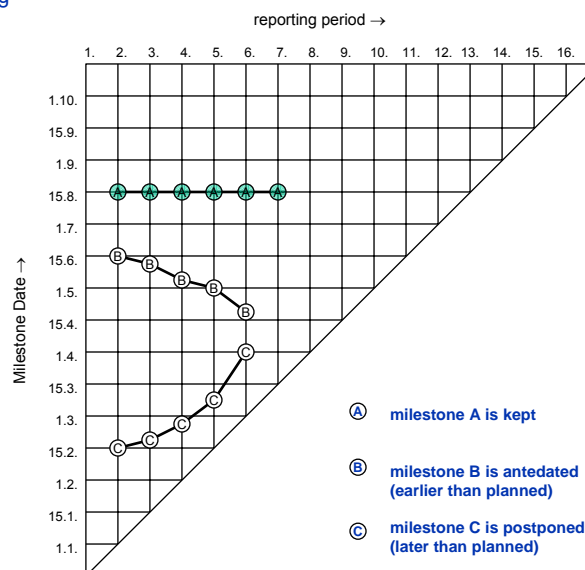
EXAMPLE



6 Project Control
Project Monitoring and Reporting

Milestone-Trend-Analysis

The milestone trend chart shows the development of planned milestone dates during several reporting periods.



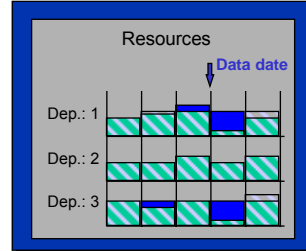
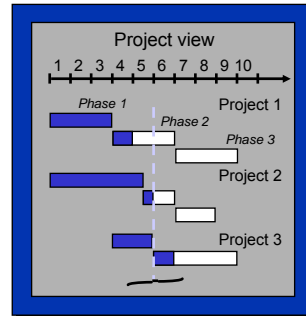
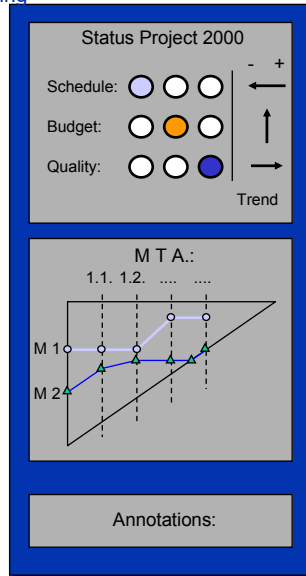
6 Project Control

Management-Information

Project Monitoring and Reporting

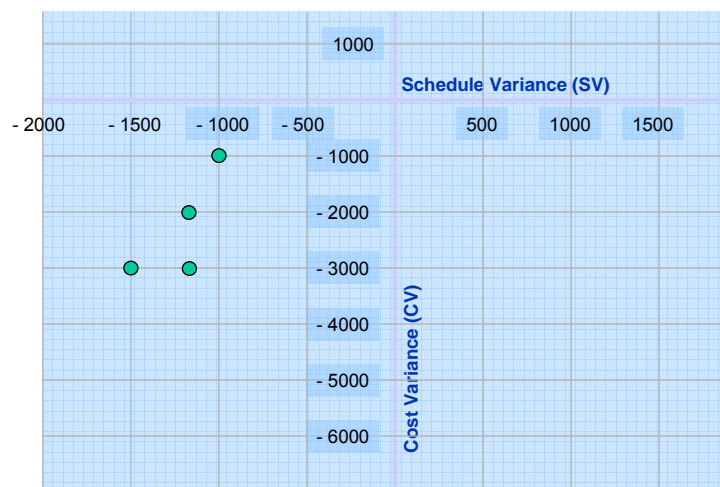
Reporting

- green-red light report
- Milestone Trend Analysis
 - Report dates
 - Milestone dates
- Project progress overview
- Resource performance

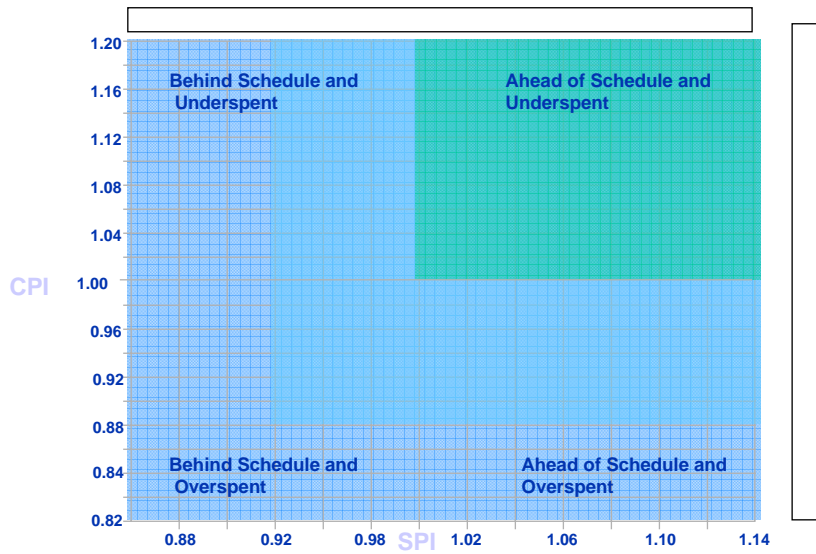


6 Project Control

Project Monitoring and Reporting



6 Project Control
Project Monitoring and Reporting



6 Project Control
Project Monitoring and Reporting

Cost Trend Analysis

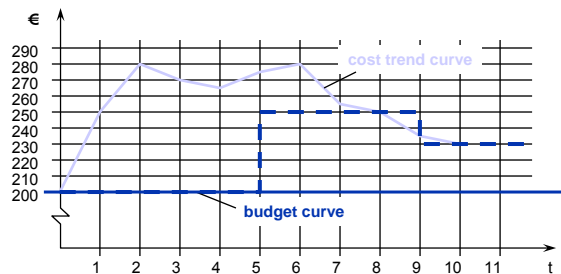
The Cost Trend Chart presented here also shows how the total costs can be extrapolated from the comparison of planned and actual data.

(A)	(B)	(C)	(D)	(E)	(F)	(G)
reporting period	budget	actual work progress	actual costs	actual earned value	cost efficiency	estimated total costs
	[\$]	[%]	[\$]	[\$]	[%]	[\$]
1	200	10	25,0	20,0	80,0	250,0
2	200	18	50,0	36,0	72,0	277,8
3	200	29	78,0	58,0	74,4	268,8
4	200	41	108,0	82,0	75,9	263,5
5	250	50	138,0	125,0	90,6	275,9
6	250	59	165,0	147,5	89,4	279,6
7	250	71	182,0	177,5	97,5	256,4
8	250	79	198,4	197,5	99,5	251,3
9	250	91	214,8	227,5	105,9	236,1
10	230	100	231,2	230,0	99,5	231,2

$$E = B \times C$$

$$F = \frac{E}{D} \times 100\%$$

$$G = \frac{B \times 100\%}{F}$$



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10-2006

143

PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

7 Project Management Software

The Project Management Software Market

The market for project management software:

Hundreds of software packages are offered.

Artemis



COMPUTER ASSOCIATES
Software superior by design.



GRANEDA
PROFESSIONAL

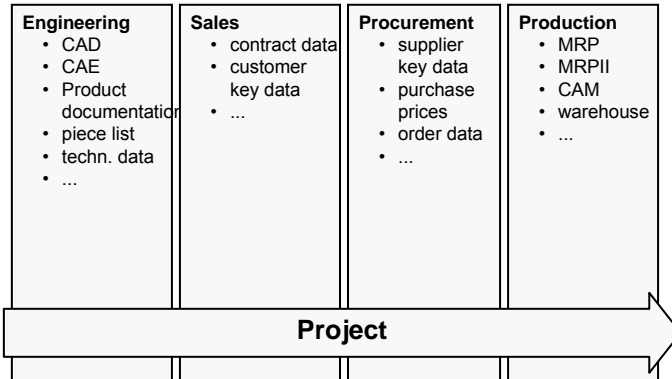


10-2006

144

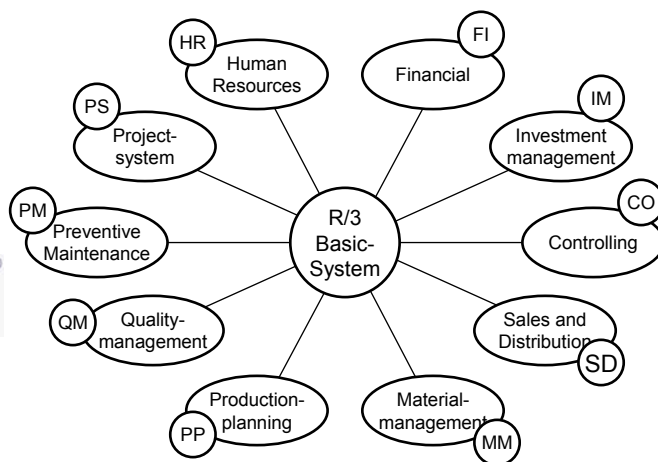
PROJECT MANAGEMENT
METHODS AND INSTRUMENTS (PM I)

As a respective number of interfaces to other functions within and outside the department and company constitute projects information processes, use of computer seems essential for project management.



Just as a project should be integrated in a company, a project software should be integrated in the company's IT-System.

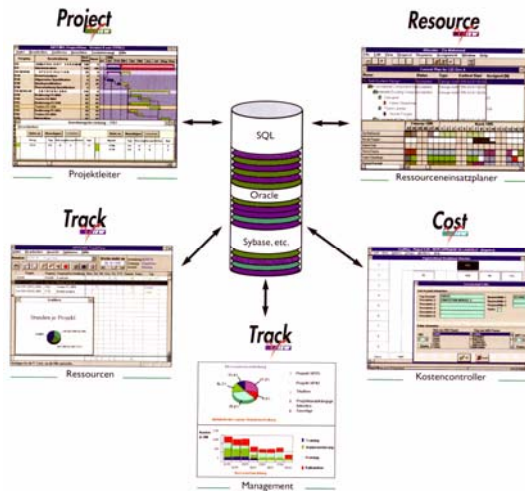
Example: SAP



7 Project Management Software

An example of a Project Management-Software based on databank

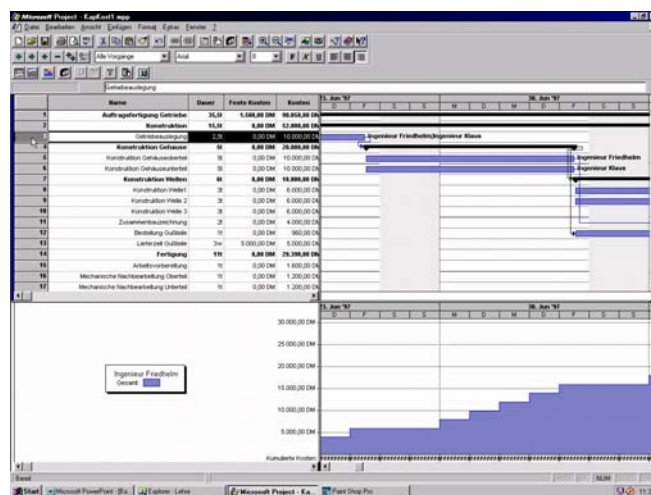
Artemis-Views-software shows the use of a relational database as information backbone.



7 Project Management Software

Typical Interface of a Project Management Software

A typical screen shot of traditional pm software. Example: MS Project



7 Project Management Software

Project Management Software Classification according to its Focus

There are traditional PM software systems but today sophisticated specialised software is available too.

<i>software focus</i>	<i>examples</i>
Integrated Products	
Project Planning & Scheduling	
Project Accounting	
Quantitative Risk	
Time Recording	

