BIM-enabled Learning Environment (BLE) Course Manual: Pilot Module 2 – Time Management

By: University of Bologna, Italy

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Co-funded by the Erasmus+ Programme of the European Union

PROJECT DELIVERABLE DETAILS

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Output Lead Organisation	TalTech – Tallinn University of Technology
Dissemination level	Final version to be public
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DOCUMENT VERSION HISTORY

Version	Date	Comments
0	30th June 2023	First draft
1	4th July 2023	Final version (for translation and publication)

Benedict
BIM-enabled Learning Environment for Digital Construction

Co-funded by the Erasmus+ Programme of the European Union

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1 General Introduction to Course Manuals

1.1 Background and purpose

Digitalization is transforming the real estate and construction (REC) sector and a key feature of this transformation is Building Information Modelling (BIM). BIM refers to the digital representation of buildings and construction operations and it offers opportunities for improving education and training through data rich virtual environments in which project-based learning experiences can be designed and delivered. This could fundamentally change the education and training of REC sector professionals from managers to site workers.

The BIM-enabled Learning Environment for Digital Construction (Benedict) project is an Erasmus+ Strategic Partnership between Tallinn University of Technology (TalTech), Tampere University (TAU) and the University of Bologna (UNIBO) aimed at leveraging the possibilities of BIM to enhance education and training by developing an innovative, BIM-enabled Learning Environment (BLE). The BLE platform is an integrated Moodle – DiStellar installation that is publicly available at www.bim-enabled-learning.com .

To demonstrate the application of the BLE in learning, the project team has developed a series of three pilot course modules that apply BIM-enabled learning using the BLE. These are:
1) Design Management - lead by TAU;
2) Risk Management - lead by TalTech;
3) Time Management - lead by UNIBO.

As the BLE is a novel and innovative concept, it is important to provide clear and easy-to-use guidance materials for all potential users. The purpose of this course manual (which is part of a set of 3 manuals – 1 manual for each module) is to ensure that interested stakeholders (programme directors, teachers, trainers, students, trainees) have access to the full details of the pilot modules so that they can:
- make use of the modules directly, or,
- adapt them to suit their own purposes, or,
- use them as templates for creating their own modules, or,
- simply gain ideas and inspiration for their own, related projects.

1.2 Objectives and scope of the pilot modules

The pilot modules were designed to demonstrate how teachers and students of construction-related disciplines can leverage Building Information Modelling (BIM) in their learning activities for:

• Visualizing the project
• Simulating building scenarios
• Analyzing and designing buildings and building elements
• Identifying conflicts between systems
• Developing estimates, e.g. for materials quantities (bill of quantities BOQ), activity durations (time schedules), costs (budget)
• Design and build decisions
• Project and construction management applications.

All partners were actively involved in the design, development and validation of the learning activities. A comprehensive evaluation tool to assess the modules was developed and applied by the Centre for Engineering Pedagogy at TalTech. (The resulting evaluation and assessment toolbox for BIM-enabled learning has been separately reported). The pilot modules were demonstrated to stakeholders at the Benedict project's 2nd Multiplier Event that was held in Tallinn in June 2022 and were directly used to teach students during the 2022/23 academic year in all 3 partner universities.

1.3 Structure of the Course Manual

All course manuals follow the same basic structure: in section 2 a brief introduction to the subject of the particular pilot module and why it was chosen is given. Section 3 describes the intended learning outcomes and section 4 presents the structure and delivery process for the module. Teaching methods and assessment procedures are described in sections 5 and 6 respectively, and, an overview of the teaching materials is provided in section 7. All the actual slides, assessment forms, assignment templates, etc. are attached to the manual as appendices.

2 Introduction to the Time Management Module

The construction industry is renowned for its complex and time-sensitive projects, making effective time management a critical skill for professionals in this field. To address this need, we introduce a time management course specifically designed for individuals pursuing careers in the construction industry. This course emphasizes the integration of Building Information Modeling (BIM) technology, which plays a pivotal role in optimizing project timelines, facilitating collaboration, and streamlining processes. By combining time management principles with the power of BIM, this course equips students with the necessary skills to excel in the fast-paced world of construction. The time management course aims to equip students with the essential tools and strategies to effectively manage time, resources, and project schedules. By incorporating BIM software into the curriculum, students will learn how to leverage this technology to enhance their time management abilities, improve project planning, and optimize construction processes. Students will learn how to utilize BIM software to create comprehensive project schedules, incorporating tasks, milestones, and dependencies. By visualizing project timelines and critical paths, students can effectively allocate resources, monitor progress, and ensure that construction projects stay on track. The time management course in the construction industry, incorporating Building Information Modeling (BIM), provides students with essential skills to excel in their careers. By leveraging BIM's capabilities, students can effectively plan, schedule, and manage construction projects, optimizing resource allocation, improving communication, and mitigating risks. This course equips students with the necessary tools to navigate the complexities of the construction industry, ensuring successful project outcomes and enhancing their professional profiles.

3 Learning Outcomes

On completion of the time management module, it is expected that the student:

- is able to describe the process, tools and techniques of project time management in construction (in a BIM-based work process).
- understands scheduling and project scheduling concepts.
- understands construction job site and site optimization concepts.
- understands the BIM workflow with respect to job site design, project time management and more generally.
- is able to apply the project time management process, tools and techniques in a realistic project scenario.
- can evaluate project schedule, estimate activity durations and resource allocation in terms of their relative significance towards total project duration.
- can critically analyze the construction job site and the industrial workflow of operations in order to recommend improvements.

4 Module Structure

4.1 Scope of the module

The time management module focuses on the project time management process, including construction job site design, using real project data within a BIM-based work flow.
Topics include, but are not limited to:

- Terms and concepts of time management
- Activity duration estimation and resource allocation
- Tools and techniques for project scheduling and control
- Design of construction job site – workplace design and requirements
- Occupational health and safety standards for construction
- Time management within the BIM work flow;

4.2 Module delivery process

The time managament module consists of:

1. An introductory lecture – focus on **BIM-based time management principles and process;**
2. Three project planning workshops at the pre-construction and construction stages:
   i. Project Planning – focus on **WBS creation, activity duration estimation (pre-construction** stage);
   ii. Project Job site design – focus on **workplace design and construction processes (pre-construction** stage);
   iii. Project Scheduling – focus on **Project Scheduling and BIM 4D (construction** stage).

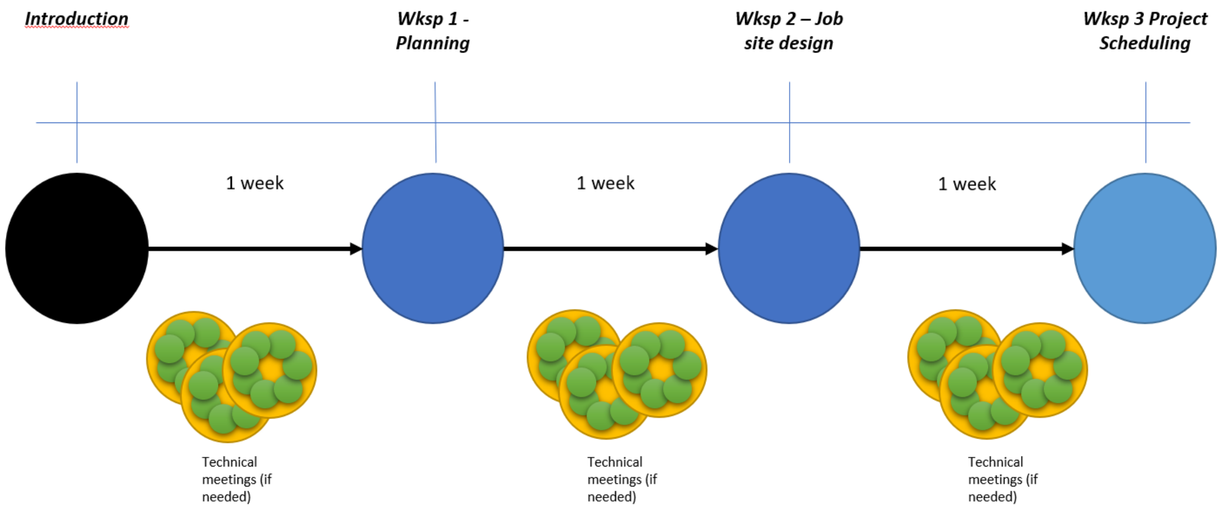

Figure 4.1 Timeline for the Risk Management module delivery

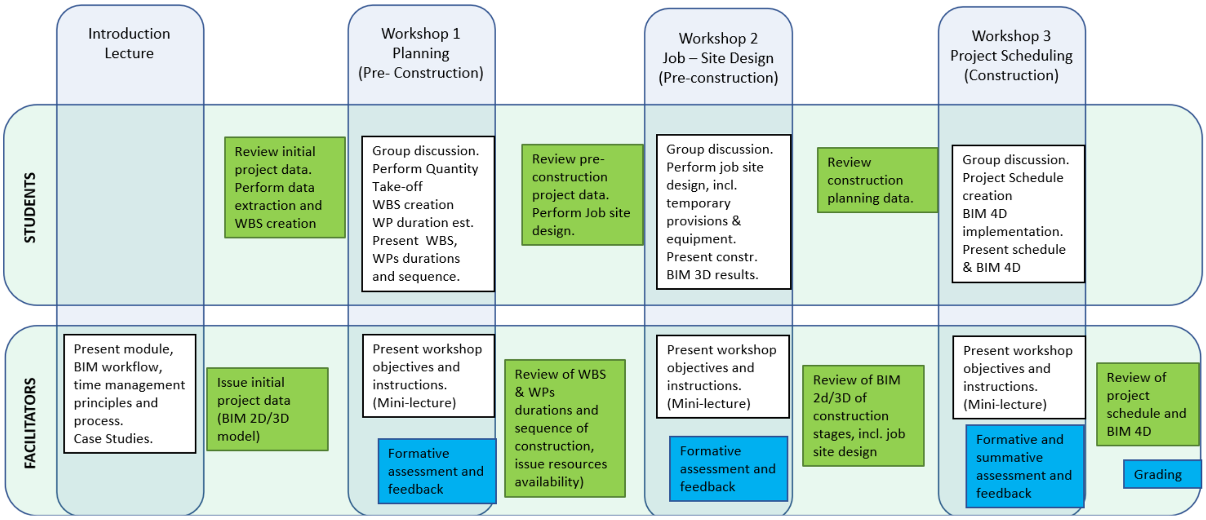

Figure 4.2 Process map for Time Management module delivery

5 Teaching Methods

Students work individually and collaboratively as needed to complete the learning activities. A project work is undertaken by small groups of students. Introductory lectures are offered to introduce the module, the project, and construction management body of knowledge, particularly focusing on time management tools and methods. BIM as a concept is considered a pre-requisite of the pilot module and 4D BIM process is presented. Supporting resources on specific topics are offered as needed during the module.

Faculty’s role is to facilitate this process and to provide feedback and advice as needed.

Delivery mode options:

- Fully online
- Mixed online and on-campus
- Hybrid (some attending online and some on-campus)
- Fully on campus

6 Assessment Procedures

Formative assessment at and after each workshop as faculty and peer feedback.

Summative assessment is based on participation and contribution.

Grade: A, B, C (pass) / D, E, F (fail) (also includes: *grade recovery assessment options C, D, E*).

For the initial pilot module implementation in Unibo as it formed part of a larger course, a few time management-related questions convering the material of the pilot module were also included in the overall course exam.

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7 Teaching Materials

7.1 Introductory Lecture

The introductory lecture sets the scene for the entire module. It gives students an overview of the time management module and provides them with all the information they need to approach the course in the correct way.

Construction management (CM) is defined as a professional service that uses specialized project management techniques to manage the planning, design, and construction of a project. CM is a professional service that can control a project's time, cost, safety records and quality. CM provides methods and tools to organize and manage the production processes of civil and building works on site. The goal is to plan, design, schedule and control the construction stage of a project. This means to plan the logic sequence of activities according to time – project time, and space – workspace of jobsite. This is achieved through the planning and scheduling of the construction operations and by the design of the jobsite layout. 4D BIM provides a visual modelling and data gathering of both planning and designing activities, summarizing project information with a final animation video.
The project work, an actual construction project simulation. is presented with some examples of the final output.

The Powerpoint slides /word documents for the introductory lecture are provided in Appendix A.1.

7.2 Workshop 1

Workshop 1 refers to Work Breakdown Structure – WBS and activity duration estimation

A Work Breakdown Structure (WBS) provides a hierachical decomposition framework for presenting the Work that needs to be completed in order to achieve project objectives. WBS provides a framework for dividing and subdividing the project work into smaller and manageable work packages. The WBS is specific for each project and represents the scope referred to construction operations.
The estimation of activity or Work Package (WP) duration for the development of project schedule can be achieved in three steps:
1. Analysis of WP's operations, productivity rates and resources;
2. Estimation of the WP duration, with direct or indirect estimate (analogy or labor-days / productivity rates)
3. Implementation of the logic sequence of activities in the project plan.

A lecture serves to present the objectives of Workshop 1 and the instructions for the student groups to carry it out. (All the Powerpoint slides for this lecture are provided in Appendix A.2.)

7.3 Workshop 2

Workshop 2 refers to design of construction job site (workplace design and requirements).

The design of the construction job site layout includes the following sub-systems: workstations, construction activities performed by operational resources, site plants and power systems, site roads, infrastructures, welfare and logistics sheds, temporary works and scaffoldings. Occupational healths and safety standards concerning construction site and activities defines some specific requirements to be fulfilled in job site design. Anyway, the first requirement of a good job layout is the rational development of the production cycles. Therefore, the most efficient flow of materials, components and semifinished products should be implemented.

A lecture serves to present the objectives of Workshop 2 and the instructions for the student groups to carry it out. (All the Powerpoint slides /word documents for this lecture are provided in Appendix A.3.)

7.4 Workshop 3

Workshop 3 refers to the project scheduling (planning and programming with graphic methods) and to BIM 4D.

Activity – based planning and scheduling methods and tools are presented. Gantt chart is a scheduling method that represents project activities on a time – activity chart. Project control can be achieved by updating the schedule and measuring Key Performance Indicators. Activity networking techniques are introduced and Precedence Diagramming Method is explained. These scheduling methods are based on a topological representation of the process, the network logic, and a scheduling algorithm that computes activity times and total project duration.
4D BIM modeling combines the benefits of 3D modeling of BIM objects with the element of time of construction processes. BIM objects are linked to the project schedule and a construction animation can be developed.

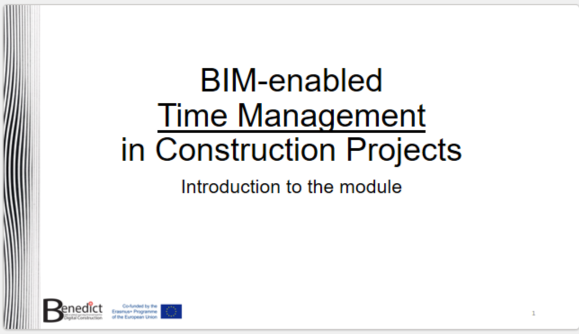
A lecture serves to present the objectives of Workshop 3 and the instructions for the student groups to carry it out. (All the Powerpoint slides for this lecture are provided in Appendix A.4.)

7.5 Assessment

Formative assessment takes place as feedback and discussion after each time management meeting. Summative assessment includes evaluation of student participation and engagement, and exam questions. This is discussed in chapter 6. Students are required to reflect on their own learning experiences during the module. An example questionnaire format for the self-reflection exercise is provided in Appendix C.1.

Appendix A – Presentation Slides

A.1. Introductory Lecture Slides



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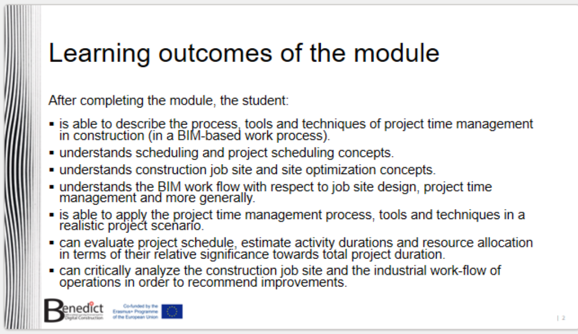

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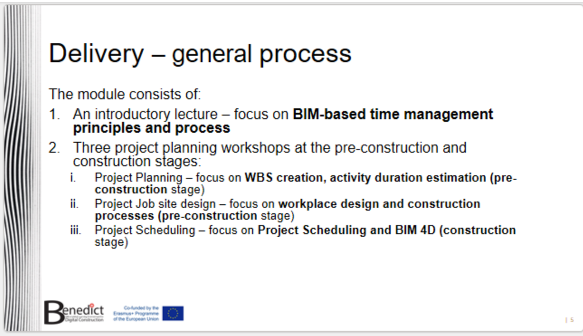

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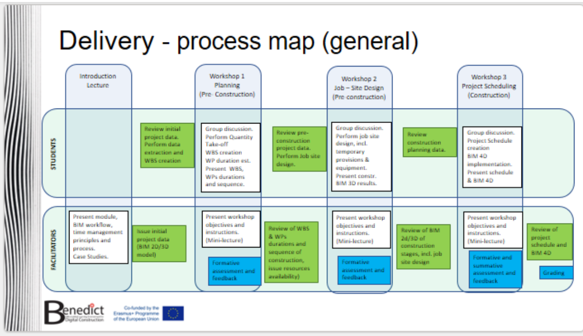

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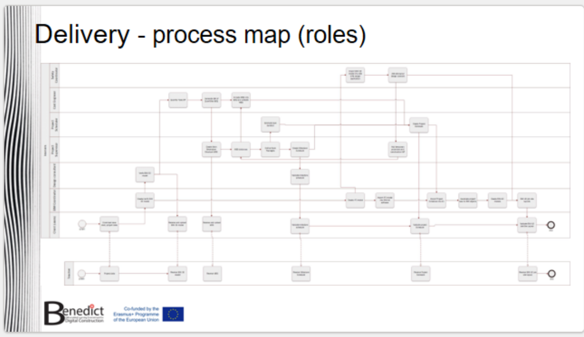

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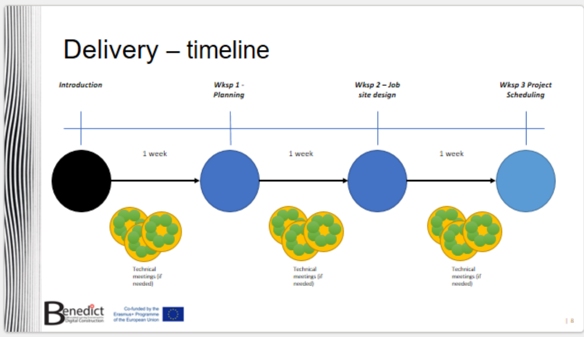

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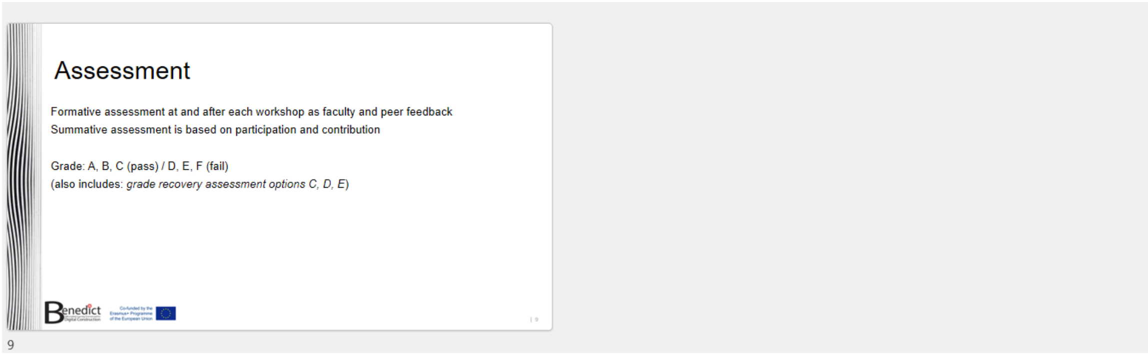
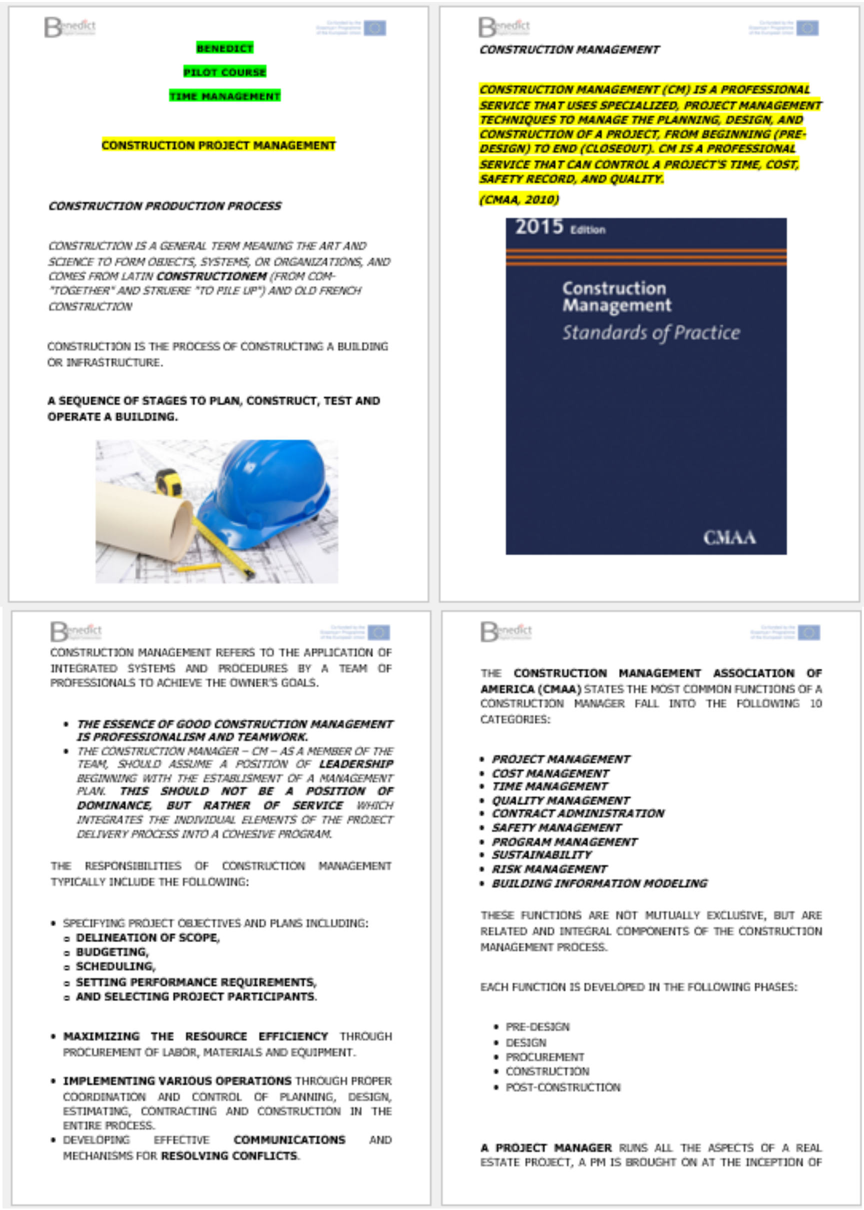




BENEDICT

PILOT COURSE

TIME MANAGEMENT

CONSTRUCTION PROJECT MANAGEMENT

CONSTRUCTION PRODUCTION PROCESS

*CONSTRUCTION IS A GENERAL TERM MEANING THE ART AND SCIENCE TO FORM OBJECTS, SYSTEMS, OR ORGANIZATIONS, AND COMES FROM LATIN **CONSTRUCTIONEM** (FROM COM- "TOGETHER" AND STRUERE "TO PILE UP") AND OLD FRENCH CONSTRUCTION*

CONSTRUCTION IS THE PROCESS OF CONSTRUCTING A BUILDING OR INFRASTRUCTURE.

A SEQUENCE OF STAGES TO PLAN, CONSTRUCT, TEST AND OPERATE A BUILDING.

CONSTRUCTION MANAGEMENT

CONSTRUCTION MANAGEMENT (CM) IS A PROFESSIONAL SERVICE THAT USES SPECIALIZED, PROJECT MANAGEMENT TECHNIQUES TO MANAGE THE PLANNING, DESIGN, AND CONSTRUCTION OF A PROJECT, FROM BEGINNING (PRE-DESIGN) TO END (CLOSEOUT). CM IS A PROFESSIONAL SERVICE THAT CAN CONTROL A PROJECT'S TIME, COST, SAFETY RECORD, AND QUALITY.

(CMAA, 2010)

2015 Edition
Construction Management
Standards of Practice
CMAA

CONSTRUCTION MANAGEMENT REFERS TO THE APPLICATION OF INTEGRATED SYSTEMS AND PROCEDURES BY A TEAM OF PROFESSIONALS TO ACHIEVE THE OWNER'S GOALS.

- ***THE ESSENCE OF GOOD CONSTRUCTION MANAGEMENT IS PROFESSIONALISM AND TEAMWORK.***
- *THE CONSTRUCTION MANAGER – CM – AS A MEMBER OF THE TEAM, SHOULD ASSUME A POSITION OF **LEADERSHIP** BEGINNING WITH THE ESTABLISMENT OF A MANAGEMENT PLAN. **THIS SHOULD NOT BE A POSITION OF DOMINANCE, BUT RATHER OF SERVICE** WHICH INTEGRATES THE INDIVIDUAL ELEMENTS OF THE PROJECT DELIVERY PROCESS INTO A COHESIVE PROGRAM.*

THE RESPONSIBILITIES OF CONSTRUCTION MANAGEMENT TYPICALLY INCLUDE THE FOLLOWING:

- SPECIFYING PROJECT OBJECTIVES AND PLANS INCLUDING:
  - **DELINEATION OF SCOPE,**
  - **BUDGETING,**
  - **SCHEDULING,**
  - **SETTING PERFORMANCE REQUIREMENTS,**
  - **AND SELECTING PROJECT PARTICIPANTS.**
- **MAXIMIZING THE RESOURCE EFFICIENCY** THROUGH PROCUREMENT OF LABOR, MATERIALS AND EQUIPMENT.
- **IMPLEMENTING VARIOUS OPERATIONS** THROUGH PROPER COORDINATION AND CONTROL OF PLANNING, DESIGN, ESTIMATING, CONTRACTING AND CONSTRUCTION IN THE ENTIRE PROCESS.
- DEVELOPING EFFECTIVE **COMMUNICATIONS** AND MECHANISMS FOR **RESOLVING CONFLICTS**.

THE **CONSTRUCTION MANAGEMENT ASSOCIATION OF AMERICA (CMAA)** STATES THE MOST COMMON FUNCTIONS OF A CONSTRUCTION MANAGER FALL INTO THE FOLLOWING 10 CATEGORIES:

- ***PROJECT MANAGEMENT***
- ***COST MANAGEMENT***
- ***TIME MANAGEMENT***
- ***QUALITY MANAGEMENT***
- ***CONTRACT ADMINISTRATION***
- ***SAFETY MANAGEMENT***
- ***PROGRAM MANAGEMENT***
- ***SUSTAINABILITY***
- ***RISK MANAGEMENT***
- ***BUILDING INFORMATION MODELING***

THESE FUNCTIONS ARE NOT MUTUALLY EXCLUSIVE, BUT ARE RELATED AND INTEGRAL COMPONENTS OF THE CONSTRUCTION MANAGEMENT PROCESS.

EACH FUNCTION IS DEVELOPED IN THE FOLLOWING PHASES:

- PRE-DESIGN
- DESIGN
- PROCUREMENT
- CONSTRUCTION
- POST-CONSTRUCTION

A PROJECT MANAGER RUNS ALL THE ASPECTS OF A REAL ESTATE PROJECT, A PM IS BROUGHT ON AT THE INCEPTION OF

THE PROJECT AND HAS A COMPREHENSIVE UNDERSTANDING OF THE CLIENT'S GOALS, INCLUDING PROJECT BRIEF AND DIFFERENT DESIGN STAGES.

CONSTRUCTION MANAGER WILL MANAGE ONLY THE CONSTRUCTION PORTION OF THE PRODUCT, CM IS INVOLVED IN PERSONNEL MANAGEMENT AT THE CONSTRUCTION SITE.

A CM OVERSEES ALL CONSTRUCTION ACTIVITIES, A PM SUPERVISES THE CM.

IN THE **INTERNATIONAL AND NATIONAL CONTEXT**, THE **CONSTRUCTION PROJECT MANAGEMENT COMPETENCIES** ARE NEEDED BY THE FOLLOWING OPERATORS:

CLIENT / OWNER	***CONTRACTOR / EMPLOYER***
PROJECT SUPERVISOR	**PROJECT MANAGER (PM)**
WORKS SUPERVISOR (DL) (ENGINEER OR SITE ENGINEER)	**CONSTRUCTION MANAGER**
HEALTH AND SAFETY CO-ORDINATOR	**HEAD OF THE PREVENTION AND PROTECTION SERVICE / SAFETY MANAGER**

PROBLEMS OF PROJECT MANAGEMENT

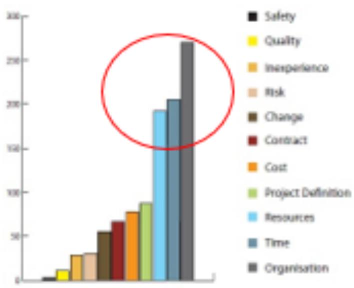
A RESEARCH GROUP OF THE UNIVERSITY OF MANCHESTER, UK (WEARNE, 2005) ASKED WHAT ARE THE GREATEST PROBLEMS OF PROJECT MANAGEMENT TO MORE THAN A THOUSAND PEOPLE, WHO WORKED AS **TECHNICIANS, COMMERCIALS AND MIDDLE MANAGERS FOR PROCESS, MANUFACTURING, CONSTRUCTION, PUBLIC AND PRIVATE SERVICE INDUSTRIES** OF WESTERN EUROPE.

THE MANAGERS IDENTIFIED THE MAJOR PROBLEMS OF PROJECTS THAT CAN CAUSE CRITICISM, EMBARASSMENT, LEGAL DISPUTES AND THE POSSIBLE PROJECT FAILURE.

THE GREATEST PROBLEMS WERE CLASSIFIED INTO 11 CATEGORIES:

- **SAFETY**
- **QUALITY**
- **INEXPERIENCE**
- **RISK**
- **VARIANTS**
- **CONTRACT**
- **COSTS**
- **DEFINITION OF THE PROJECT**
- **RESOURCES**
- **TIMES**
- **ORGANIZATION**

THE GREATEST PROBLEMS OF PROJECT MANAGEMENT:

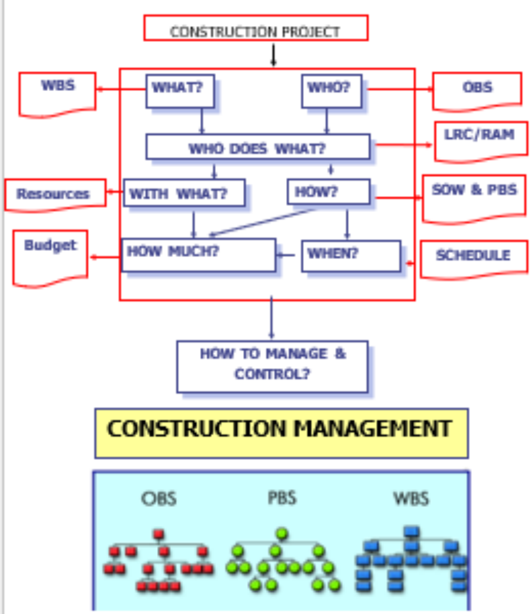


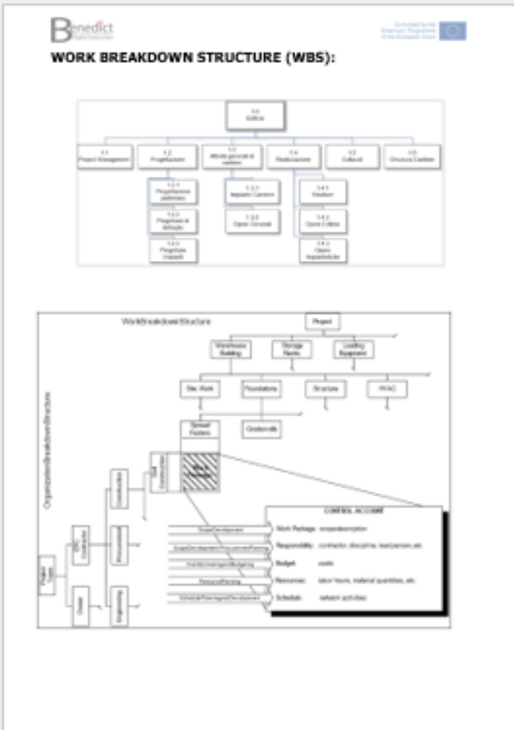
- THE THREE CATEGORIES: **ORGANISATION, TIME AND RESOURCES** ARE **65%** OF ALL STATEMENTS THAT IDENTIFY MAJOR MANAGEMENT PROBLEMS.
- **PROJECT DEFINITION, COST, CONTRACT AND CHANGE ARE 28%.**
- RISK (3%) AND INEXPERIENCE ARE ABOUT 6%.
- THE LOW VALUES OF **THE CATEGORIES OF RISK (3%), QUALITY (1%) AND SAFETY (> 1%)** ARE BECAUSE OF THE EXISTING CONSOLIDATED STRATEGIES OF THE COMPANY ORGANIZATION, AND REGULATION PROVISIONS TO PREVENT ALL OR ALMOST ALL POTENTIAL PROBLEMS.

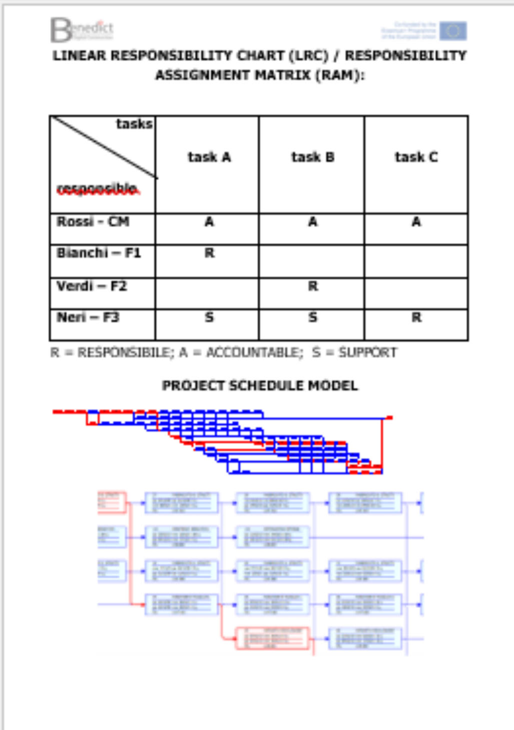
IT FOLLOWS THAT **QUALITY AND SAFETY ARE SEEN AS CONSTRAINTS AND NOT AS VARIABLES** OF THE PRODUCTION PROCESS, AND IN PRACTICE THEY ARE NOT SEEN AS GREAT PROBLEMS.

CONSTRUCTION MANAGEMENT:

THE QUESTIONS OF A CONSTRUCTION PROJECT







tasks / responsible	task A	task B	task C
Rossi – CM	A	A	A
Bianchi – F1	R		
Verdi – F2		R	
Neri – F3	S	S	R

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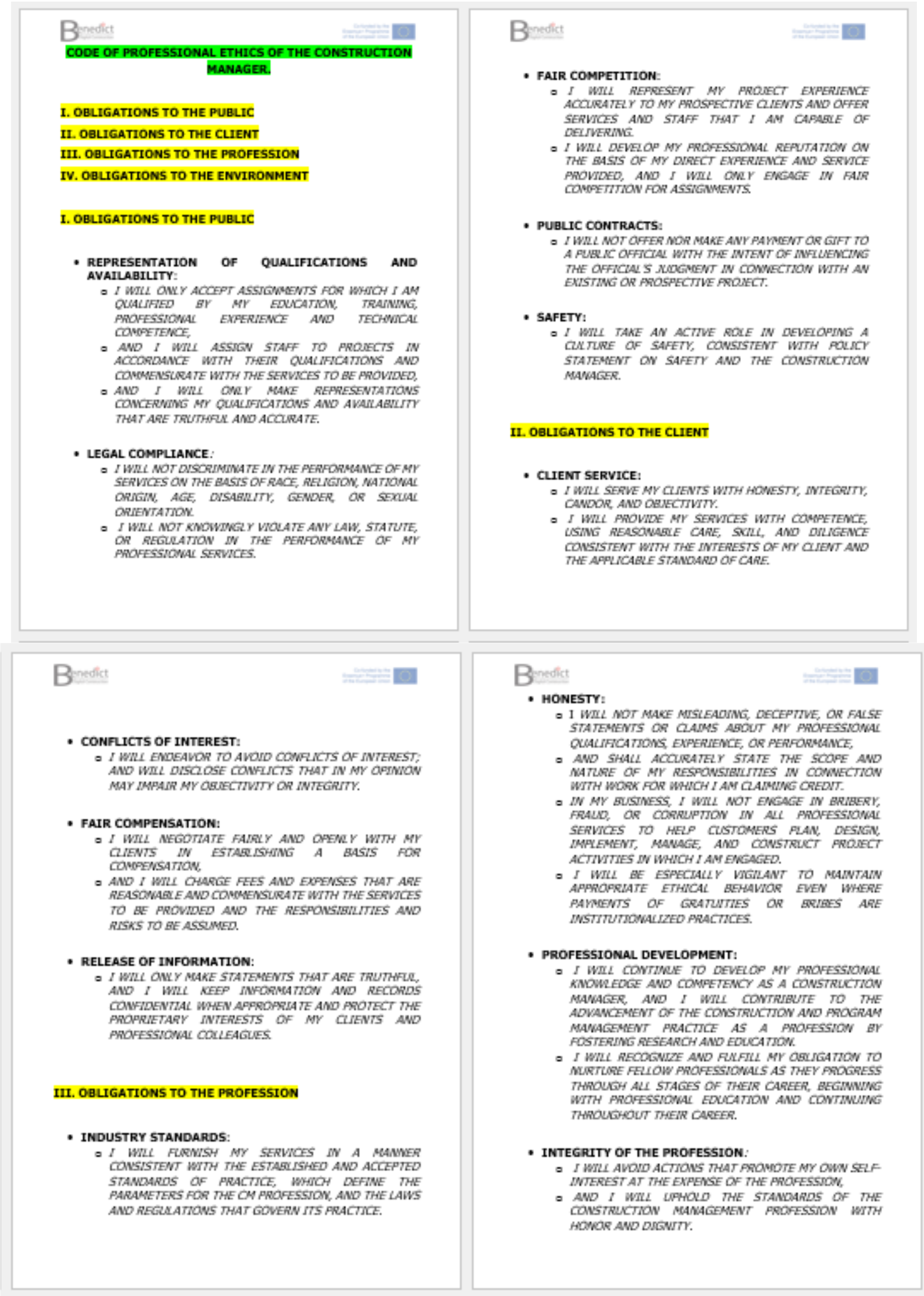


CODE OF PROFESSIONAL ETHICS OF THE CONSTRUCTION MANAGER.

I. OBLIGATIONS TO THE PUBLIC
II. OBLIGATIONS TO THE CLIENT
III. OBLIGATIONS TO THE PROFESSION
IV. OBLIGATIONS TO THE ENVIRONMENT

I. OBLIGATIONS TO THE PUBLIC

- **REPRESENTATION OF QUALIFICATIONS AND AVAILABILITY:**
  - *I WILL ONLY ACCEPT ASSIGNMENTS FOR WHICH I AM QUALIFIED BY MY EDUCATION, TRAINING, PROFESSIONAL EXPERIENCE AND TECHNICAL COMPETENCE,*
  - *AND I WILL ASSIGN STAFF TO PROJECTS IN ACCORDANCE WITH THEIR QUALIFICATIONS AND COMMENSURATE WITH THE SERVICES TO BE PROVIDED,*
  - *AND I WILL ONLY MAKE REPRESENTATIONS CONCERNING MY QUALIFICATIONS AND AVAILABILITY THAT ARE TRUTHFUL AND ACCURATE.*
- **LEGAL COMPLIANCE:**
  - *I WILL NOT DISCRIMINATE IN THE PERFORMANCE OF MY SERVICES ON THE BASIS OF RACE, RELIGION, NATIONAL ORIGIN, AGE, DISABILITY, GENDER, OR SEXUAL ORIENTATION.*
  - *I WILL NOT KNOWINGLY VIOLATE ANY LAW, STATUTE, OR REGULATION IN THE PERFORMANCE OF MY PROFESSIONAL SERVICES.*
- **FAIR COMPETITION:**
  - *I WILL REPRESENT MY PROJECT EXPERIENCE ACCURATELY TO MY PROSPECTIVE CLIENTS AND OFFER SERVICES AND STAFF THAT I AM CAPABLE OF DELIVERING.*
  - *I WILL DEVELOP MY PROFESSIONAL REPUTATION ON THE BASIS OF MY DIRECT EXPERIENCE AND SERVICE PROVIDED, AND I WILL ONLY ENGAGE IN FAIR COMPETITION FOR ASSIGNMENTS.*
- **PUBLIC CONTRACTS:**
  - *I WILL NOT OFFER NOR MAKE ANY PAYMENT OR GIFT TO A PUBLIC OFFICIAL WITH THE INTENT OF INFLUENCING THE OFFICIAL'S JUDGMENT IN CONNECTION WITH AN EXISTING OR PROSPECTIVE PROJECT.*
- **SAFETY:**
  - *I WILL TAKE AN ACTIVE ROLE IN DEVELOPING A CULTURE OF SAFETY, CONSISTENT WITH POLICY STATEMENT ON SAFETY AND THE CONSTRUCTION MANAGER.*

II. OBLIGATIONS TO THE CLIENT

- **CLIENT SERVICE:**
  - *I WILL SERVE MY CLIENTS WITH HONESTY, INTEGRITY, CANDOR, AND OBJECTIVITY.*
  - *I WILL PROVIDE MY SERVICES WITH COMPETENCE, USING REASONABLE CARE, SKILL, AND DILIGENCE CONSISTENT WITH THE INTERESTS OF MY CLIENT AND THE APPLICABLE STANDARD OF CARE.*
- **CONFLICTS OF INTEREST:**
  - *I WILL ENDEAVOR TO AVOID CONFLICTS OF INTEREST; AND WILL DISCLOSE CONFLICTS THAT IN MY OPINION MAY IMPAIR MY OBJECTIVITY OR INTEGRITY.*
- **FAIR COMPENSATION:**
  - *I WILL NEGOTIATE FAIRLY AND OPENLY WITH MY CLIENTS IN ESTABLISHING A BASIS FOR COMPENSATION,*
  - *AND I WILL CHARGE FEES AND EXPENSES THAT ARE REASONABLE AND COMMENSURATE WITH THE SERVICES TO BE PROVIDED AND THE RESPONSIBILITIES AND RISKS TO BE ASSUMED.*
- **RELEASE OF INFORMATION:**
  - *I WILL ONLY MAKE STATEMENTS THAT ARE TRUTHFUL, AND I WILL KEEP INFORMATION AND RECORDS CONFIDENTIAL WHEN APPROPRIATE AND PROTECT THE PROPRIETARY INTERESTS OF MY CLIENTS AND PROFESSIONAL COLLEAGUES.*

III. OBLIGATIONS TO THE PROFESSION

- **INDUSTRY STANDARDS:**
  - *I WILL FURNISH MY SERVICES IN A MANNER CONSISTENT WITH THE ESTABLISHED AND ACCEPTED STANDARDS OF PRACTICE, WHICH DEFINE THE PARAMETERS FOR THE CM PROFESSION, AND THE LAWS AND REGULATIONS THAT GOVERN ITS PRACTICE.*
- **HONESTY:**
  - *I WILL NOT MAKE MISLEADING, DECEPTIVE, OR FALSE STATEMENTS OR CLAIMS ABOUT MY PROFESSIONAL QUALIFICATIONS, EXPERIENCE, OR PERFORMANCE,*
  - *AND SHALL ACCURATELY STATE THE SCOPE AND NATURE OF MY RESPONSIBILITIES IN CONNECTION WITH WORK FOR WHICH I AM CLAIMING CREDIT.*
  - *IN MY BUSINESS, I WILL NOT ENGAGE IN BRIBERY, FRAUD, OR CORRUPTION IN ALL PROFESSIONAL SERVICES TO HELP CUSTOMERS PLAN, DESIGN, IMPLEMENT, MANAGE, AND CONSTRUCT PROJECT ACTIVITIES IN WHICH I AM ENGAGED.*
  - *I WILL BE ESPECIALLY VIGILANT TO MAINTAIN APPROPRIATE ETHICAL BEHAVIOR EVEN WHERE PAYMENTS OF GRATUITIES OR BRIBES ARE INSTITUTIONALIZED PRACTICES.*
- **PROFESSIONAL DEVELOPMENT:**
  - *I WILL CONTINUE TO DEVELOP MY PROFESSIONAL KNOWLEDGE AND COMPETENCY AS A CONSTRUCTION MANAGER, AND I WILL CONTRIBUTE TO THE ADVANCEMENT OF THE CONSTRUCTION AND PROGRAM MANAGEMENT PRACTICE AS A PROFESSION BY FOSTERING RESEARCH AND EDUCATION.*
  - *I WILL RECOGNIZE AND FULFILL MY OBLIGATION TO NURTURE FELLOW PROFESSIONALS AS THEY PROGRESS THROUGH ALL STAGES OF THEIR CAREER, BEGINNING WITH PROFESSIONAL EDUCATION AND CONTINUING THROUGHOUT THEIR CAREER.*
- **INTEGRITY OF THE PROFESSION:**
  - *I WILL AVOID ACTIONS THAT PROMOTE MY OWN SELF-INTEREST AT THE EXPENSE OF THE PROFESSION,*
  - *AND I WILL UPHOLD THE STANDARDS OF THE CONSTRUCTION MANAGEMENT PROFESSION WITH HONOR AND DIGNITY.*

IV. OBLIGATIONS TO THE ENVIRONMENT

- **SUSTAINABILITY:**
  - *I WILL CONDUCT MYSELF AND ENCOURAGE OTHERS IN KEEPING WITH ENVIRONMENTAL AND SUSTAINABLE BUSINESS PRACTICES, PROVIDING FOR THE NEEDS OF THE PRESENT WITHOUT COMPROMISING THE NEEDS OF FUTURE GENERATIONS.*

BY CONSTRUCTION MANAGEMENT ASSOCIATION OF AMERICA, APPROVED ON APRIL 1, 2017

CONSTRUCTION MANAGEMENT: PROJECT THEORY

CONSTRUCTION MANAGEMENT PROVIDES METHODS AND TOOLS TO ORGANIZE AND MANAGE THE PRODUCTION PROCESSES OF CIVIL AND BUILDING WORKS ON SITE.

THE GOAL IS TO

- **PLAN,**
- **DESIGN,**
- **SCHEDULE,**
- **CONTROL**

THE FUNDAMENTAL ASPECTS OF CONSTRUCTION PROJECTS:

- **SEQUENCE AND CO-ORDINATION OF CONSTRUCTION ACTIVITIES**
- **PRELIMINARY ACTIVITIES AND TEMPORARY WORKS**
- **DESIGN & COST MANAGEMENT**
- **RESOURCE MANAGEMENT**
- **SAFETY MANAGEMENT**

ORGANIZING AND MANAGING CONSTRUCTION MEANS ORGANIZING THE USE OF PRODUCTION RESOURCES (LABOR, MACHINES, MATERIALS) FOR THEIR USE IN THE IMPLEMENTATION OF CONSTRUCTION TECHNIQUES IN THE PRODUCTION PROCESS.

THIS MEANS TO PLAN THE LOGIC SEQUENCE OF ACTIVITIES ACCORDING TO

- **TIME – PROJECT TIME**
- **SPACE - WORKSPACE**

THIS MEANS THAT CONSTRUCTION MANAGER SHOULD:

1) PLAN CONSTRUCTION ACTIVITIES:

A) **OVER TIME**, THROUGH THE VARIOUS PROJECT STEPS, PLANNING THE CORRECT SEQUENCE OF THE VARIOUS ACTIVITIES OF PROJECT EXECUTION: PLANNING AND SCHEDULING BUILDING / CONSTRUCTION WORKS,
B) **IN SPACE**, DESIGNING THE LAY-OUT OF THE CONSTRUCTION SITE, CHANGING IN EACH DIFFERENT PROJECT STEPS: DESIGN THE SITE OF THE JOB.

INDEED,

A) PLANNING AND SCHEDULING THE WORKS:

THE SEQUENCE OF ACTIVITIES DEPENDS ON THE FOLLOWINGS NEEDS:

- TECHNOLOGY
- RESOURCES & EQUIPMENT
- SAFETY
- CLIENT'S & CONTRACTOR'S

DEFINING THE CORRECT SEQUENCE OF ACTIVITIES IS THE FUNDAMENTAL STEP FOR THE PROJECT SUCCESS.

B) DESIGN THE SITE LAYOUT PLAN:

SITE LAY-OUT PLANNING INVOLVES THE DESIGN OF THE CORRECT LOCATION OF:

- WORKSTATIONS,
- MACHINE AND PLANT LOCATIONS,
- TEMPORARY AND SAFETY EQUIPMENTS

AND DEPENDS ON THE FOLLOWINGS NEEDS:

- TECHNOLOGY
- RESOURCES & EQUIPMENT
- SAFETY
- CLIENT'S & CONTRACTOR'S

DEFINING THE CORRECT SITE LAY-OUT IS FUNDAMENTAL IS THE FUNDAMENTAL STEP FOR THE PROJECT SUCCESS.

2) TAKE THE NECESSARY IN PROGRESS CONTROL ACTIONS

CONTROL PROCESS CONSISTS IN THE FOLLOWING:

A) **MONITORING OF PRODUCTION DATA** (RESOURCES, PRODUCTION REALIZED, COSTS AND REVENUES)

B) **CONTROL:** DECISION AND IMPLEMENTATION OF ORGANIZATIONAL CORRECTIVE ACTIONS FOR THE REMAINING PRODUCTION PROCESSES TO BE CARRIED OUT

PROJECT CONTROL PROCESSES ARE BASED UPON THE MONITORING AND THE ESTIMATION OF **KEY PERFORMANCE INDICATORS KPIS** THAT ALLOWS CONSTRUCTION MANAGERS TO REACH PROJECT OBJECTIVE CONCERNING:

- **TIME,**
- **COST**
- **QUALITY**

ACCORDING TO THE AVAILABLE RESOURCES.

THE CONTROL ACTIONS ARE CARRIED OUT CONSIDERING QUALITY AND QUANTITY OF THE PRODUCTION OUTPUTS OR THROUGH COST AND TIME RELATED KPIS.

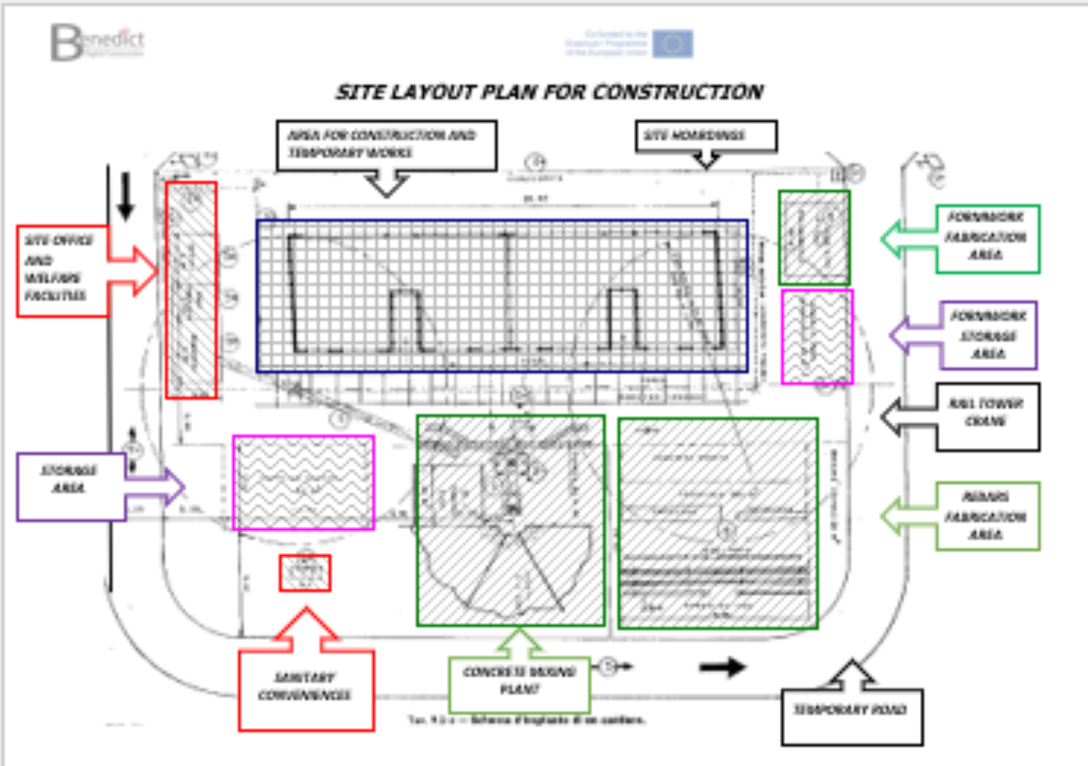
BY THE UNDERSTANDING OF THESE INDICATORS IT IS POSSIBLE TO EVALUATE:

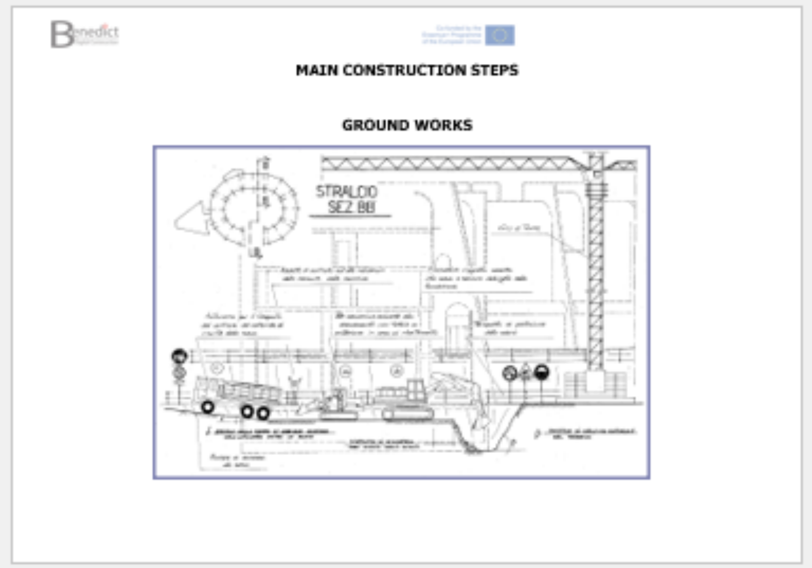
- PROFITABILITY MARGINS OF PROJECT FOR PERFORMING ORGANIZATION
- EXPENDITURE FOR THE CLIENT

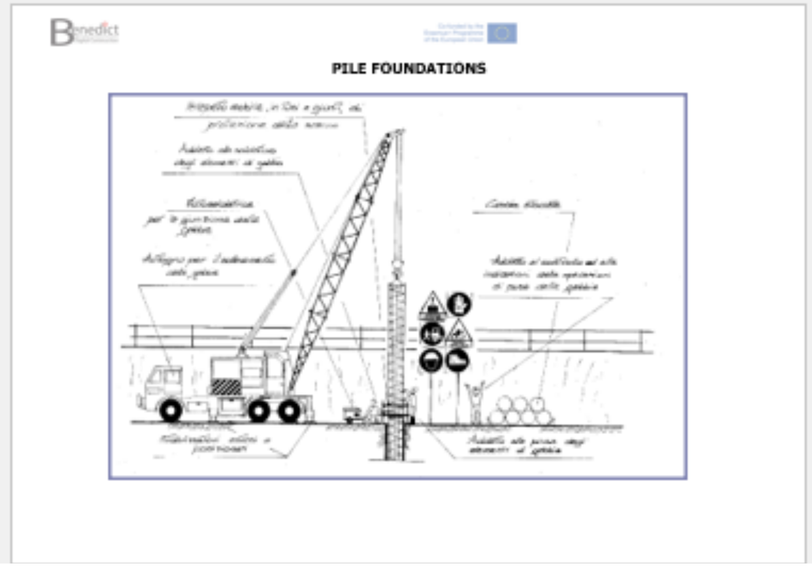
THE CONSTRUCTION SITE LAYOUT PLAN

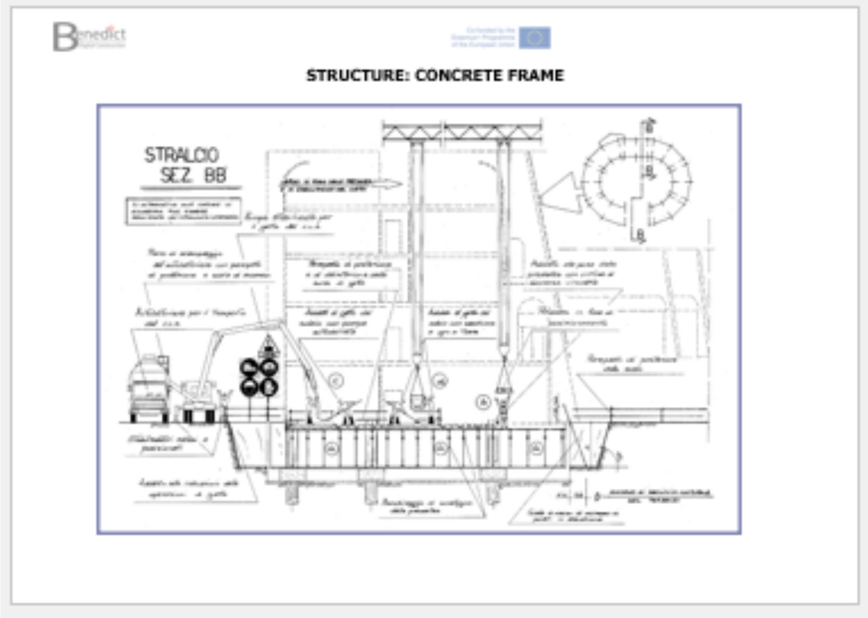
CONSTRUCTION SITE LAYOUT PLANNING SHOULD TAKE INTO ACCOUNT TWO DIFFERENT AIMS:

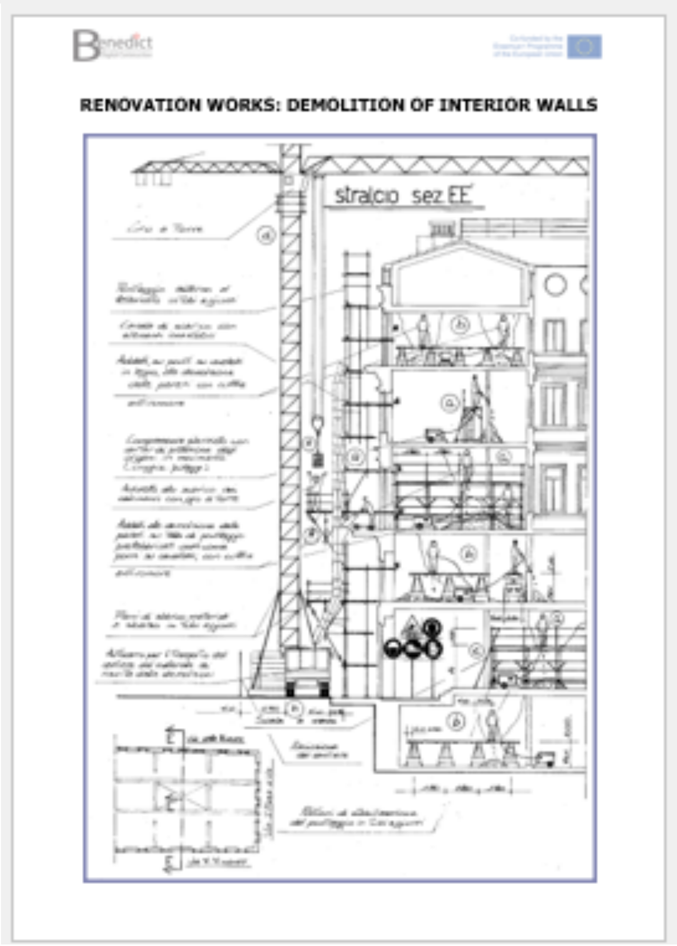
- **PROCESS EFFICIENCY**
- **HEALTH AND SAFETY PROVISIONS**

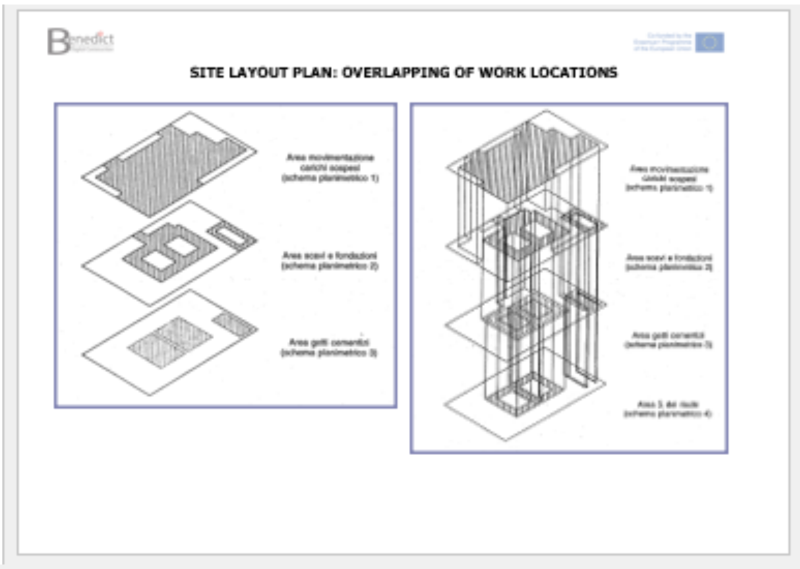


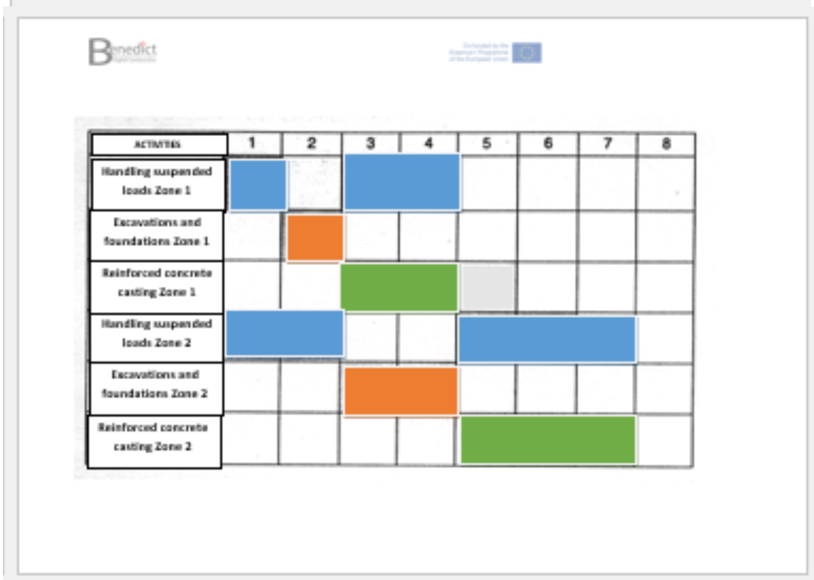

MAIN CONSTRUCTION STEPS
GROUND WORKS
STRALCIO
SEZ BB


PILE FOUNDATIONS


STRUCTURE: CONCRETE FRAME
STRALCIO
SEZ. BB


RENOVATION WORKS: DEMOLITION OF INTERIOR WALLS
stralcio sez EE


SITE LAYOUT PLAN: OVERLAPPING OF WORK LOCATIONS
Area movimentazione carichi sospesi (schema planimetrico 1)
Area scavi e fondazioni (schema planimetrico 2)
Area getti cementizi (schema planimetrico 3)

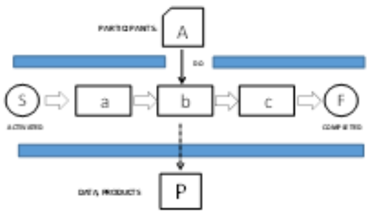

ACTIVITIES
1
2
3
4
5
6
7
8
Handling suspended loads Zone 1
Excavations and foundations Zone 1
Reinforced concrete casting Zone 1
Handling suspended loads Zone 2
Excavations and foundations Zone 2
Reinforced concrete casting Zone 2

EFFICIENCY AND RELIABILITY OF PRODUCTION PROCESSES

PROCESS

A PROCESS IS IN GENERAL A SUCCESSION AND DEVELOPMENT OF CONCATENATED PHENOMENA THAT PRODUCE A GRADUAL TRANSIT FROM ONE STATE TO ANOTHER.

THE PRODUCTION PROCESS IS A SERIES OF OPERATIONS THAT ARE CARRIED OUT TO ACHIEVE A CERTAIN GOAL.



CONSTRUCTION PROCESS

THE CONSTRUCTION PROCESS IS THEREFORE THE ORGANIZED SET OF OPERATIONS THAT ARE CARRIED OUT FOR THE REALIZATION OF THE BUILDING OR CIVIL WORK.

THE MEASURE OF PERFORMANCE OF A PRODUCTION PROCESS

TO "MEASURE" THE PERFORMANCE OF ANY PRODUCTION PROCESS THE CONCEPTS OF EFFICIENCY AND RELIABILITY ARE INTRODUCED.

EFFICIENCY

IT MUST BE ASSESSED RELATED TO PRODUCTION OBJECTIVES.

EFFICIENCY IS GENERALLY INTENDED THE ABILITY TO OPERATE CORRECTLY, TO PRODUCE AN EFFECT - EFFECTIVENESS. IT IS THE CONSTANT CAPACITY OF PERFORMANCE AND RESPONDING TO ITS OWN FUNCTIONS OR PURPOSES:

QUALITATIVELY, EFFICIENCY EXPRESSES THE RATE OF THE OBJECTIVES ACHIEVED RELATED TO THE RESOURCES USED FOR THE PURPOSE.

A PRODUCTION PROCESS IS TERMED EFFICIENT IF IT GUARANTEES THE MAXIMUM PRODUCTIVITY OBTAINABLE BY CERTAIN RESOURCES OR TECHNIQUES.

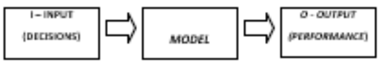
E.g.: PRODUCED QUANTITY / WORK HOURS NEEDED

OR

ACTUAL PRODUCT QUANTITY / EXPECTED PRODUCT QUANTITY

AT PRODUCTION TIME "T"

THEREFORE, CONSTRUCTION IS AN ORGANIZED PROCESS THAT CAN BE MODELED LIKE THE FOLLOWING



- **INPUTS (INPUTS, I), DECISIONS OR CONTROLS,**

I.E. VARIABLES WE TRY TO CONTROL AND CORRESPONDING:

- **OUTPUTS, THAT IS, PERFORMANCE THAT WE TRY TO FORECAST BY A PRODUCTION MODEL.**

IF THE CONSTRUCTION ACTUALLY PRODUCES A CERTAIN ACTUAL OUTPUT "OA" BY ABSORBING AN ACTUAL INPUT "IA", IT IS POSSIBLE TO DEFINE THE FOLLOWING:

EFFECTIVENESS "E"

OF CONSTRUCTION, THE RATE OF THE **ACTUAL OUTPUT "OA"** AND THE **EXPECTED OUTPUT "OE"**:

$$E = OA / OE$$

FOR EXAMPLE.

E = M3 OF CONCRETE CAST / M3 OF CONCRETE - EXPECTED = 150/125 = 1.2

IN A SPECIFIC TIME, E.G. 4 DAYS OF WORK

PRODUCTIVITY "P"

"PE" EXPECTED PRODUCTIVITY:

$$PE = OE / IE$$

WHERE:

"OE" = EXPECTED OUTPUT

"IE" = EXPECTED INPUT

EXAMPLE:

PE = EXPECTED SQUARE METERS OF PLASTER / EXPECTED LABOR HOURS

= 48 SQM / 16 H = 3 SQM / H

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ACTUAL PRODUCTIVITY "PA":

PA= OA / IA

WHERE:

"OA" = ACTUAL OUTPUT

"IA" = ACTUAL INPUT

E.G.: PA = M2 OF COMPLETED PLASTERING / ACTUAL LABOR HOURS = 55 SQM / 19 H = 2.89 SQM / H

THERFORE, THE **"EFC" EFFICIENCY IS THE RATE OF ACTUAL PRODUCTIVITY "PA" AND THE EXPECTED PRODUCTIVITY "PE":**

EFC = PA / PE

EFFICIENCY = EFC = 2.89 / 3 = 0.96

RELIABILITY

IT IS THE GUARANTEE OF CORRECT OPERATION OR THE PROBABILITY OF GIVING POSITIVE RESULTS.

RELIABILITY IS THE ABILITY OF A SYSTEM OR EQUIPMENT TO FUNCTION UNDER STATED CONDITIONS FOR A SPECIFIED PERIOD OF TIME

RELIABILITY IS CLOSELY RELATED TO **AVAILABILITY,** WHICH IS TYPICALLY DESCRIBED AS THE ABILITY OF A COMPONENT OR SYSTEM TO FUNCTION AT A SPECIFIED MOMENT OR INTERVAL OF TIME.

THE RELIABILITY FUNCTION IS THEORETICALLY DEFINED AS THE MEASURE OF THE PROBABILITY THAT THE SYSTEM UNDER CONSIDERATION WILL HAVE SUCCESS, I.E WILL NOT FAIL IN A DETERMINED PERIOD OF TIME.

QUALITATIVELY WITH RELIABILITY OF A PROCESS IT IS MEANT:

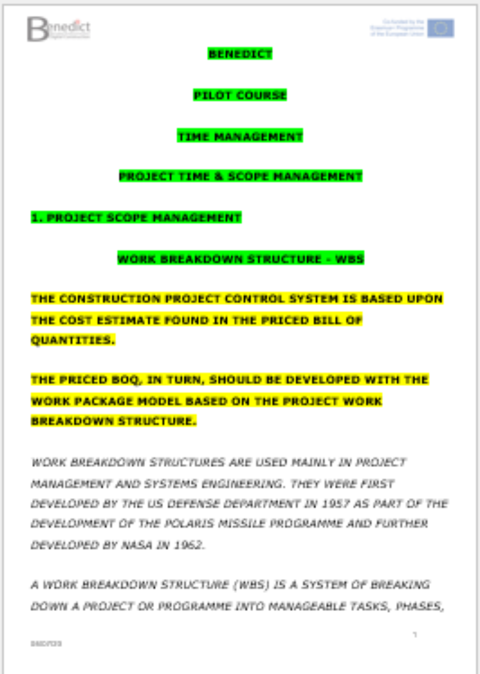
- THE **ABILITY TO ABSORB THE DISTURBANCES** THAT TEND TO CHANGE THE PROCESS, REDUCING THEIR INFLUENCE ON EXPECTED PERFORMANCE.
- THE **RESISTANCE TO FAILURE OF AN ITEM OVER TIME**

THE RELIABILITY OF A PRODUCTION PROCESS CAN BE ASSESSED BASING ON DIFFERENT QUANTITIES.

THE MOST IMMEDIATE IS GENERALLY THE **OVERALL DURATION** OF THE PROCESS ITSELF.

THEREFORE, **THE MORE THE DURATION OF THE PROCESS DOES NOT CHANGE IN CASE OF UNEXPECTED EVENTS, THE MORE THE PROCESS CAN BE TERMED RELIABLE.**

A.2. Workshop 1 lecture Slides



BENEDICT

PILOT COURSE

TIME MANAGEMENT

PROJECT TIME & SCOPE MANAGEMENT

1. PROJECT SCOPE MANAGEMENT

WORK BREAKDOWN STRUCTURE - WBS

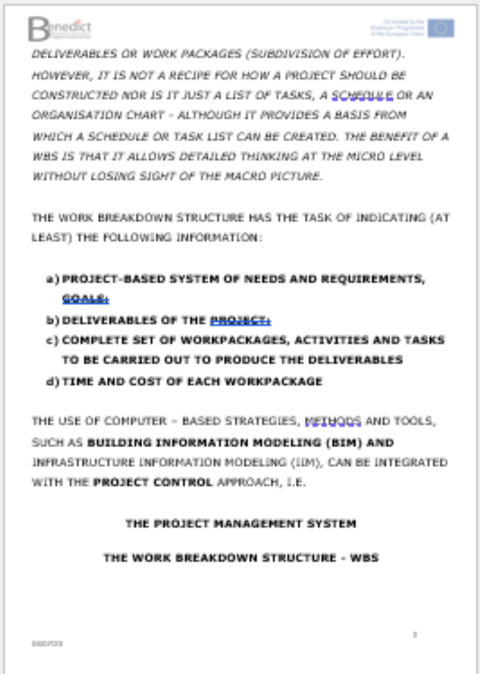
THE CONSTRUCTION PROJECT CONTROL SYSTEM IS BASED UPON THE COST ESTIMATE FOUND IN THE PRICED BILL OF QUANTITIES.

THE PRICED BOQ, IN TURN, SHOULD BE DEVELOPED WITH THE WORK PACKAGE MODEL BASED ON THE PROJECT WORK BREAKDOWN STRUCTURE.

WORK BREAKDOWN STRUCTURES ARE USED MAINLY IN PROJECT MANAGEMENT AND SYSTEMS ENGINEERING. THEY WERE FIRST DEVELOPED BY THE US DEFENSE DEPARTMENT IN 1957 AS PART OF THE DEVELOPMENT OF THE POLARIS MISSILE PROGRAMME AND FURTHER DEVELOPED BY NASA IN 1962.

A WORK BREAKDOWN STRUCTURE (WBS) IS A SYSTEM OF BREAKING DOWN A PROJECT OR PROGRAMME INTO MANAGEABLE TASKS, PHASES,

1



DELIVERABLES OR WORK PACKAGES (SUBDIVISION OF EFFORT). HOWEVER, IT IS NOT A RECIPE FOR HOW A PROJECT SHOULD BE CONSTRUCTED NOR IS IT JUST A LIST OF TASKS, A SCHEDULE OR AN ORGANISATION CHART - ALTHOUGH IT PROVIDES A BASIS FROM WHICH A SCHEDULE OR TASK LIST CAN BE CREATED. THE BENEFIT OF A WBS IS THAT IT ALLOWS DETAILED THINKING AT THE MICRO LEVEL WITHOUT LOSING SIGHT OF THE MACRO PICTURE.

THE WORK BREAKDOWN STRUCTURE HAS THE TASK OF INDICATING (AT LEAST) THE FOLLOWING INFORMATION:

a) PROJECT-BASED SYSTEM OF NEEDS AND REQUIREMENTS, GOALS;
b) DELIVERABLES OF THE PROJECT;
c) COMPLETE SET OF WORKPACKAGES, ACTIVITIES AND TASKS TO BE CARRIED OUT TO PRODUCE THE DELIVERABLES
d) TIME AND COST OF EACH WORKPACKAGE

THE USE OF COMPUTER - BASED STRATEGIES, METHODS AND TOOLS, SUCH AS **BUILDING INFORMATION MODELING (BIM) AND** INFRASTRUCTURE INFORMATION MODELING (IIM), CAN BE INTEGRATED WITH THE **PROJECT CONTROL** APPROACH, I.E.

THE PROJECT MANAGEMENT SYSTEM

THE WORK BREAKDOWN STRUCTURE - WBS

2

THE WORK BREAKDOWN STRUCTURE (WBS) IS THE BREAKDOWN OF A PROJECT INTO WORKPACKAGES AND ACTIVITES CLASSIFIED ACCORDING DIFFERENT CATEGORIES OF WORKS.

THE WBS CONTAINS THE LIST OF ALL THE ACTIVITIES OF A PROJECT.

WITH THE AIM OF PERFORMING THE PROJECT MANAGEMENT OF CONSTRUCTION, THE ENTIRE PRODUCTION PROCESS HAS TO BE DIVIDED INTO WORK ITEMS WITH THE FOLLOWING CHARACTERISTICS:

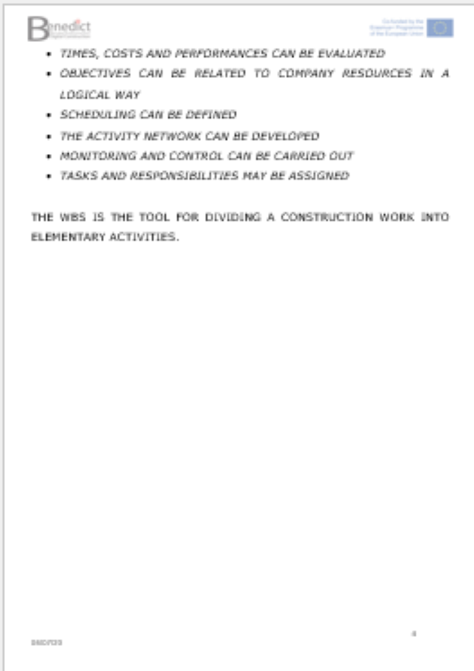
- MANAGEABLE, TO ASSIGN SPECIFIC AUTHORITY AND RESPONSIBILITIES
- INDEPENDENT OR WITH A MINIMUM INTERFACE AND DEPENDENCE ON OTHER ELEMENTARY ACTIVITIES
- INTEGRATED TO BE ABLE TO SEE THE WHOLE WORK PACKAGE
- ASSESSABLE IN TERMS OF PROGRESS.

THE WBS IS A HIERARCHICAL SUBDIVISION OF PROJECT WORK THAT IS ORIENTED TO THE DELIVERY OF THE FINAL PRODUCT.

THE WBS IS THE MOST IMPORTANT ELEMENT OF THE PLANNING AND CONTROL SYSTEM BECAUSE IT PROVIDES A COMMON WORK STRUCTURE ON THE BASIS OF WHICH:

- *THE TOTAL PROJECT CAN BE DESCRIBED AS A SUMMARY OF THE ELEMENTS BREAKDOWN IN THE WBS*
- *THE PLANNING CAN BE CARRIED OUT*
- *COSTS AND BUDGETS MAY BE ESTIMATED*

3



- *TIMES, COSTS AND PERFORMANCES CAN BE EVALUATED*
- *OBJECTIVES CAN BE RELATED TO COMPANY RESOURCES IN A LOGICAL WAY*
- *SCHEDULING CAN BE DEFINED*
- *THE ACTIVITY NETWORK CAN BE DEVELOPED*
- *MONITORING AND CONTROL CAN BE CARRIED OUT*
- *TASKS AND RESPONSIBILITIES MAY BE ASSIGNED*

THE WBS IS THE TOOL FOR DIVIDING A CONSTRUCTION WORK INTO ELEMENTARY ACTIVITIES.

4

CONSTRUCTION PROJECT WORK BREAKDOWN STRUCTURE TEMPLATE

INTERNATIONAL STANDARD ISO 21500 (GUIDANCE ON PROJECT MANAGEMENT):

- **THE PURPOSE OF THE WBS IS TO PROVIDE A HIERARCHICAL DECOMPOSITION FRAMEWORK FOR PRESENTING THE WORK THAT NEEDS TO BE COMPLETED IN ORDER TO ACHIEVE THE PROJECT OBJECTIVES**
- **WBS PROVIDES A FRAMEWORK FOR DIVIDING AND SUBDIVIDING THE PROJECT WORK INTO SMALLER, THUS MORE MANAGEABLE, PIECES OF WORK.**
- THE WBS CAN BE STRUCTURED, FOR EXAMPLE, IN PROJECT PHASES, MAJOR DELIVERABLE, DISCIPLINE AND LOCATION.

- EACH DESCENDING LEVEL OF THE WORK BREAKDOWN STRUCTURE DESCRIBES PROJECT WORK IN AN INCREASINGLY DETAILED LEVEL.

IT IS ALSO POSSIBLE TO DEVELOP OTHER HIERARCHICAL BREAKDOWN STRUCTURES FOR METHODICALLY ASSESSING ITEMS SUCH AS:

- **DELIVERABLES - PRODUCT BREAKDOWN STRUCTURE**
- **ORGANIZATION - ORGANIZATION BREAKDOWN STRUCTURE**
- **RISK - RISK BREAKDOWN STRUCTURE**
- **COST ACCOUNTING - COST BREAKDOWN STRUCTURE**

OF THE PROJECT.

PMBOK BY PROJECT MANAGEMENT INSTITUTE (PMI) – A GUIDE TO THE PROJECT MANAGEMENT BODY OF KNOWLEDGE

WORK BREAKDOWN STRUCTURE

A HIERARCHICAL DECOMPOSITION OF THE TOTAL SCOPE OF WORK TO BE CARRIED OUT BY THE PROJECT TEAM TO ACCOMPLISH THE PROJECT OBJECTIVES AND CREATE THE REQUIRED DELIVERABLES.

THE WBS ORGANIZES AND DEFINES THE OVERALL SCOPE OF THE PROJECT. EACH DESCENDING LEVEL REPRESENTS AN INCREASINGLY DETAILED DEFINITION OF THE PROJECT WORK. THE WBS IS DECOMPOSED INTO "WORK PACKAGE".

CREATE WBS IS THE PROCESS OF SUBDIVIDING PROJECT DELIVERABLES AND PROJECT WORK INTO SMALLER, MORE MANAGEABLE COMPONENTS.

THE KEY BENEFIT OF THIS PROCESS IS THAT IT PROVIDES A STRUCTURED VISION OF WHAT HAS TO BE DELIVERED.

EARNED VALUE MANAGEMENT HANDBOOK, PUBLISHED BY THE **ASSOCIATION FOR PROJECT MANAGEMENT (APM)** IN MARCH 2013 SUGGESTS THAT:

- **PROJECTS MAY USE A WORK BREAKDOWN STRUCTURE DICTIONARY (WBSD), THE PURPOSE OF WHICH IS TO DESCRIBE THE ENTIRE SCOPE OF WORK TO BE UNDERTAKEN WITHIN THE PROJECT.**
- **IT MUST CAPTURE THE CONTRACT SCOPE AND ALL CONTRACT REQUIREMENTS.**
- TO ENABLE THIS TO BE CHECKED IT MUST PROVIDE A READY REFERENCE BETWEEN THE WBS AND CONTRACT ELEMENTS. IT ALSO PROVIDES THE BASIS FOR THE **SOW** INCLUDED ON THE CONTROL ACCOUNT PLANS.

SOME OTHER KEY CONCEPTS:

1. WORK BREAKDOWN STRUCTURE COMPONENT

AN ENTRY IN THE WORK BREAKDOWN STRUCTURE THAT CAN BE AT ANY LEVEL.

2. WORK PACKAGE

THE WORK DEFINED AT THE LOWEST LEVEL OF THE WORK BREAKDOWN STRUCTURE FOR WHICH **COST AND DURATION** CAN BE ESTIMATED AND MANAGED

3. WBS DICTIONARY (WBSD)

A DOCUMENT THAT PROVIDES DETAILED DELIVERABLE, ACTIVITY, AND SCHEDULING INFORMATION ABOUT EACH COMPONENT IN THE WBS

FOR EACH ELEMENT OF THE WBS, THE DICTIONARY SHOULD CONTAIN:

- A CONTRACT NUMBER;
- A WBS NUMBER AND TITLE;
- THE WBSD ISSUE NUMBER AND DATE;
- THE CONTRACT PARAGRAPH NUMBER;

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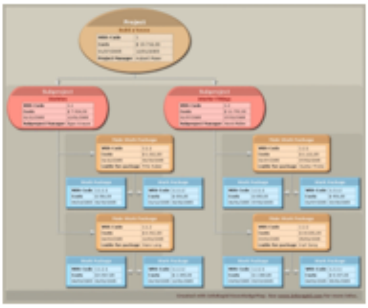
- A SOW (**STATEMENT OF WORK**) INCLUDING ALL CONTRACT DELIVERABLES TO BE PRODUCED AS PART OF THE WORK ELEMENT.

THE WBS DICTIONARY SHOULD INCLUDE ALL ELEMENTS TO BE SUB-CONTRACTED AND SHOULD SPECIFICALLY IDENTIFY THE SUB-CONTRACTOR UNDERTAKING THE WBS ELEMENT.



4. DELIVERABLE

ANY UNIQUE AND VERIFIABLE PRODUCT, RESULT OR CAPABILITY TO PERFORM A SERVICE THAT IS REQUIRED TO BE PRODUCED TO COMPLETE A PROCESS, A PHASE, OR PROJECT.

5. TREE STRUCTURE & OUTLINE

IN TERMS OF REPRESENTATION, A WBS CAN BE SHOWN VERTICALLY AS A TREE OR HORIZONTALLY IN OUTLINE FORM.

TREE STRUCTURE

WBS IS REPRESENTED AS AN INVERTED TREE STRUCTURE, THE ELEMENTS OF WHICH ARE:

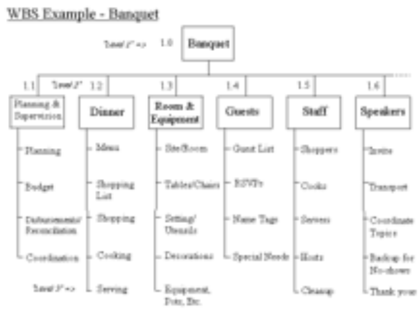
- **THE TOP**, WHICH REPRESENTS THE PURPOSE OF THE PROJECT;
- **LEAVES**, WHICH REPRESENT COMPONENTS OR WORK PACKAGES;
- **THE BRANCHES**, CORRELATIONS OF THE LEAVES.

THIS REPRESENTATION IS A "TOP-DOWN" METHODOLOGY, FROM THE TOP TO THE LEAVES, FOR THE STUDY OF THE PROJECT.

EVERY COMPONENT OF THE WBS (TOP AND LEAVES) HAS AN ALPHANUMERIC CODE THAT HAS THE PURPOSE OF IDENTIFYING EACH ELEMENT OF THE WBS.

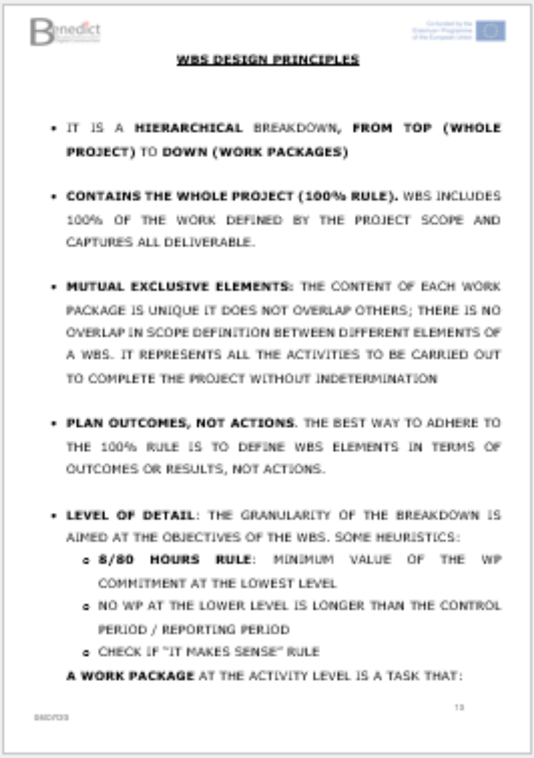
OUTLINE

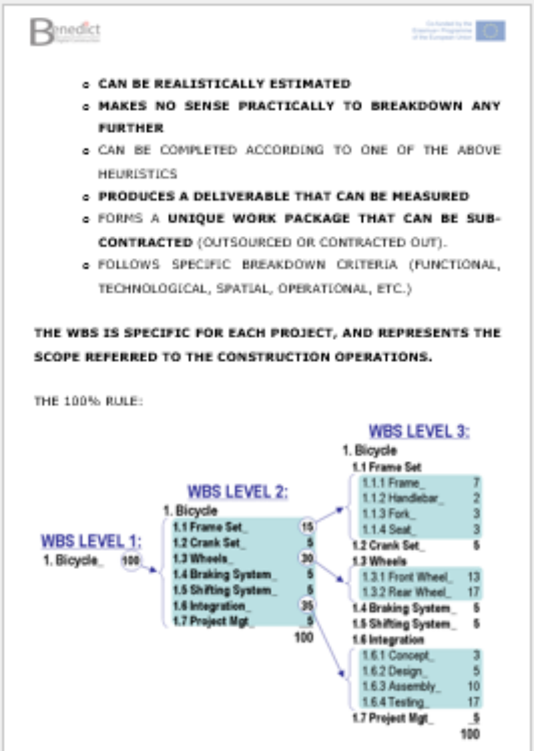
THE WBS REPRESENTED IN DESCRIPTIVE FORM – OUTLINE - IS MADE BY WRITING THE SET OF STRUCTURED ELEMENTS ACCORDING TO THE RESPECTIVE ALPHANUMERIC CODE.

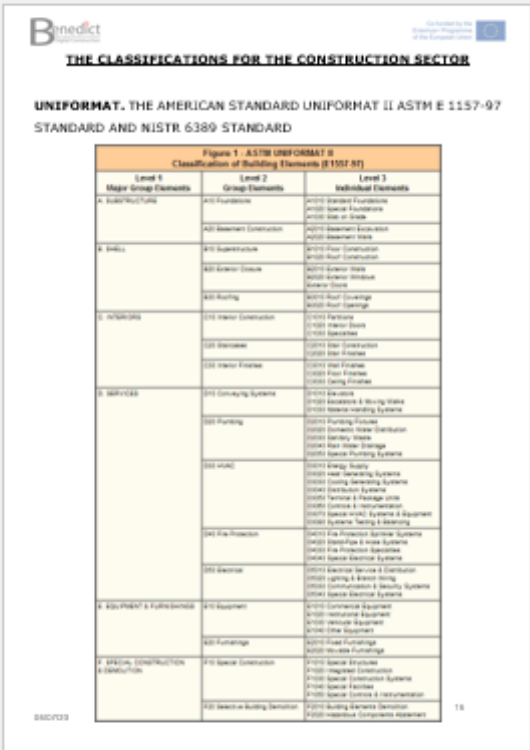


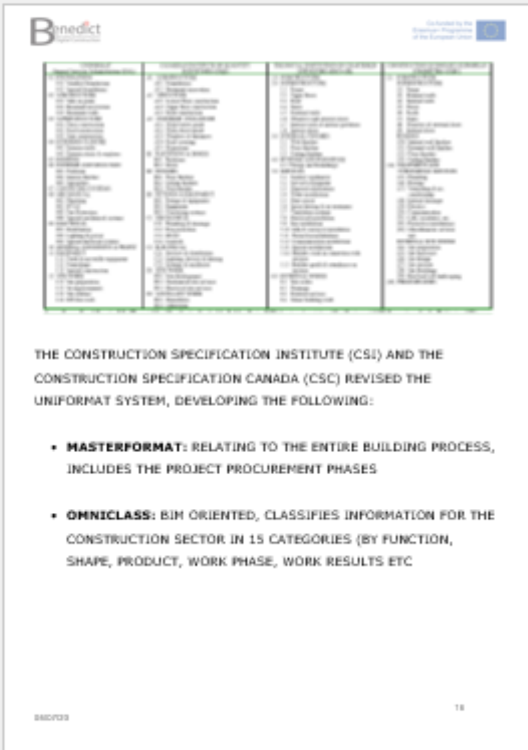
WBS – OUTLINE

1	BANQUET
1.1.	Planning and supervision
1.1.1	Planning
1.1.2	Budget
1.1.3	Disbursement/ reconciliation
1.1.4	Coordination
1.2	Dinner
1.3	Room and Equipment
1.4	Guests
1.5	Staff
1.6	Speakers


WBS DESIGN PRINCIPLES
IT IS A HIERARCHICAL BREAKDOWN, FROM TOP (WHOLE PROJECT) TO DOWN (WORK PACKAGES)
CONTAINS THE WHOLE PROJECT (100% RULE). WBS INCLUDES 100% OF THE WORK DEFINED BY THE PROJECT SCOPE AND CAPTURES ALL DELIVERABLE.
MUTUAL EXCLUSIVE ELEMENTS: THE CONTENT OF EACH WORK PACKAGE IS UNIQUE IT DOES NOT OVERLAP OTHERS; THERE IS NO OVERLAP IN SCOPE DEFINITION BETWEEN DIFFERENT ELEMENTS OF A WBS. IT REPRESENTS ALL THE ACTIVITIES TO BE CARRIED OUT TO COMPLETE THE PROJECT WITHOUT INDETERMINATION
PLAN OUTCOMES, NOT ACTIONS. THE BEST WAY TO ADHERE TO THE 100% RULE IS TO DEFINE WBS ELEMENTS IN TERMS OF OUTCOMES OR RESULTS, NOT ACTIONS.
LEVEL OF DETAIL: THE GRANULARITY OF THE BREAKDOWN IS AIMED AT THE OBJECTIVES OF THE WBS. SOME HEURISTICS:
8/80 HOURS RULE: MINIMUM VALUE OF THE WP COMMITMENT AT THE LOWEST LEVEL
NO WP AT THE LOWER LEVEL IS LONGER THAN THE CONTROL PERIOD / REPORTING PERIOD
CHECK IF "IT MAKES SENSE" RULE
A WORK PACKAGE AT THE ACTIVITY LEVEL IS A TASK THAT:


CAN BE REALISTICALLY ESTIMATED
MAKES NO SENSE PRACTICALLY TO BREAKDOWN ANY FURTHER
CAN BE COMPLETED ACCORDING TO ONE OF THE ABOVE HEURISTICS
PRODUCES A DELIVERABLE THAT CAN BE MEASURED
FORMS A UNIQUE WORK PACKAGE THAT CAN BE SUB-CONTRACTED (OUTSOURCED OR CONTRACTED OUT).
FOLLOWS SPECIFIC BREAKDOWN CRITERIA (FUNCTIONAL, TECHNOLOGICAL, SPATIAL, OPERATIONAL, ETC.)
THE WBS IS SPECIFIC FOR EACH PROJECT, AND REPRESENTS THE SCOPE REFERRED TO THE CONSTRUCTION OPERATIONS.
THE 100% RULE:
WBS LEVEL 1:
1. Bicycle 100
WBS LEVEL 2:
1. Bicycle
1.1 Frame Set 15
1.2 Crank Set 5
1.3 Wheels 30
1.4 Braking System 5
1.5 Shifting System 5
1.6 Integration 35
1.7 Project Mgt 5
100
WBS LEVEL 3:
1. Bicycle
1.1 Frame Set
1.1.1 Frame 7
1.1.2 Handlebar 2
1.1.3 Fork 3
1.1.4 Seat 3
1.2 Crank Set 5
1.3 Wheels
1.3.1 Front Wheel 13
1.3.2 Rear Wheel 17
1.4 Braking System 5
1.5 Shifting System 5
1.6 Integration
1.6.1 Concept 3
1.6.2 Design 5
1.6.3 Assembly 10
1.6.4 Testing 17
1.7 Project Mgt 5
100


THE CLASSIFICATIONS FOR THE CONSTRUCTION SECTOR
UNIFORMAT. THE AMERICAN STANDARD UNIFORMAT II ASTM E 1157-97 STANDARD AND NISTR 6389 STANDARD
Figure 1 - ASTM UNIFORMAT II Classification of Building Elements (E1557-97)


THE CONSTRUCTION SPECIFICATION INSTITUTE (CSI) AND THE CONSTRUCTION SPECIFICATION CANADA (CSC) REVISED THE UNIFORMAT SYSTEM, DEVELOPING THE FOLLOWING:
MASTERFORMAT: RELATING TO THE ENTIRE BUILDING PROCESS, INCLUDES THE PROJECT PROCUREMENT PHASES
OMNICLASS: BIM ORIENTED, CLASSIFIES INFORMATION FOR THE CONSTRUCTION SECTOR IN 15 CATEGORIES (BY FUNCTION, SHAPE, PRODUCT, WORK PHASE, WORK RESULTS ETC

THE BREAKDOWN OF THE PROJECT AND THE WBS

THE BILL OF QUANTITIES IS BASED UPON THE BREAK DOWN OF THE CONSTRUCTION IN VARIOUS PARTES AND ON THEIR UNDERSTANDING WITH THE AIM OF QUANTIFYING THE WORK.

MATERIALS, WORK PACKAGES AND DELIVERABLES MUST BE BROKEN DOWN AND CLASSIFIED IN ORDER TO CREATE A RELATIONSHIP BETWEEN THE CLASSIFIED ELEMENTS (COST EVALUATED) WITH THE FINAL PRODUCT TO BE CONSTRUCTED, THE PROJECT.

THE BREAKDOWN OF A CONSTRUCTION PROJECT

THE CLASSIFICATION OF A CONSTRUCTION PROJECT IS BASED ON MATERIALS AND WORKPACKAGES

- IT IS BASED UPON SITE ORGANIZATION
- IT IS BASED UPON TRADES AND WORK CATEGORIES
- CREATES A RELATIONSHIP BETWEEN BUILDING COMPONENTS AND PRODUCTION PROCESS

IN THE CONSTRUCTION INDUSTRY, A PROJECT CAN BE BROKEN DOWN IN VARIOUS WAY. TRADITIONALLY, IN ORDER TO QUANTIFY AND EVALUATE ECONOMICALLY THE PROJECT, THE BREAKDOWN CAN BE ORGANIZED ACCORDING TO:

- **CATEGORIES OF WORK**, E.G. REINFORCED CONCRETE
- **FUNCTIONALLY HOMOGENEOUS COMPONENTS**, (TECHNOLOGICAL UNITS, CLASSES OF TECHNICAL ELEMENTS, TECHNICAL ELEMENTS. FOR EXAMPLE, FOUNDATIONS, SPREAD FOOTING, GROUND BEAMS, SINGLE FOOTING TYPE 1, TYPE 2 ETC.)
- **MANUFACTURING PROCESSES - WORK ITEMS**. PARTS OF CATEGORIES WITH HOMOGENEOUS TECHNICAL, FUNCTIONAL AND ECONOMIC FEATURES. PROCESSES THAT LEADS TO THE PRODUCTION OF A WELL IDENTIFICABLE AND MEASURABLE PRODUCTS OR BY-PRODUCTS OF THE WORK (E.G. CONCRETE CASTING)

A WORK ITEM IS DEFINED BY A COMPLETE DESCRIPTION OF ITS COMPONENTS IN EACH ASPECT:

- **TECHNICAL**: SPECIFIC TYPES OF MATERIALS AND THEIR QUANTITIES.
- **OPERATIONAL**: WORKING PROCEDURES AND OPERATIONS TO COMPUTE ALL-IN UNIT RATES

E.G. TRENCH EXCAVATION:

- **OPERATIONS:** ACTIVITIES THAT CANNOT BE BROKEN DOWN FURTHER, THAT CAN BE DESCRIBED WITH RESOURCES, DURATION AND COST.

E. G. TRENCH EXCAVATION MAY INCLUDE: EXCAVATION, SUPPORTING THE SIDES, LOADING THE SOIL ON A TRUCK, TRANSPORT OF THE REMOVED SOIL, UNLOADING, ETC.

- **RESOURCES:** EXCAVATOR, MACHINE OPERATOR, SKILLED WORKER, SEMI-SKILLED WORKER, TIMBER SUPPORTS ETC...

TYPES OF CONSTRUCTION WORK, CONTENTS OF CONSTRUCTION WORK, EXAMPLES.

(BY THE MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM OF JAPAN)

Types of Construction Work	Content of construction work	Examples
Public engineering	Construction of public works based on general planning, instruction, and control (incl. repair, improvement, or demolition work)	
Construction engineering	Construction of buildings based on general planning, instruction, and control (incl. repair, improvement, or demolition work)	
[illegible]	Construction of works by processing or applying wooden materials or application of wooden structures to work	Carpentry, mold work, and finish carpentry
Plasterwork	Applying, spraying, or affixing plaster, mortar, stucco, cement, fibers, etc. to work	Plasterwork, mortar work, concrete waterproofing, spray work, grinding work, and washing out
Scaffold [illegible]/concrete work	a) Assembly of scaffolding, transport and placement of heavy objects, such as mechanical apparatuses and construction materials, assembly of steel frames, and demolition	a) Scaffold work; salvage work; pulling work; construction of footings and other auxiliary structures; transport and placement (lifting) of heavy objects; assembly of steel frames; mounting of concrete blocks; and disassembly/demolition work
	b) Driving in or pulling out piles and in-place-casting of piles	b) Pile work, pile driving, pile pulling, and in-place-casting
	c) Excavation, piling up, or compression of earth or sand	c) Earth work, excavation, root-cutting, blasting operations, and embankment work
	d) Construction work using concrete	d) Concrete work, concrete driving work, concrete compression work, and prestressed concrete work
	e) Other basic or preliminary work	e) Landslide prevention, foundation improvement, boring grout, earth retaining, temporary coffering, spraying, highway section, riprap, external construction, and shipping work
Stone work	Processing of stone materials (including quasi-stones such as concrete block and imitation	Stone masonry or pitching and concrete block masonry or pitching

	stone) and production of stone works using masonry or by attaching stone to work	
Roof work	Roof-cladding with tiles, slate, or metal sheet	Roof-cladding work
Electrical work	Installation of power generation, transformer, power distribution, and interior electrical facilities	Power generation facilities, electrical wiring, lead-in line, transformer facilities, interior electrical facilities (including electrical facilities for emergency use), illumination facilities, railway line, traffic light facilities, and neon lamp facilities work
Piping work	Work for installation of coolers, air conditioners, water supplies, hygiene facilities, and facilities for transport of water, oil, gas, and steam using metal pipes	Cooling and heating facilities, freezer/refrigerator facilities, water/hot water supply facilities, kitchen facilities, hygiene facilities, water purification facilities, water toilet facilities, gas pipe, duct, and pipe rehabilitation work
Tile/brick/block work	Constructions with bricks or concrete blocks or work to apply or attach bricks, concrete blocks, or tiles to structures	Concrete block masonry (pitching), brick masonry (pitching), tile pitching, furnace building, and asbestos plate laying
Steel structure work	Processing steel forms or sheets or assembly of derived items from them	Work related to steel structures, bridges, steel towers, petrol or gas reservoirs, outside advertisements, and gate facilities for locks and [illegible]
Steel reinforcement work	Processing, connecting, and assembly of steel bars and other steel materials	Steel reinforcement processing and assembly and gas pressure welding
Paving work	Paving streets and other flat surfaces with asphalt, concrete, sand, gravel, or rubble	Asphalt, concrete, and block paving and road construction
Dredging work	Dredging the bottoms of rivers and bays	Dredging work
Sheet metal work	Attaching metal sheet to structures or attaching metal sheet fixtures to structures	Sheet metal processing and attachment and sheet metal work related to building construction
Glass work	Installation of glass in structures	Glass processing and installation work
Coating work	Spraying, coating, or attaching coating materials to structures	Coating, spraying, lining, textile upholstering and finishing, steel structures painting, and pavement marking
Waterproofing work	Waterproofing with asphalt, mortar, or sealing materials	Asphalt waterproofing, mortar waterproofing, sealing work, paint membrane waterproofing, sheet waterproofing, and injection waterproofing
Interior finishing	Interior finishing using wood, plaster board, sound absorbing board, wallpaper, tatami mat, vinyl floor tiles, carpeting, or fusuma sliding doors	Interior work, ceiling finishing work, wallpapering, interior room finishing work, floor finishing work, tatami work, fusuma work, furniture work, and soundproofing
Machinery installation	Building of structures through assembly of machinery or attaching machinery to structures	Plant installation, transport machinery setup, internal combustion power plant installation, separating machinery setup, water collecting machinery setup, storage

		and drainage machinery setup, temporary dam setup, children's play facilities installation, stage set setup, silo installation, and automobile parking facilities work
Thermal insulation work	Thermally insulating structures or their facilities	Cooling and heating installation, freezing and refrigeration work, thermally insulating motive power facilities the facilities of fuel or chemical industries
Telecommunications work	Installation of wired telecommunication facilities, wireless telecommunication facilities, broadcasting machinery facilities, or data communication facilities	Telecommunication line facilities work, broadcasting machinery facilities work, antenna facilities work, data communication facilities work, information control facilities work, and work on facilities for the prevention of TV wave disturbances
Landscape gardening	Land forming, tree planting, and construction of gardens, parks, and green areas by placement landscape stones	Planting trees and plants, soil-cover work, site preparation work, park facilities work, work related to public places, park road work, waterscape work, and planting of vegetation on rooftops
Well-drilling work	Hole and well drilling using well drilling machinery and subsequent water pumping facilities work	Well drilling, observation well work, injection well work, hot spa drilling work, well construction work, hole drilling work, petrol drilling work, natural gas drilling work, and water pumping facilities work
Fixture work	Attachment of wooden or metal fittings to structures	Work related to attachment of metal fittings, sashes, metal curtain walls, shutters, automatic doors, wooden fittings, and fusuma
Water facilities work	Construction of facilities for water intake, water purification, or water distribution for public water supplies or factories or installation of public sewage or basin sewage handling facilities	Work related to water-intake facilities, water purification facilities, water distribution facilities, and sewage handling
Firefighting facilities work	Installation of disaster warning facilities, fire extinguishing facilities, evacuation facilities, or facilities for firefighting or installation of such facilities in structures	Interior fire hydrant installation work; sprinkler installation work; work on facilities for firefighting with water spray, foam, nonflammable gas, volatile liquids, or powders; exterior fire hydrant installation; movable firefighting pump installation; fire alarm facilities work; short circuit fire alarm facilities work; emergency alarm facilities work; and installation of metal evacuation ladders, escape chutes, slowdown machines, evacuation bridges, or smoke emission facilities
Waste facilities work	Installation of human waste management or garbage management facilities	Garbage management facilities and human waste management facilities work

WBS FOR A BUILDING PROJECT

AN EXAMPLE IS **THE BUILDING OF A HOUSE** WHICH REPRESENTS THE **TOP-LEVEL DELIVERABLE.**

STARTING WITH THIS END OBJECTIVE, WBS DETERMINES A HIERARCHY BY SUBDIVIDING THE PROJECT INTO MANAGEABLE COMPONENTS (OR SUB-DELIVERABLES, E.G. SYSTEMS, SUBSYSTEMS, COMPONENTS, TASKS AND SUBTASKS), THEREBY DEFINING ALL THE NECESSARY STEPS TO ACHIEVE THE END GOAL (IE THE FINISHED BUILDING) IN INCREASING LEVELS OF DETAIL.

FOR EXAMPLE, THIS MAY MEAN:

- **LEVEL 1 TOP-LEVEL DELIVERABLE OR PROJECT** (THE FINISHED BUILDING).
- **LEVEL 2:** SUB-DIVIDING THE PROJECT INTO **MAIN COMPONENTS,** EG **SUBSTRUCTURE AND SUPERSTRUCTURE.**
- **LEVEL 3:** BREAKING DOWN EACH COMPONENT INTO **SMALLER COMPONENTS** (EG **SUBSTRUCTURE > EXCAVATION**).
- **LEVEL 4:** BREAKING DOWN EACH COMPONENT INTO MORE COMPONENTS – **WORK ITEMS.** (**EG EXCAVATION > PLACE REINFORCEMENT**)

- **LEVEL N: FINAL BREAKDOWN INTO SMALLEST COMPONENT – WORK PACKAGES (EG PLACE REINFORCEMENT > POUR CONCRETE)**

THE PROCESS IS BROKEN DOWN UNTIL **A POINT IS REACHED AT WHICH SUFFICIENT DETAIL EXISTS TO ALLOW PRECISE PLANNING AND MANAGEMENT. THIS LOWEST LEVEL IS KNOWN AS LEVEL N** (SEE ABOVE).

AT THIS LEVEL, THE WORK IS ASSIGNED TO A SPECIFIC DEPARTMENT OR UNIT TO UNDERTAKE THE WORK.

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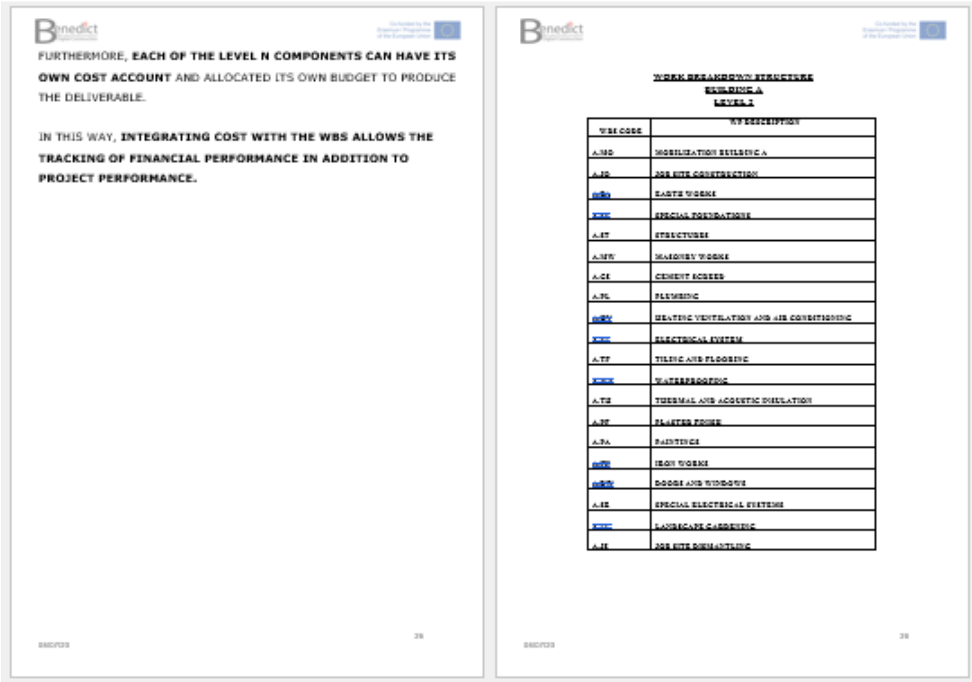
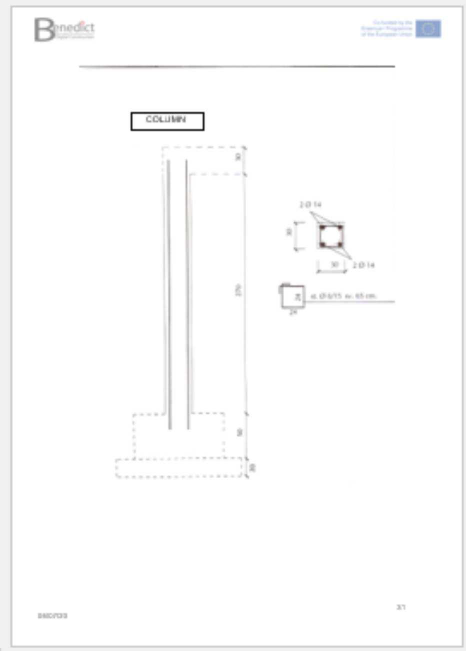


FURTHERMORE, **EACH OF THE LEVEL N COMPONENTS CAN HAVE ITS OWN COST ACCOUNT** AND ALLOCATED ITS OWN BUDGET TO PRODUCE THE DELIVERABLE.

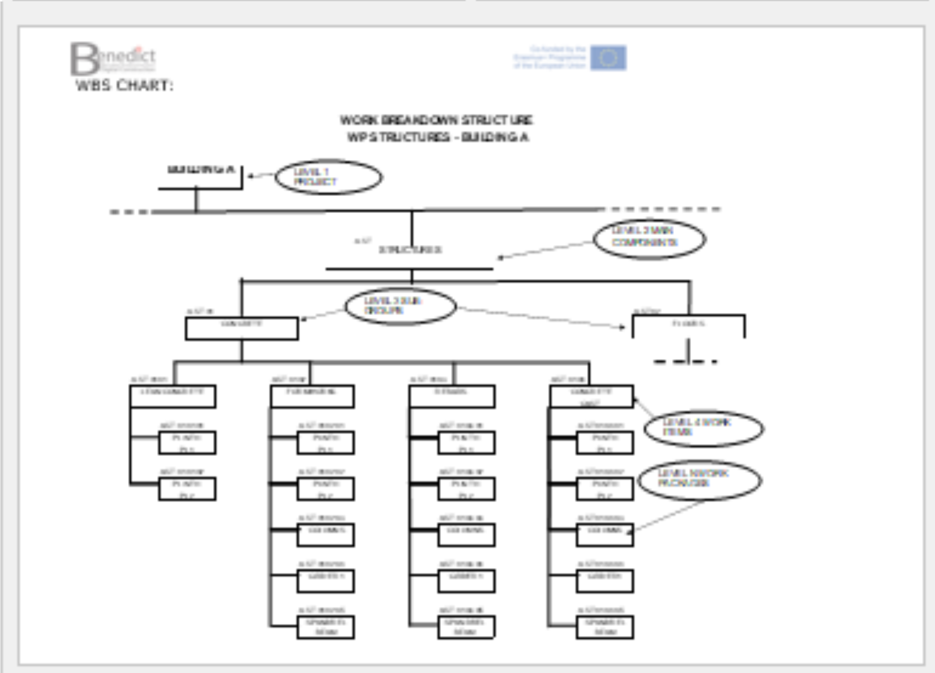
IN THIS WAY, **INTEGRATING COST WITH THE WBS ALLOWS THE TRACKING OF FINANCIAL PERFORMANCE IN ADDITION TO PROJECT PERFORMANCE.**

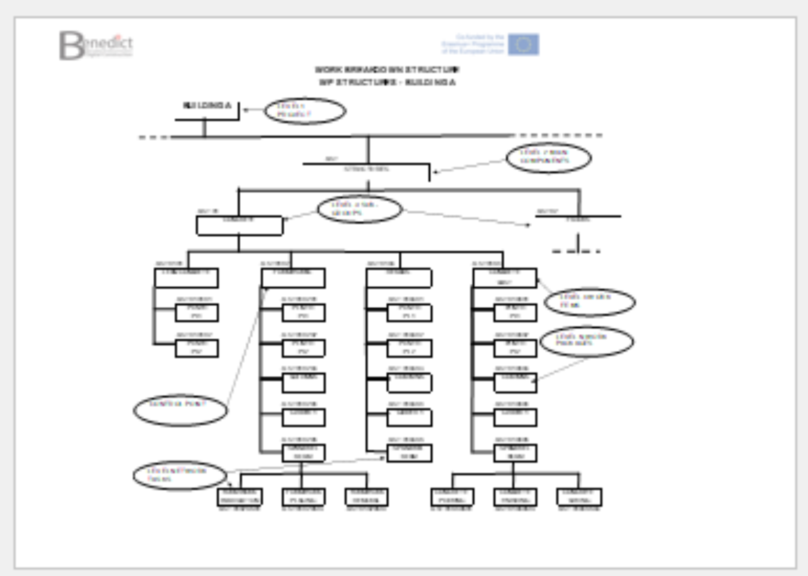
WORK BREAKDOWN STRUCTURE
BUILDING A
LEVEL 2

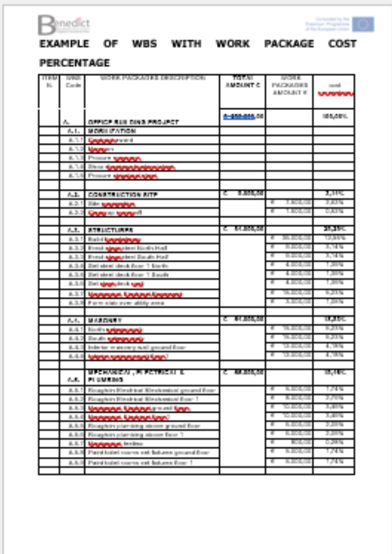
WBS CODE	WP DESCRIPTION
A.MO	MOBILIZATION BUILDING A
A.JO	JOB SITE CONSTRUCTION
[illegible]	EARTH WORKS
[illegible]	SPECIAL FOUNDATIONS
A.ST	STRUCTURES
A.MW	MASONRY WORKS
A.CE	CEMENT SCREED
A.PL	PLUMBING
[illegible]	HEATING VENTILATION AND AIR CONDITIONING
[illegible]	ELECTRICAL SYSTEM
A.TF	TILING AND FLOORING
[illegible]	WATERPROOFING
A.TI	THERMAL AND ACOUSTIC INSULATION
A.PF	PLASTER FINISH
A.PA	PAINTINGS
[illegible]	IRON WORKS
[illegible]	DOORS AND WINDOWS
A.SE	SPECIAL ELECTRICAL SYSTEMS
[illegible]	LANDSCAPE GARDENING
A.JE	JOB SITE DISMANTLING

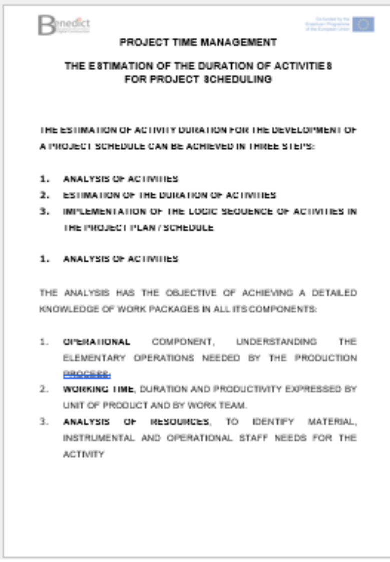

COLUMN

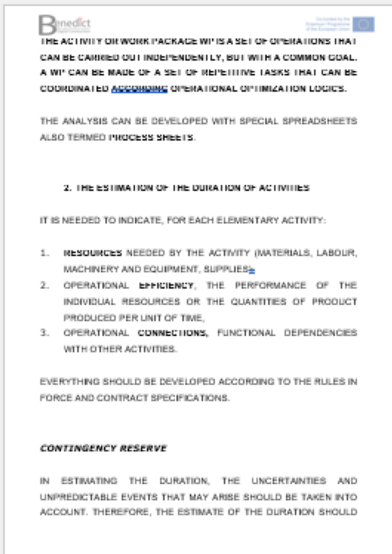

WBS OUTLINE:
WORK BREAKDOWN STRUCTURE
WP STRUCTURES - BUILDING A


WBS CHART:
WORK BREAKDOWN STRUCTURE
WP STRUCTURES - BUILDING A
BUILDING A
LEVEL 1 PROJECT
STRUCTURES
LEVEL 2 MAIN COMPONENTS
LEVEL 3 SUB GROUPS
LEVEL 4 WORK ITEMS
LEVEL 5 WORK PACKAGES




EXAMPLE OF WBS WITH WORK PACKAGE COST PERCENTAGE


PROJECT TIME MANAGEMENT
THE ESTIMATION OF THE DURATION OF ACTIVITIES FOR PROJECT SCHEDULING
THE ESTIMATION OF ACTIVITY DURATION FOR THE DEVELOPMENT OF A PROJECT SCHEDULE CAN BE ACHIEVED IN THREE STEPS:
1. ANALYSIS OF ACTIVITIES
2. ESTIMATION OF THE DURATION OF ACTIVITIES
3. IMPLEMENTATION OF THE LOGIC SEQUENCE OF ACTIVITIES IN THE PROJECT PLAN / SCHEDULE
1. ANALYSIS OF ACTIVITIES
THE ANALYSIS HAS THE OBJECTIVE OF ACHIEVING A DETAILED KNOWLEDGE OF WORK PACKAGES IN ALL ITS COMPONENTS:
1. OPERATIONAL COMPONENT, UNDERSTANDING THE ELEMENTARY OPERATIONS NEEDED BY THE PRODUCTION PROCESS.
2. WORKING TIME, DURATION AND PRODUCTIVITY EXPRESSED BY UNIT OF PRODUCT AND BY WORK TEAM.
3. ANALYSIS OF RESOURCES, TO IDENTIFY MATERIAL, INSTRUMENTAL AND OPERATIONAL STAFF NEEDS FOR THE ACTIVITY


THE ACTIVITY OR WORK PACKAGE WP IS A SET OF OPERATIONS THAT CAN BE CARRIED OUT INDEPENDENTLY, BUT WITH A COMMON GOAL. A WP CAN BE MADE OF A SET OF REPETITIVE TASKS THAT CAN BE COORDINATED ACCORDING OPERATIONAL OPTIMIZATION LOGICS.
THE ANALYSIS CAN BE DEVELOPED WITH SPECIAL SPREADSHEETS ALSO TERMED PROCESS SHEETS.
2. THE ESTIMATION OF THE DURATION OF ACTIVITIES
IT IS NEEDED TO INDICATE, FOR EACH ELEMENTARY ACTIVITY:
1. RESOURCES NEEDED BY THE ACTIVITY (MATERIALS, LABOUR, MACHINERY AND EQUIPMENT, SUPPLIES;
2. OPERATIONAL EFFICIENCY, THE PERFORMANCE OF THE INDIVIDUAL RESOURCES OR THE QUANTITIES OF PRODUCT PRODUCED PER UNIT OF TIME,
3. OPERATIONAL CONNECTIONS, FUNCTIONAL DEPENDENCIES WITH OTHER ACTIVITIES.
EVERYTHING SHOULD BE DEVELOPED ACCORDING TO THE RULES IN FORCE AND CONTRACT SPECIFICATIONS.
CONTINGENCY RESERVE
IN ESTIMATING THE DURATION, THE UNCERTAINTIES AND UNPREDICTABLE EVENTS THAT MAY ARISE SHOULD BE TAKEN INTO ACCOUNT. THEREFORE, THE ESTIMATE OF THE DURATION SHOULD

INCLUDE AN ADDITIONAL SAFETY "BUFFER" TIME, CALLED THE CONTINGENCY RESERVE.

THE CONTINGECY RESERVE MAY BE A PERCENTAGE OF INCREASE OF THE DURATION OR A FIXED NUMBER OF WORKING PERIODS ADDED TO THE TIME OF THE ACTIVITY.

METHODS FOR THE ESTIMATION OF THE DURATION

INFORMATION CAN BE OBTAINED DIRECTLY OR INDIRECTLY.

DIRECT ESTIMATION

CAN BE DEVELOPED BY DETECTING KNOWLEDGE FROM SURVEYS CARRIED OUT AT SIMILAR ACTIVITIES IN PROGRESS AT OTHER SITES.

IT IS THE METHOD OF ESTIMATION BY ANALOGY.

ESTIMATION OF DURATION BY ANALOGY

THE DURATION OF AN ACTIVITY IS ASSESSED BY COMPARISON WITH SIMILAR WORK CARRIED OUT PREVIOUSLY.

1. THE **SIZE OF THE WORK CARRIED OUT PREVIOUSLY IS COMPARED WITH THE SIZE OF THE WORK TO BE DONE.** THUS THE RATE BETWEEN THE SIZE OF THE WORK TO BE CARRIED OUT (CURRENT) AND THE LIKE IS MULTIPLIED BY THE PREVIOUS WORKING TIME IN ORDER TO OBTAIN AN ESTIMATE.
2. TO MAKE THE ESTIMATE MORE ACCURATE IT IS POSSIBLE TO FACTORIZE **SOME INDICATORS**, FOR EXAMPLE THE OVERALL WORKING TIME AVAILABILITY.
3. **THIS TYPE OF ESTIMATE IS USED WHEN AN ACCURATE ESTIMATE IS REQUIRED BUT NO DETAILED ACTIVITY DATA ARE AVAILABLE.**
4. **IT'S A QUICK BUT INACCURATE ESTIMATE**

EXAMPLE:

DURATION ESTIMATE BY ANALOGY	
SIMILAR ACTIVITY DETECTED	*THE DESCRIPTION OF THE SIMILAR ACTIVITY PREVIOUSLY DETECTED IS INSERTED.* E.G. LAYING OF 160 SQUARE METERS OF STEEL FLOOR SYSTEM WITH CORRUGATED METAL FORM AND CONCRETE SLAB
DURATION OF SIMILAR ACTIVITY	*ENTER THE DURATION PREVIOUSLY DETECTED:* E.G. 10 DAYS
CURRENT ACTIVITY	*DESCRIPTION OF THE CURRENT ACTIVITY INCLUDING ANY DIFFERENCE.* E.G. LAYING OF 200 SQUARE METERS OF STEEL FLOOR SYSTEM WITH CORRUGATED METAL FORM AND CONCRETE SLAB
MULTIPLICATIVE FACTOR	*THE SIZE OF THE CURRENT ACTIVITY IS DIVIDED BY THE SIMILAR ACTIVITY:* E.G. 200/160 = 1.25
ESTIMATE OF DURATION	*THE DURATION OF SIMILAR ACTIVITY IS MULTIPLIED BY THE MULTIPLICATIVE FACTOR TO OBTAIN AN ESTIMATE OF THE DURATION OF THE CURRENT ACTIVITY* E.G. 10 X 1.25 = 12.5 DAYS

INDIRECT ESTIMATE

THE NECESSARY DATA ARE DETECTED FROM REFERENCES AND BIBLIOGRAPHICAL INFORMATION (E.G. SCHEDULE OF RATES, UNITE RATE / PRICE **ANALYSIS, BOOKS I.E. RS MEANS BUILDING ESTIMATING MANUAL)** OR ON SURVEYS CARRIED OUT AT PREVIOUS SITES RELATING TO THE PRODUCTIVITY OF CREWS OR EQUIPMENT. **IT'S THE ESTIMATE BASED ON PRODUCTIVITY RATES, DAILY OUTPUTS, OR LABOR - DAYS / MAN - HOURS.**

IN THE INDIRECT METHOD, DATA ON THE PRODUCTIVITY OF EQUIPMENT, PLANTS AND OPERATORS ARE ANALYSED IN DETAIL.

- **EQUIPMENT**: DATA NEED TO BE RELATED TO TYPES OF PROCESSING AND DAILY OUTPUTS ACHIEVABLE IN DIFFERENT WORKING CONDITIONS. DATA CAN BE PROVIDED BY MANUFACTURERS IN MACHINE IDENTIFICATION SHEETS, OR BY DATA FROM SURVEYS.
- **OPERATORS:** DATA CAN BE GATHERED FROM **WORK REPORTS, PRODUCTION TABLES** SHOWING THE TIME REQUIRED FOR THE PRODUCTING A UNIT OF PRODUCT (E.G. RS MEANS), DATA AVAILABLE IN COMPANY DATA BASES, SCHEDULE OF RATES OR **UNIT RATES OR PRICE ANALYSES**. THEREFORE, THE TOTAL DURATION OF EACH PRODUCTION CYCLE AND THE QUANTITY OF PRODUCT PRODUCED IN THE UNIT OF TIME CAN BE DETECTED. THE BASIS IS THE DAILY OUTPUT DETECTED IN THE SURVEYED PROCESSES.

IF THESE ARE UNIQUE **PROCESSES** OF WHICH NO INDIRECT DATA ARE AVAILABLE, SAMPLING CAN BE MADE ON EXPERIMENTAL PRODUCTIONS CARRIED OUT IN THE EARLY STAGES OF THE SITE, DETECTED THROUGH PROCESS SHEETS / **PLAN OF OPERATIONS** WHICH INDICATE:

1. OPERATING PROCEDURES,
2. PRODUCTION TIMES,
3. CHARACTERISTICS OF WORKPLACES (EQUIPMENT, SIZE, NUMBER OF LABORERS AND SKILLS),
4. POSITION TAKEN BY MACHINES AND OPERATORS DURING THE COURSE OF THE WORK.

THIS IS A PARAMETRIC ESTIMATE BASED ON PRODUCTIVITY DATA WHICH DIRECTLY IDENTIFY THE DURATION ACCORDING TO THE AMOUNT OF WORK (**PRODUCTIVITY RATE**) OR THE EFFORT OF RESOURCES TO COMPLETE THE ACTIVITY MEASURED IN **LABOR-DAYS OR LABOR-HOURS OF LABOR (OR EQUIPMENT-HOURS)**.

BASIC ELEMENTS ARE:

- **CREW OF WORKERS. IT IS AN OPERATIONAL ENTITY THAT CARRY OUT PRODUCTION** INDEPENDENTLY, ALTHOUGH OPERATORS MAY USE EQUIPMENT AND MACHINES AVAILABLE ON SITE AND OR COORDINATED BY THE CONSTRUCTION SITE MANAGEMENT TEAM, AND USED BY OTHER CREWS. THE CREW MAY BE COMPOSED BY ONLY ONE EMPLOYEE OR SEVERAL EMPLOYEES WITH FUNCTIONAL COMPLEMENTARITY (WORKING GROUPS

IT SHOULD BE UNDERLINED THAT:

1. **WORKING ALONE IS** NEVER RECOMMENDED FOR SAFETY REASONS, WITH THE EXCEPTIONS OF SPECIFIC PROVISIONS ON HEALTH SAFETY (COVID-19)
2. THERE IS GENERALLY **A MINIMUM THRESHOLD AND A MAXIMUM NUMBER LIMIT OF OPERATORS** TO PERFORM THE ACTIVITY (BOTH FOR PRODUCTION AND SAFETY REASONS).

- THE UNIT OUTPUT OR **DAILY OUTPUT (DO)** (UNIT/DAY) OF THE CREW REPRESENTS THE AMOUNT OF PRODUCT COMPLETED BY THE CREW IN A CONVENTIONAL EIGHT-HOUR WORKING DAY. THE **PRODUCTIVITY RATE** IS THE UNIT OF OUTPUT PRODUCED IN ONE HOUR (UNIT/HOUR).

OR:

- **THE UNIT PERFORMANCE TIME (UPT)** (HOUR/UNIT) REPRESENTS THE AMOUNT OF TIME IT TAKES THE TEAM TO COMPLETE A UNIT OF MEASURE OF THE FINAL PRODUCT.

THE DURATION (D) IN DAYS OF AN ACTIVITY CAN BE ESTIMATED BY DIVIDING THE QUANTITY OF PRODUCT **(QP)** BY THE DAILY OUTPUT **(DO)**, OR BY MULTIPLYING THE QUANTITY OF PRODUCT BY THE UNIT PERFORMANCE TIME **(UPT)**:

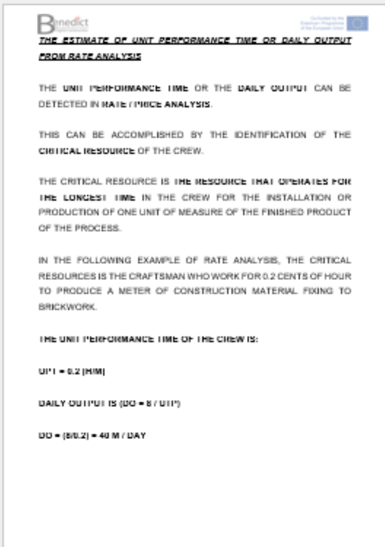
D = QP / DO

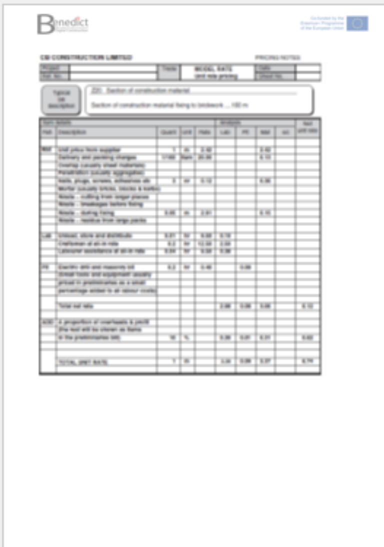
OR

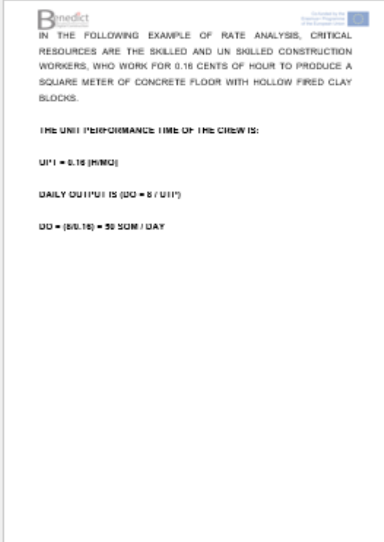
D = QP x UPT

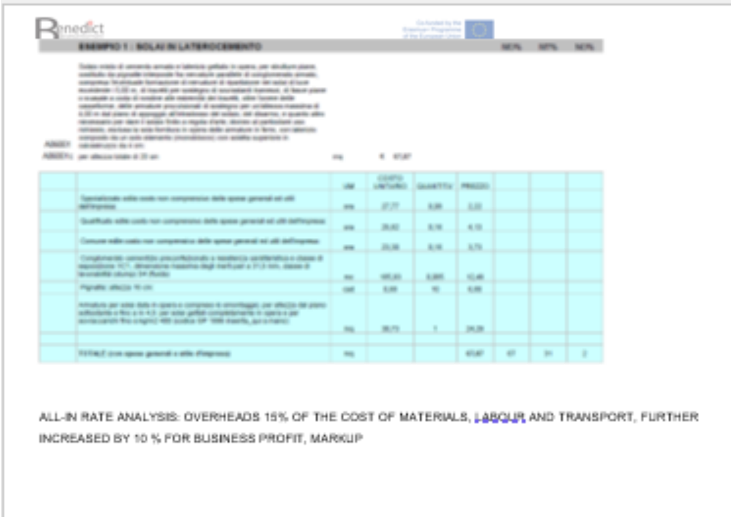
IN THE CASE OF MULTIPLE CREWS, TOTAL DAILY OUTPUT CAN BE ESTIMATED BY MULTIPLYING THE DAILY OUTPUT BY THE NUMBER OF CREWS AND EQUIPMENT.

FIGURE: RS MEANS BUILDING COST HANDBOOK EXECERPT


THE ESTIMATE OF UNIT PERFORMANCE TIME OR DAILY OUTPUT FROM RATE ANALYSIS
THE UNIT PERFORMANCE TIME OR THE DAILY OUTPUT CAN BE DETECTED IN RATE / PRICE ANALYSIS.
THIS CAN BE ACCOMPLISHED BY THE IDENTIFICATION OF THE CRITICAL RESOURCE OF THE CREW.
THE CRITICAL RESOURCE IS THE RESOURCE THAT OPERATES FOR THE LONGEST TIME IN THE CREW FOR THE INSTALLATION OR PRODUCTION OF ONE UNIT OF MEASURE OF THE FINISHED PRODUCT OF THE PROCESS.
IN THE FOLLOWING EXAMPLE OF RATE ANALYSIS, THE CRITICAL RESOURCES IS THE CRAFTSMAN WHO WORK FOR 0.2 CENTS OF HOUR TO PRODUCE A METER OF CONSTRUCTION MATERIAL FIXING TO BRICKWORK.
THE UNIT PERFORMANCE TIME OF THE CREW IS:
UPT = 0.2 [H/M]
DAILY OUTPUT IS (DO = 8 / UTP)
DO = (8/0.2) = 40 M / DAY




IN THE FOLLOWING EXAMPLE OF RATE ANALYSIS, CRITICAL RESOURCES ARE THE SKILLED AND UN SKILLED CONSTRUCTION WORKERS, WHO WORK FOR 0.16 CENTS OF HOUR TO PRODUCE A SQUARE METER OF CONCRETE FLOOR WITH HOLLOW FIRED CLAY BLOCKS.
THE UNIT PERFORMANCE TIME OF THE CREW IS:
UPT = 0.16 [H/MQ]
DAILY OUTPUT IS (DO = 8 / UTP)
DO = (8/0.16) = 50 SQM / DAY


ALL-IN RATE ANALYSIS: OVERHEADS 15% OF THE COST OF MATERIALS, LABOUR AND TRANSPORT, FURTHER INCREASED BY 10 % FOR BUSINESS PROFIT, MARKUP

THE WORK SHEETS OF THE PRODUCTION PROCESS

THEY ARE TABLES THAT LIST THE ACTIVITIES OF THE PROJECT AND THE ESTIMATE OF THEIR DURATIONS.

THE AIMS ARE MANIFOLD:

1. CHRONOLOGICALLY SORT ALL THE ACTIVITIES (PROCESSES) AS IDENTIFIED BY THE BILL OF QUANTITIES AND CONTRACT DOCUMENTATION;
2. COMPOSE ACTIVITIES OR PROCESSES ACCORDING TO THE **WBS AND CREATE THE WORK PACKAGES;**
3. CHOOSE, ALBEIT IN PRINCIPLE, THE QUANTITY AND TYPE OF OPERATORS AND MACHINES;
4. ESTIMATE THE EXECUTION TIMES OF EACH ACTIVITY, SUB-PROCESS AND CONSTRUCTION WORK PACKAGE.

A PREREQUISITE FOR DEFINING THE WORK SHEETS OF THE PRODUCTION PROCESS IS THE KNOWLEDGE OF:

1. PROJECT DETAILED DRAWINGS;
2. BILL OF QUANTITIES;
3. OPERATIONS NOT EXPLICITLY INDICATED IN THE BOQ METRIC CALCULATION BECAUSE THEY ARE ACCOUNTED FOR IN SAFETY COSTS OR TOGETHER WITH OTHER ITEMS: PREPARATION AND EQUIPMENT OF CONSTRUCTION SITES, FENCES, CONSTRUCTION OF TEMPORARY WORKS, CLEARANCE OF THE AREA AND COMPLETE OF WORK.

ONCE THE TOTAL CONTRACT PROJECT DURATION IS CONTRACT DOCUMENTATION, AND THE DESIGN PROCESS IS COMPLETED THUS IDENTIFING THE MORPHOLOGICAL AND TECHNOLOGICAL CHARACTERISTICS OF THE FINAL PRODUCT AND THE CHOOSEN CONSTRUCTION SUB-PROCESSES, THE ONLY VARIABLES ARE **THE AMOUNT OF RESOURCES, FOR PRODUCTION, I.E. THE TYPE AND NUMBER OF CREWS AND MACHINES, AND THEIR PRODUCTIVITY.**

EXAMPLE OF WORK SHEETS OF THE PRODUCTION PROCESS

WORK SHEETS OF THE PRODUCTION PROCESS

PHASE No.
Work
System

Code:

ITEM N.	WBS CODE	DESCRIPTION	UNITS	QUANTITY	EQUIPMENT	N. CREWS	DAILY OUTPUT	TOTAL DAILY OUTPUT	DURATION IN DAYS
1	A.01.01	Wooden panel construction site fence	LM	120		2	30	60	2

WORK SHEETS OF THE PRODUCTION PROCESS

N° D'ORDINE	CATEGORIA	DESIGNAZIONE DEI LAVORI	UNITÀ DI MISURA	QUANTITÀ	ATTREZZATURE IMPIEGATE	N° SQUADRE	PRODUZIONE UNITARIA	PRODUZIONE TOTALE	DURATA IN GIORNI
1	2M	[illegible]							1
2	2M	[illegible]	ml	140	[illegible]	1	180	180	2
3	2M	[illegible]	n°	4	[illegible]	1	8	8	1
4	2M	[illegible]	n°	2		1	2	2	1
5	2M	[illegible]	ml	200	[illegible]	1	70	70	3
6	2M	[illegible]	n°	13	[illegible]	1	7	7	2
7	2M	[illegible]	n°	176	[illegible]	1	35	35	5
8	MO	[illegible]	m³	18	[illegible]	1	4	4	4
9	PO	[illegible]	ml	1710	[illegible]	1	62	62	28
10	PO	[illegible]	kg	20240	[illegible]	1	723	723	28
11	PO	[illegible]	m³	284	[illegible]	1	11	11	24
12	PO	[illegible]	n°	2	[illegible]	1	2	2	1
13	PO	[illegible]	kg	37079	[illegible]	1	2472	2472	15
14	MO	[illegible]	m³	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]

THE ESTIMATION OF ACTIVITY DURATION BASED ON LABOR - DAYS

OFTEN, THE ESTIMATION OF THE DURATION OF AN ACTIVITY IS CALCULATED BY DETECTING THE AMOUNT OF WORK CONTAINED IN THE ACTIVITY (ALSO TERMED **"EFFORT"**) INDICATED BY THE **NUMBER OF DAYS OF LABOUR, LABOR-DAYS** (OR THE **NUMBER OF HOURS, "MAN HOURS"**), DEDUCED FROM COST ESTIMATIONS.

LABOR-DAY: THE AMOUNT OF WORK ASSUMED BY THE SUM OF THE WORKING DAYS WORKED BY LABORERS TO PRODUCE THE CONSTRUCTION WORK

AN INITIAL ESTIMATE OF THE AMOUNT OF WORK OF AN ACTIVITY EXPRESSED IN **LABOR - DAYS (LD)**, I.E. FOR A STANDARD WORKING DAY OF 8 HOURS OF LABOUR, CAN BE CARRIED OUT BY EVALUATING THE **TOTAL LABOUR COST (TLC) FOR THE ACTIVITY:**

INDICATING **THE AMOUNT OF THE WORK PACKAGE (AWP)**, TAKING INTO ACCOUNT THE **LABOUR INDEX (L%)** EQUAL TO THE AVERAGE RATE OF LABOUR COST, WE HAVE:

TLC = AWP x L%

BY DIVIDING THE TOTAL LABOUR COST BY THE **AVERAGE ONE-DAY LABOUR COST OF A WORKER (LC)** EQUAL TO, FOR EXAMPLE,

LC = 25 €/h x 8 h = 200 €

THE **TOTAL NUMBER OF LABOR DAYS LD** OF AN ACTIVITY (EFFORT) WILL BE:

LD = TLC / LC = (AWP x L%) / LC

INDICATING **WITH N THE NUMBER OF UNITS OF PERSONNEL** OF THE CREW, **THE DURATION OF THE ACTIVITY WILL BE:**

D = LD / N

THIS APPROXIMATE ASSESSMENT HAS AS ITS FUNDAMENTAL ELEMENT THE DIFFICULT IDENTIFICATION OF THE LABOUR **INDEX L%**, WHICH ALSO VARIES WITHIN THE SAME WORK ITEM ACCORDING TO PROCEDURES, PRODUCTIVITY AND PRODUCTION CONTEXT.

IN PARTICULAR, BY CONSIDERING THE DAILY COST OF A LABORER €200, WITH THE AVERAGE LABOUR INDEX ESTIMATED AT 40%, A COST OF 600 EUROS IS OBTAINED FOR

STANDARD PROCESSING IN A WORKING DAY, FOR A CONSTRUCTION WORKER.

IT IS ALSO POSSIBLE TO **INSERT CORRECTIVE INDEXES** ACCORDING TO:

1. **PERCENTAGE OF** TIME RESOURCES ARE AVAILABLE (**PERCENT *AVAILABLE***) TO CARRY OUT THE ACTIVITY (E.G. 75%)
2. **PERFORMANCE FACTOR** ACCORDING TO THE PRODUCTION CAPACITY OF RESOURCES: FOR EXAMPLE, THE AVERAGE RESOURCE HAS A FACTOR OF 1, VERY SPECIALIZED RESOURCES CAN ALSO HAVE 0.8, LOW-SKILLED RESOURCES 1.2.

EXAMPLE:

EFFORT HOURS	AMOUNT OF WORK IN HOURS OF LABOUR (OR DAYS) E.G. E=150 HOURS (EFFORT)
AMOUNT OF RESOURCES	NUMBER OF PEOPLE OF THE TEAM EG. N = 2
PERCENTAGE OF AVAILABILITY	THE TIME (AS A PERCENTAGE) OF AVAILABILITY PER DAY OR PER WEEK (IF KNOWN) IS INDICATED. EG. % A = 75%
PERFORMANCE FACTOR	(IN CASE OF A LOT OF DIFFERENCE BETWEEN THE PRODUCTIVITY OF RESOURCES) A FACTOR OF 0.8 IS INSERTED FOR SPECIALISTS, 1 FOR AVERAGE AND 1.2 FOR LOW QUALIFIED E.G. PF=0.8 (HIGH SPECIALIZATION)
ESTIMATE OF DURATION (HOURS)	DURATION D (H) IS CALCULATED AS: **D (H)= E/(N x %A x PF)** EG. D(H) =150/(2x0.75x0.8)=125 HOURS
ESTIMATE OF DURATION (DAYS)	THE DURATION IN HOURS D(H) IS DIVIDED BY EIGHT HOURS PER DAY: D= 125/8 =15.625= 16 DAYS


IN ITALY, DATA CAN BE TAKEN FROM A SCHEDULE OF RATES (%MDO), E.G. PRICE BOOK PUBLIC WORKS LOMBARDY REGION:

IN THE EVENT OF A LACK OF DATA, AND ONLY IN THE FIRST APPROXIMATION, THE INDICATIONS OF THE D.M. OF 11 DECEMBER 1978 CAN BE TAKEN: "LABOUR FORCE INDEXES BY LABOUR CATEGORY, FOR THE PURPOSES OF PRICE UPDATING"

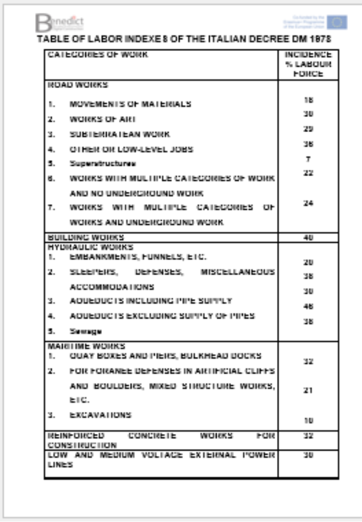
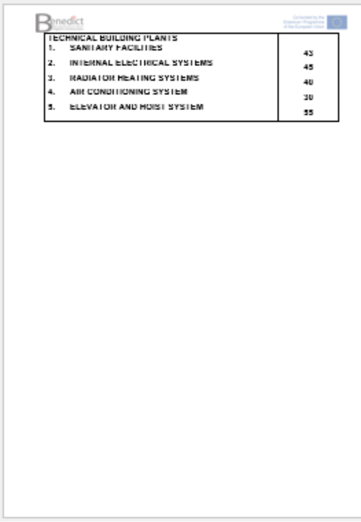
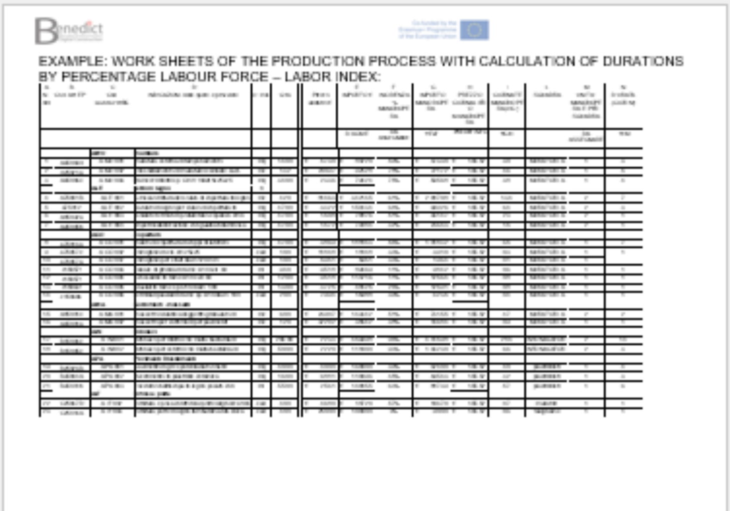


TABLE OF LABOR INDEXES OF THE ITALIAN DECREE DM 1978

CATEGORIES OF WORK	INCIDENCE % LABOUR FORCE
ROAD WORKS	
1. MOVEMENTS OF MATERIALS	18
2. WORKS OF ART	30
3. SUBTERRATEAN WORK	29
4. OTHER OR LOW-LEVEL JOBS	36
5. Superstructures	7
6. WORKS WITH MULTIPLE CATEGORIES OF WORK AND NO UNDERGROUND WORK	22
7. WORKS WITH MULTIPLE CATEGORIES OF WORKS AND UNDERGROUND WORK	24
BUILDING WORKS	40
HYDRAULIC WORKS	
1. EMBANKMENTS, FUNNELS, ETC.	20
2. SLEEPERS, DEFENSES, MISCELLANEOUS ACCOMMODATIONS	38
3. AQUEDUCTS INCLUDING PIPE SUPPLY	30
4. AQUEDUCTS EXCLUDING SUPPLY OF PIPES	46
5. Sewage	38
MARITIME WORKS	
1. QUAY BOXES AND PIERS, BULKHEAD DOCKS	32
2. FOR FORANEE DEFENSES IN ARTIFICIAL CLIFFS AND BOULDERS, MIXED STRUCTURE WORKS, ETC.	21
3. EXCAVATIONS	10
REINFORCED CONCRETE WORKS FOR CONSTRUCTION	32
LOW AND MEDIUM VOLTAGE EXTERNAL POWER LINES	30



TECHNICAL BUILDING PLANTS	
1. SANITARY FACILITIES	43
2. INTERNAL ELECTRICAL SYSTEMS	45
3. RADIATOR HEATING SYSTEMS	40
4. AIR CONDITIONING SYSTEM	30
5. ELEVATOR AND HOIST SYSTEM	35


EXAMPLE: WORK SHEETS OF THE PRODUCTION PROCESS WITH CALCULATION OF DURATIONS BY PERCENTAGE LABOUR FORCE – LABOR INDEX:

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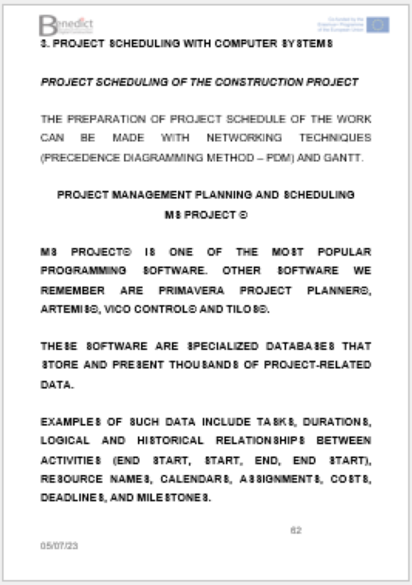
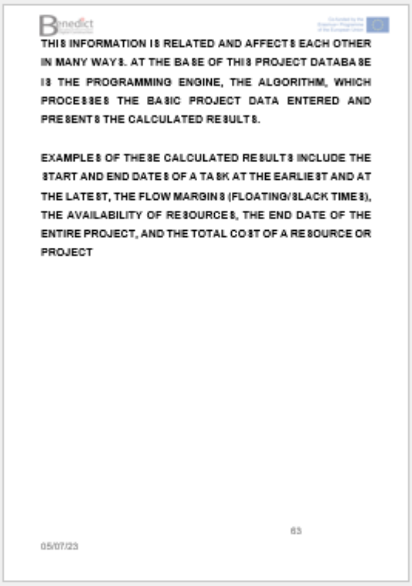
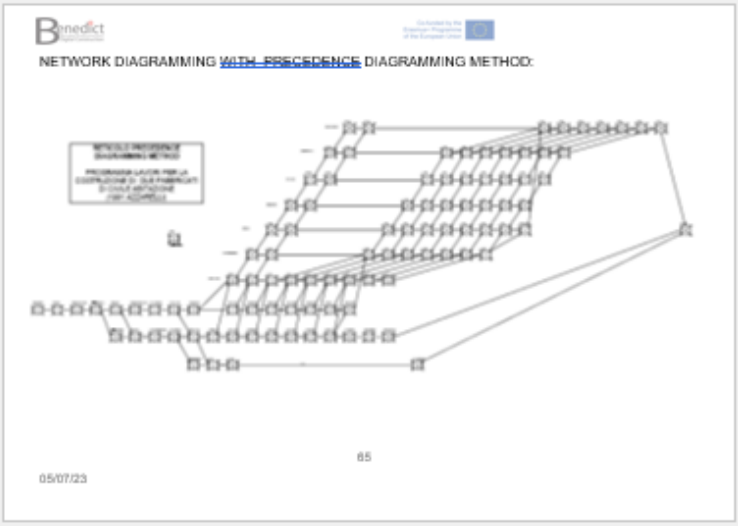
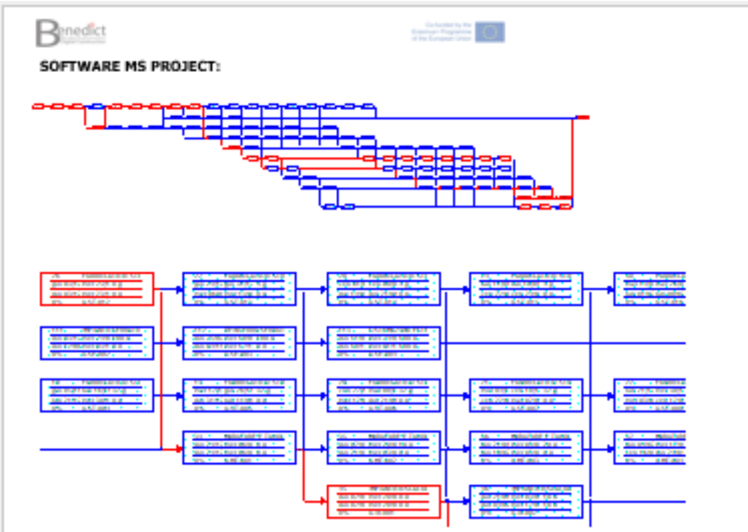

3. PROJECT SCHEDULING WITH COMPUTER SYSTEMS
PROJECT SCHEDULING OF THE CONSTRUCTION PROJECT
THE PREPARATION OF PROJECT SCHEDULE OF THE WORK CAN BE MADE WITH NETWORKING TECHNIQUES (PRECEDENCE DIAGRAMMING METHOD – PDM) AND GANTT.
PROJECT MANAGEMENT PLANNING AND SCHEDULING
MS PROJECT ©
MS PROJECT© IS ONE OF THE MOST POPULAR PROGRAMMING SOFTWARE. OTHER SOFTWARE WE REMEMBER ARE PRIMAVERA PROJECT PLANNER©, ARTEMIS©, VICO CONTROL© AND TILOS©.
THESE SOFTWARE ARE SPECIALIZED DATABASES THAT STORE AND PRESENT THOUSANDS OF PROJECT-RELATED DATA.
EXAMPLES OF SUCH DATA INCLUDE TASKS, DURATIONS, LOGICAL AND HISTORICAL RELATIONSHIPS BETWEEN ACTIVITIES (END START, START, END, END START), RESOURCE NAMES, CALENDARS, ASSIGNMENTS, COSTS, DEADLINES, AND MILESTONES.
62
05/07/23

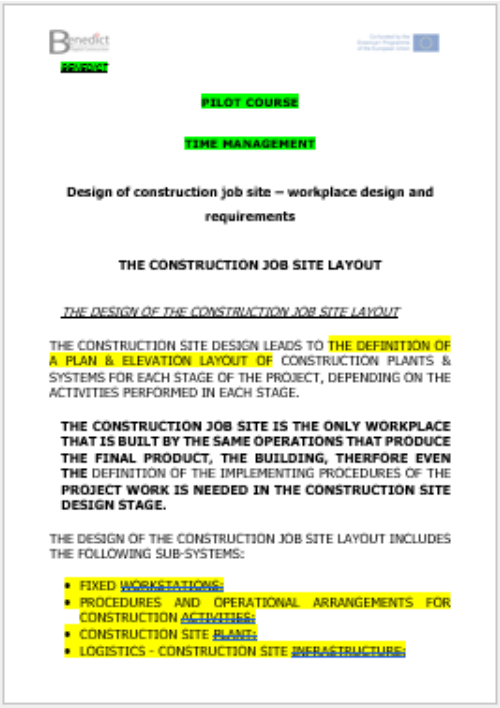

THIS INFORMATION IS RELATED AND AFFECTS EACH OTHER IN MANY WAYS. AT THE BASE OF THIS PROJECT DATABASE IS THE PROGRAMMING ENGINE, THE ALGORITHM, WHICH PROCESSES THE BASIC PROJECT DATA ENTERED AND PRESENTS THE CALCULATED RESULTS.
EXAMPLES OF THESE CALCULATED RESULTS INCLUDE THE START AND END DATES OF A TASK AT THE EARLIEST AND AT THE LATEST, THE FLOW MARGINS (FLOATING/SLACK TIMES), THE AVAILABILITY OF RESOURCES, THE END DATE OF THE ENTIRE PROJECT, AND THE TOTAL COST OF A RESOURCE OR PROJECT
63
05/07/23

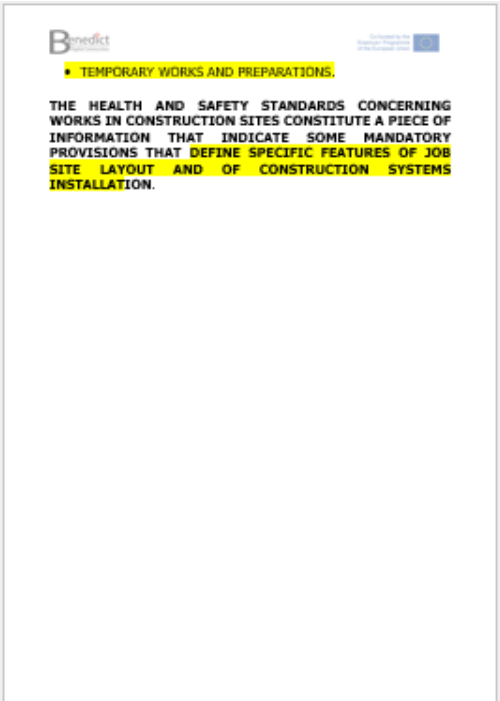

BAR CHART:
05/07/23

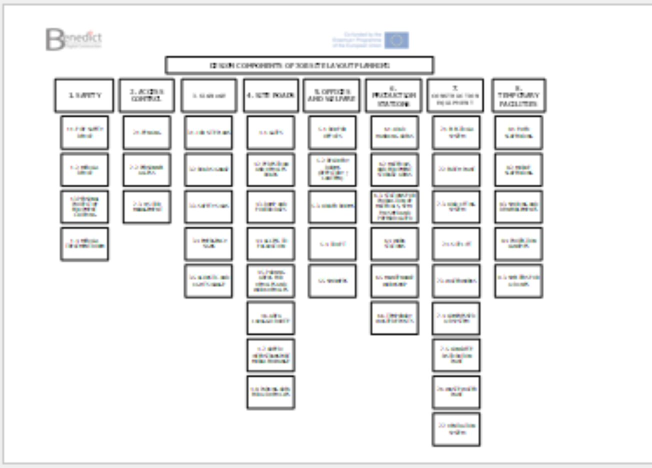

NETWORK DIAGRAMMING WITH PRECEDENCE DIAGRAMMING METHOD:
65
05/07/23

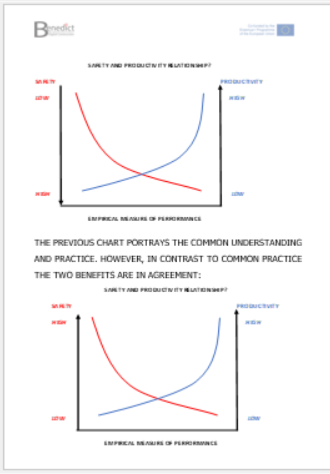

SOFTWARE MS PROJECT:

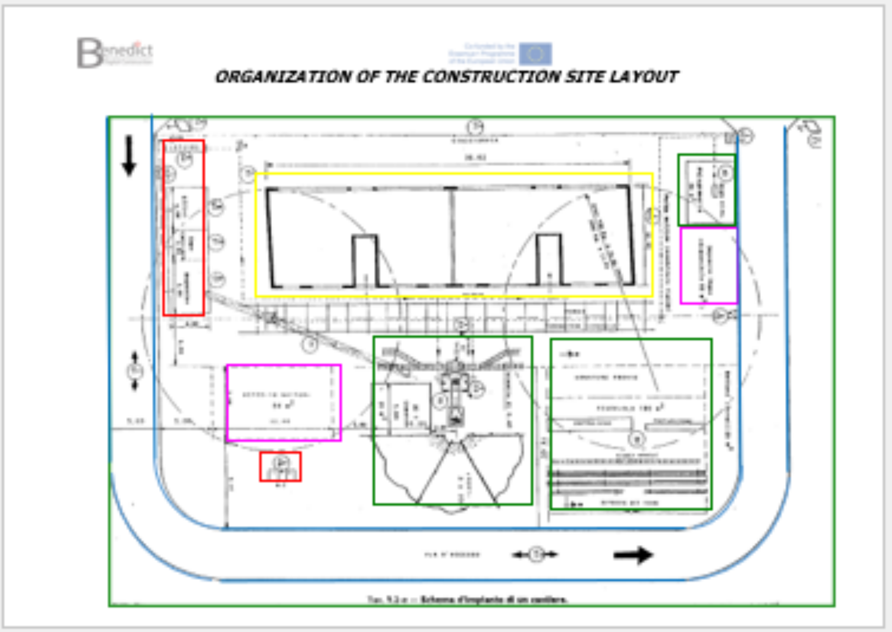
A.3. Workshop 2 lecture Slides

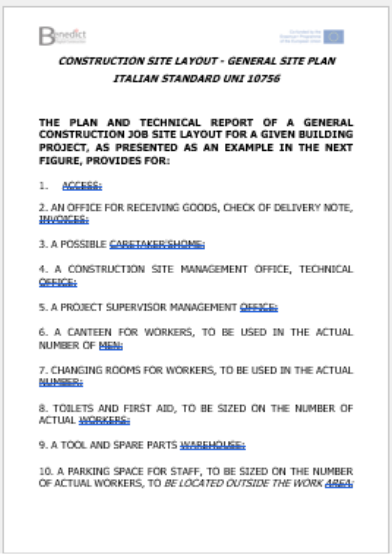








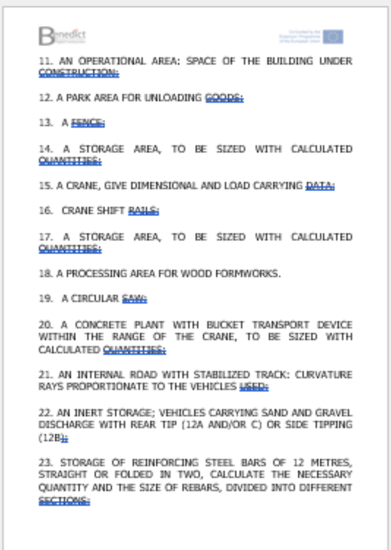




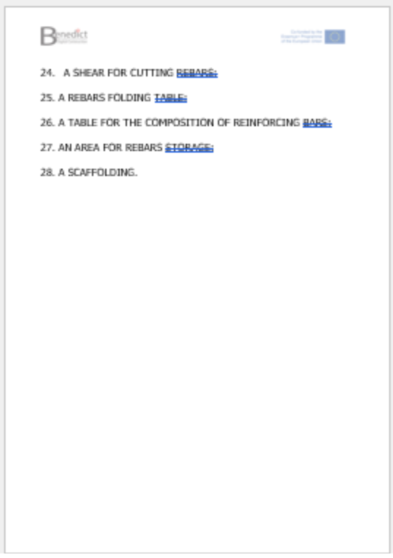
CONSTRUCTION SITE LAYOUT - GENERAL SITE PLAN
ITALIAN STANDARD UNI 10756

THE PLAN AND TECHNICAL REPORT OF A GENERAL CONSTRUCTION JOB SITE LAYOUT FOR A GIVEN BUILDING PROJECT, AS PRESENTED AS AN EXAMPLE IN THE NEXT FIGURE, PROVIDES FOR:

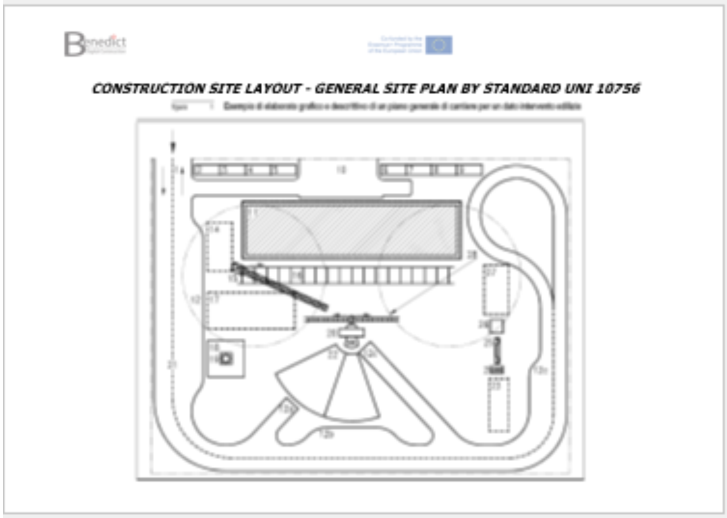
1. ACCESS;
2. AN OFFICE FOR RECEIVING GOODS, CHECK OF DELIVERY NOTE, INVOICES;
3. A POSSIBLE CARETAKER'SHOME;
4. A CONSTRUCTION SITE MANAGEMENT OFFICE, TECHNICAL OFFICE;
5. A PROJECT SUPERVISOR MANAGEMENT OFFICE;
6. A CANTEEN FOR WORKERS, TO BE USED IN THE ACTUAL NUMBER OF MEN;
7. CHANGING ROOMS FOR WORKERS, TO BE USED IN THE ACTUAL NUMBER;
8. TOILETS AND FIRST AID, TO BE SIZED ON THE NUMBER OF ACTUAL WORKERS;
9. A TOOL AND SPARE PARTS WAREHOUSE;
10. A PARKING SPACE FOR STAFF, TO BE SIZED ON THE NUMBER OF ACTUAL WORKERS, TO *BE LOCATED OUTSIDE THE WORK AREA;*



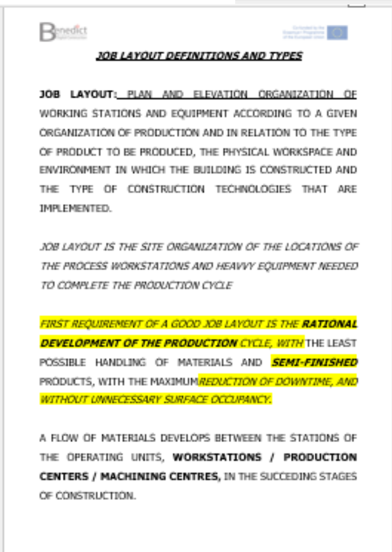
11. AN OPERATIONAL AREA: SPACE OF THE BUILDING UNDER CONSTRUCTION;
12. A PARK AREA FOR UNLOADING GOODS;
13. A FENCE;
14. A STORAGE AREA, TO BE SIZED WITH CALCULATED QUANTITIES;
15. A CRANE, GIVE DIMENSIONAL AND LOAD CARRYING DATA;
16. CRANE SHIFT RAILS;
17. A STORAGE AREA, TO BE SIZED WITH CALCULATED QUANTITIES;
18. A PROCESSING AREA FOR WOOD FORMWORKS.
19. A CIRCULAR SAW;
20. A CONCRETE PLANT WITH BUCKET TRANSPORT DEVICE WITHIN THE RANGE OF THE CRANE, TO BE SIZED WITH CALCULATED QUANTITIES;
21. AN INTERNAL ROAD WITH STABILIZED TRACK: CURVATURE RAYS PROPORTIONATE TO THE VEHICLES USED;
22. AN INERT STORAGE; VEHICLES CARRYING SAND AND GRAVEL DISCHARGE WITH REAR TIP (12A AND/OR C) OR SIDE TIPPING (12B);
23. STORAGE OF REINFORCING STEEL BARS OF 12 METRES, STRAIGHT OR FOLDED IN TWO, CALCULATE THE NECESSARY QUANTITY AND THE SIZE OF REBARS, DIVIDED INTO DIFFERENT SECTIONS;



24. A SHEAR FOR CUTTING REBARS;
25. A REBARS FOLDING TABLE;
26. A TABLE FOR THE COMPOSITION OF REINFORCING BARS;
27. AN AREA FOR REBARS STORAGE;
28. A SCAFFOLDING.



CONSTRUCTION SITE LAYOUT - GENERAL SITE PLAN BY STANDARD UNI 10756



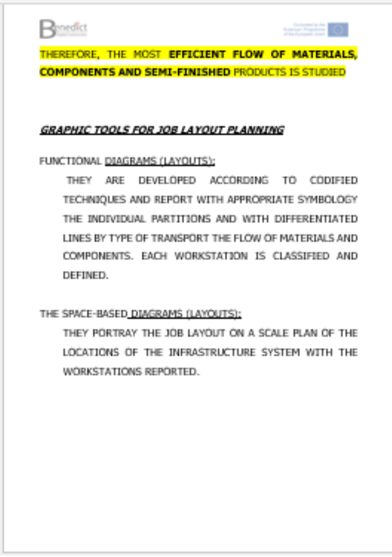
<u>JOB LAYOUT DEFINITIONS AND TYPES</u>

JOB LAYOUT: <u>PLAN AND ELEVATION ORGANIZATION OF</u> WORKING STATIONS AND EQUIPMENT ACCORDING TO A GIVEN ORGANIZATION OF PRODUCTION AND IN RELATION TO THE TYPE OF PRODUCT TO BE PRODUCED, THE PHYSICAL WORKSPACE AND ENVIRONMENT IN WHICH THE BUILDING IS CONSTRUCTED AND THE TYPE OF CONSTRUCTION TECHNOLOGIES THAT ARE IMPLEMENTED.

JOB LAYOUT IS THE SITE ORGANIZATION OF THE LOCATIONS OF THE PROCESS WORKSTATIONS AND HEAVY EQUIPMENT NEEDED TO COMPLETE THE PRODUCTION CYCLE

*FIRST REQUIREMENT OF A GOOD JOB LAYOUT IS THE **RATIONAL DEVELOPMENT OF THE PRODUCTION** CYCLE, WITH* THE LEAST POSSIBLE HANDLING OF MATERIALS AND ***SEMI-FINISHED*** PRODUCTS, WITH THE MAXIMUM *REDUCTION OF DOWNTIME, AND WITHOUT UNNECESSARY SURFACE OCCUPANCY.*

A FLOW OF MATERIALS DEVELOPS BETWEEN THE STATIONS OF THE OPERATING UNITS, **WORKSTATIONS / PRODUCTION CENTERS / MACHINING CENTRES,** IN THE SUCCEDING STAGES OF CONSTRUCTION.



THEREFORE, THE MOST **EFFICIENT FLOW OF MATERIALS, COMPONENTS AND SEMI-FINISHED** PRODUCTS IS STUDIED

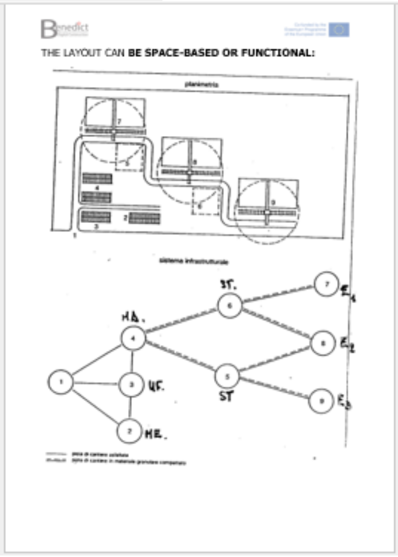
<u>GRAPHIC TOOLS FOR JOB LAYOUT PLANNING</u>

FUNCTIONAL <u>DIAGRAMS (LAYOUTS):</u>

THEY ARE DEVELOPED ACCORDING TO CODIFIED TECHNIQUES AND REPORT WITH APPROPRIATE SYMBOLOGY THE INDIVIDUAL PARTITIONS AND WITH DIFFERENTIATED LINES BY TYPE OF TRANSPORT THE FLOW OF MATERIALS AND COMPONENTS. EACH WORKSTATION IS CLASSIFIED AND DEFINED.

THE SPACE-BASED <u>DIAGRAMS (LAYOUTS):</u>

THEY PORTRAY THE JOB LAYOUT ON A SCALE PLAN OF THE LOCATIONS OF THE INFRASTRUCTURE SYSTEM WITH THE WORKSTATIONS REPORTED.

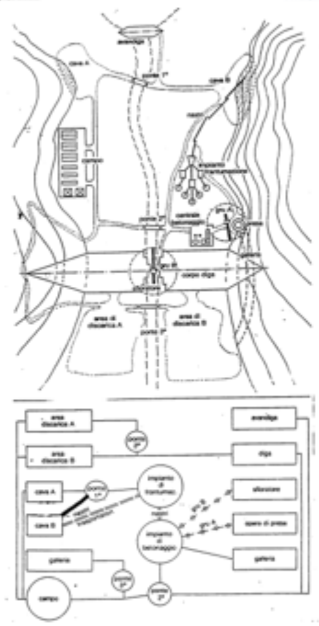


THE LAYOUT CAN **BE SPACE-BASED OR FUNCTIONAL:**

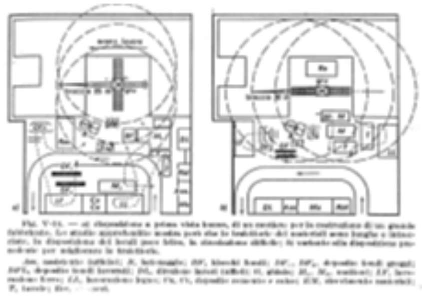
THE EXAMINATION OF THE GRAPHS **IDENTIFIES THE CONNECTIONS** BETWEEN THE PRODUCTION AND/OR EXCHANGE NODES THAT ARE MADE WITH SITE ROADS, PAVED AND UN-PAVED TRACKS, BRIDGES, CONVEYOR BELTS OR CABLE CAR.

AN ANALYSIS OF **THE AMOUNT OF RESOURCE FLOW** MOVING BETWEEN TWO WORKSTATIONS DEFINES THE SIZE OF THE INFRASTRUCTURE IN RELATION TO THE TRANSPORT TECHNIQUE ADOPTED, THE TYPE OF PAVING, THE SLOPE, ETC.

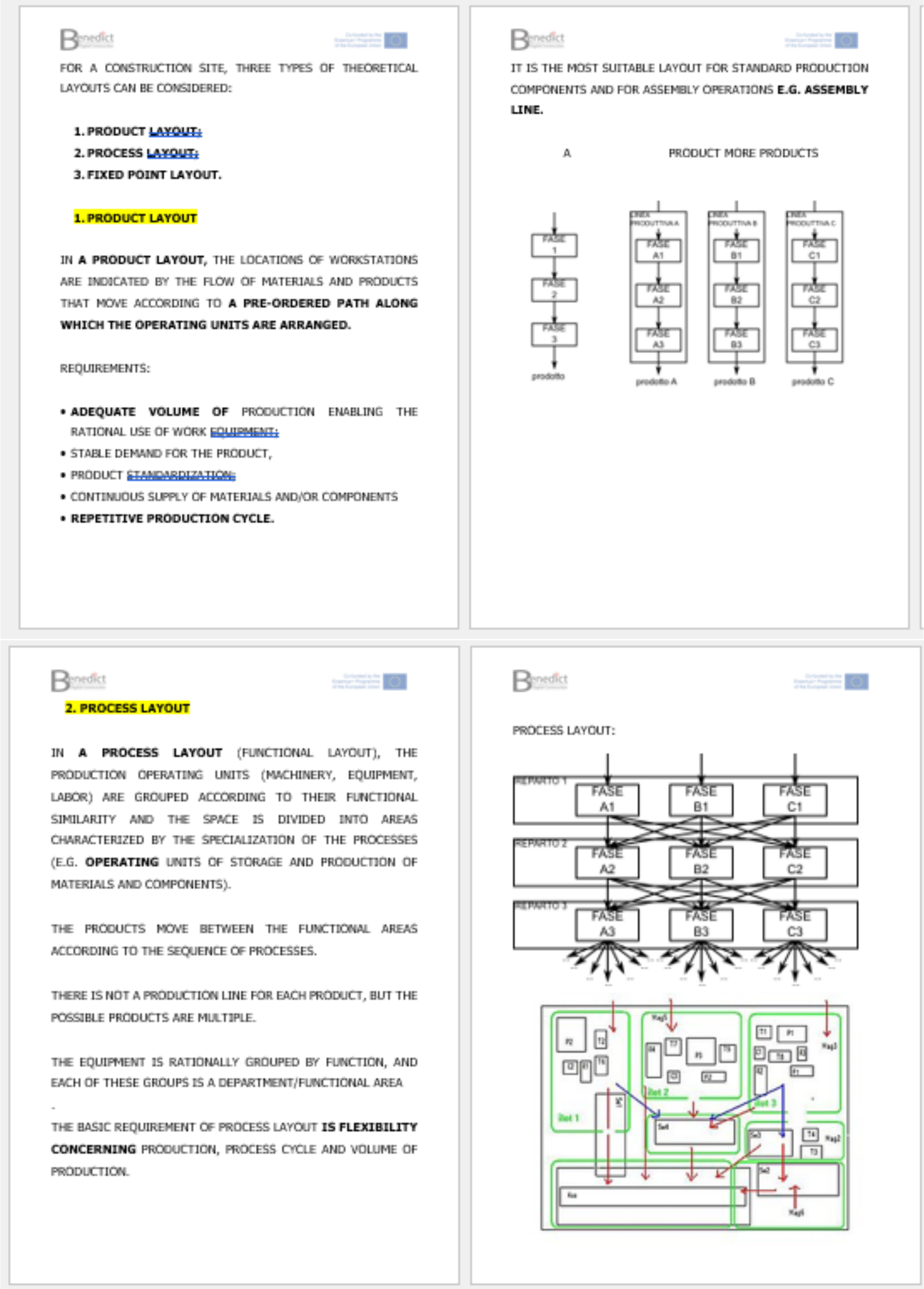
IN **ORDER TO REDUCE INFRASTRUCTURE COSTS**, THE PATHS ARE ALSO SELECTED IN RELATION TO SUBSEQUENT USE, FOR EXAMPLE FOR INSPECTION AND MAINTENANCE OF THE COMPLETED WORK AND IN OPERATION.



OPTIMIZED TRANSPORTS IN LAYOUT:



THE POSITION AND TRANSPORT OF MATERIALS AND PRODUCTS AND THE POSITION AND MOVEMENTS OF PRODUCTION RESOURCES, WORSTATIONS, GANGS OR SQUADS AND PLANTS, INDICATE DIFFERENT TYPES OF THEORETICAL LAYOUTS



FOR A CONSTRUCTION SITE, THREE TYPES OF THEORETICAL LAYOUTS CAN BE CONSIDERED:

1. PRODUCT LAYOUT;
2. PROCESS LAYOUT;
3. FIXED POINT LAYOUT.

1. PRODUCT LAYOUT

IN **A PRODUCT LAYOUT,** THE LOCATIONS OF WORKSTATIONS ARE INDICATED BY THE FLOW OF MATERIALS AND PRODUCTS THAT MOVE ACCORDING TO **A PRE-ORDERED PATH ALONG WHICH THE OPERATING UNITS ARE ARRANGED.**

REQUIREMENTS:

- **ADEQUATE VOLUME OF** PRODUCTION ENABLING THE RATIONAL USE OF WORK EQUIPMENT;
- STABLE DEMAND FOR THE PRODUCT,
- PRODUCT STANDARDIZATION;
- CONTINUOUS SUPPLY OF MATERIALS AND/OR COMPONENTS
- **REPETITIVE PRODUCTION CYCLE.**

IT IS THE MOST SUITABLE LAYOUT FOR STANDARD PRODUCTION COMPONENTS AND FOR ASSEMBLY OPERATIONS **E.G. ASSEMBLY LINE.**

A PRODUCT MORE PRODUCTS

2. PROCESS LAYOUT

IN A **PROCESS LAYOUT** (FUNCTIONAL LAYOUT), THE PRODUCTION OPERATING UNITS (MACHINERY, EQUIPMENT, LABOR) ARE GROUPED ACCORDING TO THEIR FUNCTIONAL SIMILARITY AND THE SPACE IS DIVIDED INTO AREAS CHARACTERIZED BY THE SPECIALIZATION OF THE PROCESSES (E.G. **OPERATING** UNITS OF STORAGE AND PRODUCTION OF MATERIALS AND COMPONENTS).

THE PRODUCTS MOVE BETWEEN THE FUNCTIONAL AREAS ACCORDING TO THE SEQUENCE OF PROCESSES.

THERE IS NOT A PRODUCTION LINE FOR EACH PRODUCT, BUT THE POSSIBLE PRODUCTS ARE MULTIPLE.

THE EQUIPMENT IS RATIONALLY GROUPED BY FUNCTION, AND EACH OF THESE GROUPS IS A DEPARTMENT/FUNCTIONAL AREA.

THE BASIC REQUIREMENT OF PROCESS LAYOUT **IS FLEXIBILITY CONCERNING** PRODUCTION, PROCESS CYCLE AND VOLUME OF PRODUCTION.

PROCESS LAYOUT:

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3. FIXED POINT LAYOUT.

IN A FIXED POINT LAYOUT, **PRODUCTION RESOURCES MOVE ON THE PRODUCT WHOSE LOCATION IS FIXED** (E.G. ASSEMBLY OPERATING UNITS).

THE PRODUCT REMAINS FIXED IN A POSITION, IT IS THE EQUIPMENT NECESSARY FOR PRODUCTION THAT IS MOVED TO THE PRODUCT AND NOT VICE - VERSA.

IT IS THE LAYOUT FOR THE CONSTRUCTION SITE, FOR THE PRODUCTION OF AIRCRAFT, SHIPS ETC.

FOR THIS COMPLEX LAYOUT CASE, PRODUCTION RESOURCE MANAGEMENT MUST BE OPTIMIZED WITH **PROJECT MANAGEMENT METHODS**

THE LAYOUT OF THE CONSTRUCTION SITE

THE ORGANIZATION OF OPERATING UNITS CAN BASICALLY BE TRACED BACK TO TWO TYPES OF LAYOUTS.

- PROCESS LAYOUT: IT IS THE MODEL FOR ORGANIZING STORAGE AND PRODUCTION OPERATING UNITS FOR MATERIALS AND COMPONENTS.
- FIXED POINT LAYOUT: THIS IS THE APPROACH FOR ORGANIZING INSTALLATION OPERATIVE UNITS. INFACT, PRODUCT COMPONENT, MATERIALS AND HUMAN RESOURCES MOVE ON THE PRODUCT AND LOCATE IN RELATION TO THE FINAL LOCATION THAT IS FIXED.

THE EFFICIENCY OF THE INSTALLATION OF WORKSTATIONS:

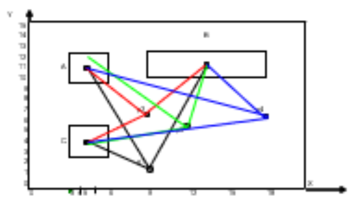
WITH THE SAME PROCESSING TIMES THAT DEPENDS ON THE CHOICE OF TYPE OF MACHINE OR EQUIPMENT, THE REDUCTION OF TIME AND THE OPTIMIZATION OF COSTS IS IN PRINCIPLE THE CONSEQUENCE OF THAT OF THE COST OF HANDLING **MATERIALS, COMPONENTS AND LABOR.**

THE OPTIMAL SOLUTION IS OBTAINED BY CHOOSING BETWEEN THE COMBINATIONS OF SYSTEM ACCOMMODATION, THE ONE THAT MINIMIZES THE PRODUCT:

$$E = \Sigma_{IJ} A_{IJ} \times D_{IJ} = MINIMUM$$

WHERE:

E = EFFICIENCY
A_{IJ} = NUMBER OF LOADS PER UNIT OF TIME TO BE TRANSPORTED
D_{IJ} = DISTANCE BETWEEN DEPARTMENTS I AND J



A, C, TOWER BUILDINGS (5 STORIES)
B, TWO STOREY BUILDING

TYPE OF CONSTRUCTION SITES

CLASSIFICATION BY OBJECTIVE OF PRODUCTION

1. BUILDING CONSTRUCTION SITES

- PUNCTUAL LOCATION, COINCIDING WITH THE AREA OF THE BUILDING AND THE AREA NEXT TO THE CONSTRUCTION SITE;
- VERTICAL GROWTH DEVELOPMENT;
- TRADITIONAL TYPE CONSTRUCTION TECHNOLOGIES ARE PREVALENT;
- HIGH EMPLOYMENT OF SUFFICIENTLY SKILLED LABOUR;
- LOW LEVEL OF MECHANIZATION;
- REDUCED INTERACTION WITH THE EXTERNAL TERRITORY (IMPACT ON EXTERNAL ROAD AND MORE GENERALLY ON THE EXTERNAL ENVIRONMENT).

2. CONSTRUCTION SITES FOR WORKS THAT ARE DISTRIBUTED OVER A NETWORK.

THESE ARE THOSE FOR THE CONSTRUCTION OF CIVIL AND ENERGY INFRASTRUCTURES:

- ROAD (ROADS, RAILWAYS, METRO);

- TECHNOLOGICAL SYSTEMS (SEWERAGE, WATER, GAS)
- ENERGY DISTRIBUTION SYSTEMS (LIGHTING, F.M., DATA NETWORK);

THEY ARE CHARACTERIZED BY:

- MOBILE CONSTRUCTION SITES - DEVELOP ALONG THE ROUTE FOLLOWING THE PATH OF THE WORKS TO BE CARRIED OUT;
- LARGE SIZE;
- INDUSTRIALIZED CONSTRUCTION TECHNOLOGIES;
- LOW USE OF HIGHLY SKILLED LABOUR AND VERY HIGH LEVEL OF MECHANIZATION;
- HIGH INTERACTION WITH THE EXTERNAL ENVIRONMENT -
- IMPACT ON EXTERNAL ROAD FOR THE SUPPLY AND DISPOSAL OF EXCAVATION MATERIAL;
- THE NEED FOR TRANSPORT INFRASTRUCTURE.

3. CONSTRUCTION SITES FOR TERRITORIAL OR URBAN EQUIPMENT (DAMS, BRIDGES, PLANT POWER STATIONS)

THEY HAVE A PUNCTUAL LOCATION, BUT THE OTHER FEATURES ARE SIMILAR TO THOSE OF NETWORK – BASED WORKS.

THE USE OF PREFABRICATION AND INDUSTRIALIZATION OF METAL FORMWORKS FOR POURING OF CONCRETE IS A STANDARD OPERATION.

4. INDUSTRIAL PRODUCTION SITES FOR SEMI-FINISHED PRODUCTS, PREFABRICATED COMPONENTS.

CEMENT CONGLOMERATE, BITUMEN CONGLOMERATE, STABILIZED INERTS, THEY ARE PRODUCED AND TRANSPORTED TO CONSTRUCTION SITES BY SPECIALIZED VEHICLES (E.G. TRUCK MIXER).

- THEY ARE CENTRAL TO THE MARKETING AREA OF PRODUCTION AND THE SUPPLY OF RAW MATERIALS TO MINIMIZE TRANSPORT COSTS AND TIMES AND GIVE CONTINUITY TO THE PRODUCTION PROCESS;
- MECHANISED AND INDUSTRIAL-CYCLE PRODUCTION PROCESSES;
- LOW USE OF HIGHLY SKILLED LABOUR AND VERY HIGH LEVEL OF MECHANIZATION;
- HIGH INTERACTION WITH THE EXTERNAL ENVIRONMENT -
- IMPACT ON EXTERNAL ROAD FOR THE SUPPLY AND DISPOSAL OF EXCAVATION MATERIAL;
- THE NEED FOR TRANSPORT INFRASTRUCTURE.

CLASSIFICATION BY TYPE OF INTERVENTION:

NEW CONSTRUCTION – IN URBAN AND SUBURBAN AREAS, LOW USE OF LABOUR, INDUSTRIALIZED PRODUCTS, REDUCED DEGREE OF MECHANIZATION;

RENOVATION / RESTORATION - IN URBAN CONTEXTS, HIGH USE OF SKILLED LABOUR, TRADITIONAL PROCESSING, LOW LEVEL OF MECHANIZATION;

MAINTENANCE – SMALL SIZE, HIGH USE OF SKILLED LABOUR, POOR MECHANIZATION, ABSENCE OF CONSTRUCTION SITE;

DEMOLITION – HIGH ENVIRONMENTAL IMPACT, USE OF SKILLED LABOUR, HIGH DEGREE OF MECHANIZATION.

THE POSSIBLE EFFECTS OF POOR JOB SITE DESIGN

DESIGN ERRORS IN SITE PLANNING CREATE OPERATIONAL **INEFFICIENCIES AND** UNCONTROLLED COST INCREASES, IN ADDITION TO AN INCREASE OF SAFETY **RISKS.**

WITHOUT A DETAILED JOB SITE DESIGN, THE FOLLOWING PROBLEMS MAY OCCUR:

1. POORLY LOCATED STORAGES OF MATERIAL:

- STACKED ON A DRAINAGE OR NEAR THE EDGE OF AN EXCAVATION
- TOO FAR FROM THE WORK PLACE
- TOO FAR FROM THE HOIST OR OUT OF THE CRANE'S REACH
- PREVENT THE CORRECT FLOW OF TRAFFIC ON SITE
- THEIR DELIVERY HAS BEEN BADLY PLANNED AND WILL BE USED MUCH LATER IN THE WORKS
- THEY ARE FRAGILE
- THEY ARE NOT STABLE

2. POORLY LOCATED PLANTS AND EQUIPMENT:

- THE CEMENT MIXER IS INACCESSIBLE FOR THE DELIVERY OF MATERIALS
- THE CEMENT MIXER IS NOT STABLE
- THERE IS NO SPACE FOR STORAGE OF AGGREGATES FOR THE CONCRETE
- CRANES DO NOT REACH ALL WORKING AREAS
- WINCHES OR HOISTS WITH INSUFFICIENT PAYLOAD / OR INSUFFICIENT HEIGHT TO MOVE LOADS OR POORLY LOCATED IN RELATION TO THE WORK TOP
- NOT STABLE CRANES AND HOISTS

3. INADEQUATE SPACES FOR ROADS, MATERIAL STORAGE OR FOR CARRYING OUT OPERATIONS:

- INADEQUATE OR CLUTTERED WITH DEPOSITS/RUBBLE;
- MATERIALS STACKED UNSTABLELY OR NEAR THE ROAD CAUSING HAZARDS;
- WORKSPACES THAT ARE TOO SMALL, NEED ADDITIONAL AREAS TO LOCATE OR POOR LOCALIZED WITH TIME-WASTING BECAUSE OF MOVEMENT TIMES.

4. POORLY LOCATED SHEDS:

- OFFICE SHEDS LOCATED TOO CLOSE TO NOISY ACTIVITIES (E.G. CEMENT MIXER), OR LOCATED TOO CLOSE TO THE CONSTRUCTION SITE WITH DUST PRODUCTION, OR TOO FAR AWAY WITH POOR PANORAMIC VIEW OF THE SITE;
- WAREHOUSES WITH INADEQUATE ACCESS TO THE LOADING/UNLOADING OR LIFTING OF MATERIALS OR IN UNSAFE AREAS.

5. POORLY DESIGNED OR INSTALLATED TEMPORARY WORKS:

- POORLY DESIGNED / INSTALLED SCAFFOLDING AND PROVISIONAL WORKS;
- UNSTABLE FORMWORK AND SHORING;
- LACK OF PROTECTIONS

WORKSTATIONS AND CONNECTION SYSTEMS

THE DESIGN OF A JOB SITE LAYOUT INVOLVES THE LOCALIZATION AND SIZING OF MANY COMPONENTS, TERMED **WORKSTATIONS AND CONNECTION** SYSTEMS:

a. THE WORKSTATIONS:

- **a.1. PRODUCTION STATIONS;**
- **a.2. THE PRODUCTION STATIONS OF COMPONENTS OR SEMI-FINISHED PRODUCTS;**
- **a.3. INVENTORY STORAGE STATIONS;**
- **a.4. SHEDS FOR MANAGEMENT SERVICE ACTIVITIES (ENGINEERS AND MANAGERS);**
- **a.5. STAFF SERVICE SHEDS;**
- **a.6. THE STATIONS OF PRODUCTION SUPPORT ACTIVITIES;**
- **a.7. WASTE STORAGE STATIONS – TEMPORARY STORAGE**
- **a.8. TECHNOLOGY PLANT POWER STATIONS**
- **a.9. PARKING AREAS FOR VEHICLES**
- **a.10. BASE CAMPS**
- **a.11. PRODUCTION STATIONS FOR RAW MATERIALS AND PRODUCTS FOR CIVIL WORKS**
- **a.12. INTERMODALITY STATIONS OF TRANSPORT SYSTEMS**

b. CONNECTION SYSTEMS

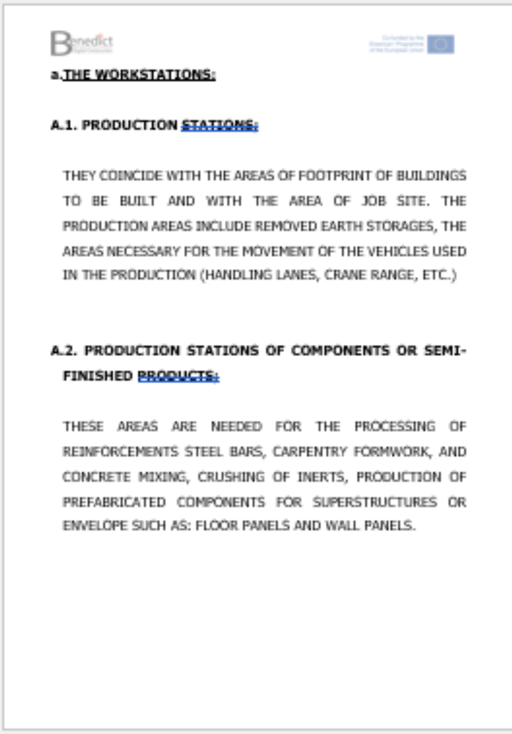
- b.1. HORIZONTAL AND VERTICAL HANDLING SYSTEM;
- b.2. ELECTRICAL SYSTEM;
- b.3. SANITARY AND INDUSTRIAL WATER SYSTEM.

THE SYSTEM OF WORKSTATIONS

IT IS THE FUNCTIONALLY HOMOGENEOUS AREAS THAT MAKE UP THE ELEMENTARY COMPONENTS OF THE CONSTRUCTION SITE.

THEIR TYPE, ENDOWMENT AND SIZE DEPEND ON THE TYPE OF CONSTRUCTION SITE:

- OBJECT OF PRODUCTION AND ITS PROCESSES;
- TYPE OF CONSTRUCTION PROJECT



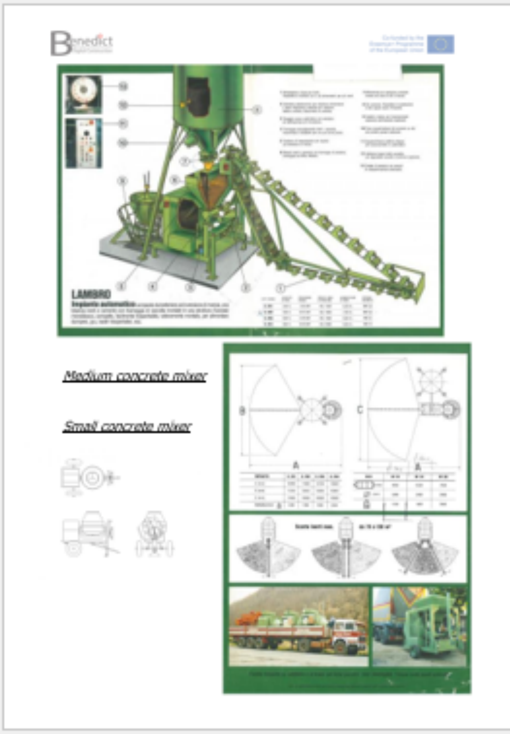
a.THE WORKSTATIONS:

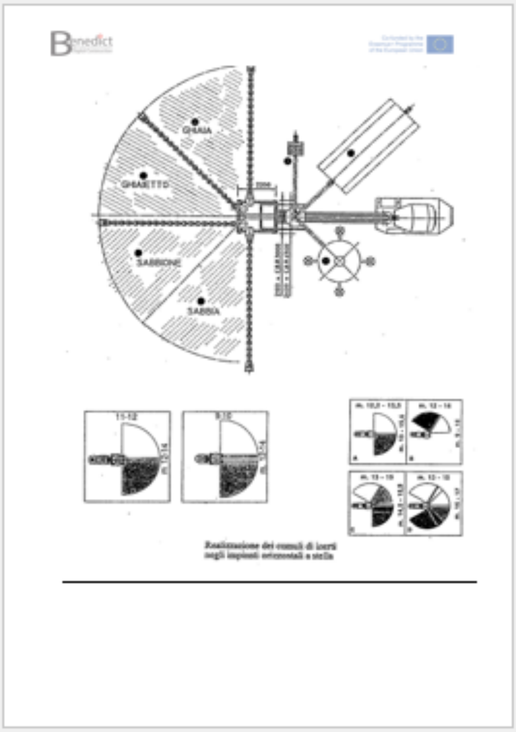
A.1. PRODUCTION STATIONS:

THEY COINCIDE WITH THE AREAS OF FOOTPRINT OF BUILDINGS TO BE BUILT AND WITH THE AREA OF JOB SITE. THE PRODUCTION AREAS INCLUDE REMOVED EARTH STORAGES, THE AREAS NECESSARY FOR THE MOVEMENT OF THE VEHICLES USED IN THE PRODUCTION (HANDLING LANES, CRANE RANGE, ETC.)

A.2. PRODUCTION STATIONS OF COMPONENTS OR SEMI-FINISHED PRODUCTS:

THESE AREAS ARE NEEDED FOR THE PROCESSING OF REINFORCEMENTS STEEL BARS, CARPENTRY FORMWORK, AND CONCRETE MIXING, CRUSHING OF INERTS, PRODUCTION OF PREFABRICATED COMPONENTS FOR SUPERSTRUCTURES OR ENVELOPE SUCH AS: FLOOR PANELS AND WALL PANELS.





LOCATION

THEIR POSITION DEPENDS ON THE FOLLOWING CONSTRAINTS:

- LOCATION OF THE AREA OF THE WORKS (BRIDGE OR BUILDING);
- LOCATION OF PRODUCTS STORAGE AREAS;
- LOCATION OF GATES FOR THE TRANSIT OF SUPPLIES; SIZE OF UTILITIES PRODUCED
- FREQUENCY OF ENTRY AND EXIT OF UTILITIES FROM THE AREAS THEMSELVES, THUS DEPENDING ON THE METHODS AND TIMES OF USE OF THE PRODUCTION UTILITIES;
- SIZE OF STORAGE AREAS OF REFUELLING MATERIALS;
- STORAGE TECHNIQUES OF REFUELLING MATERIALS.

IN GENERAL, THE POSITIONING OF THESE AREAS MUST BE **AS BARYCENTRIC AS** POSSIBLE WITH RESPECT TO THE AREA OF LOCATION OF THE WORK OR IN SUCH A POSITION AS TO SIMPLIFY THE MORPHOLOGY OF TRANSPORT FLOWS AND THEREFORE TRANSPORT TECHNIQUES.

SIZING

THE AREA IS CALCULATED AS THE SUM OF THE SURFACE OF THE WORK STATION CONSISTING OF THE MACHINES AND EQUIPMENT, THE SURFACE NECESSARY FOR LABOR, THE HANDLING OF MATERIALS AND COMPONENTS WAITING FOR PROCESSING AND DISPATCH, THE SURFACE NECESSARY FOR THE MAINTENANCE OF THE MACHINE, THE SPACES NECESSARY FOR THE COMMISSIONING AND DISASSEMBLY OF THE MACHINE.

AS AN EXAMPLE, THE FOLLOWING SIZE INDEXES CAN BE GIVEN:

- *CONCRETE PLANTS: 1 SQM/20 CM OF CONCRETE PRODUCED PER MONTH WITH A MINIMUM OF 50 SQUARE METERS;*
- *REINFORCEMENT STEEL BARS PROCESSING: 1 SQM/1 TON. OF WORKED STEEL;*
- *STEEL-COMPONENTS WORKSHOP: 1 SQM /500 KG OF STEEL PROCESSED MONTHLY;*
- *CRUSHING PLANT: 1 SQM/5 MC OF INERTS PRODUCED MONTHLY;*
- *PREFABRICATED PLANT: 15 SQM / 1 MC OF CONCRETE PRODUCED DAILY.*

A.3. INVENTORY STORAGE STATIONS

GENERAL INFORMATION

THESE ARE THE JUNCTION STATIONS BETWEEN SUPPLY SYSTEM AND PROCESSING OPERATIONS.

SIZING

THE SIZE OF THE STORAGE STATIONS DEPENDS ON THE SIZE OF THE PROJECT AND ITS GEOGRAPHICAL LOCATION. WITH REGARD TO CONSTRUCTION IN ITALY, THE FOLLOWING STANDARDS CAN BE GIVEN:

- *STORAGE AREA (TOTAL) COVERED: 1 SQM / 50 SQUARE METERS OF BUILDING;*
- *STORAGE AREA (TOTAL) UNCOVERED: 1 SQM / 20 SQUARE METERS OF BUILDING.*
- *FOR CONSTRUCTION SITES ABROAD, THESE AREAS ARE TO BE QUADRUPLED.*

LOGISTIC CLASSIFICATION OF INVENTORYS

STORAGE AREAS ARE SIZED THROUGH THE LOGISTICAL TYPOLOGY OF UTILITY INVENTORIES, WHICH CAN BE:

- TRANSIT **INVENTORIES (JUST IN TIME SUPPLIES):** THOSE REQUIRED FOR THE TIME NECESSARY FOR PROCESSING OPERATIONS, OR FOR THE TIME NECESSARY FOR HANDLING OPERATIONS ON SITE.
- BATCH **INVENTORIES: WHEN** UTILITIES ARE SUPPLIED ACCORDING TO BATCHES OF DIFFERENT SIZES FROM THOSE NECESSARY FOR PRODUCTION, BUT WITH THE AIM OF OPTIMIZING THE COST OF ADDUCTION.
- SAFETY **INVENTORIES:** NEEDED TO COMPENSATE FOR ANY DISCONTINUITY OF SUPPLY.

CLASSIFICATION BY MATERIAL OR PRODUCT

STORAGE STATIONS GENERALLY REFER TO THE TYPE OF MATERIAL STORED:

- INERTS;
- BINDERS;
- WOODEN AND METAL CARPENTRY;
- REINFORCING OR CONSTRUCTION STEEL;

- INDUSTRIALLY PRODUCED COMPONENTS;
- PREFABRICATED CONCRETE OR STEEL;
- WATER;
- FUELS;
- ETC.

REQUIREMENTS

THE FUNCTIONAL REQUIREMENTS OF STORAGE AREAS RELATE MAINLY TO:

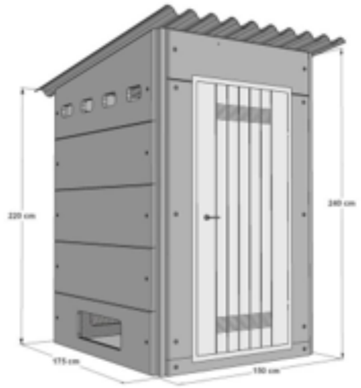
- SAFETY OF WORKERS;
- PRESERVATION OF THE PERFORMANCE OF COMPONENTS AND STORED MATERIALS.

STORAGE STATIONS CAN BE COVERED, UNCOVERED AND EQUIPPED WITH A CONTAINER.

LOCATION

THEY ARE THE HINGE BETWEEN SUPPLY AND PRODUCTION. FOR THIS **REASON, THEIR POSITION WITH RESPECT TO THE ACCESSES OF THE CONSTRUCTION SITE AND THE AREA OF LOCATIONS** OF THE WORK IS IMPORTANT TO OPTIMIZE TRANSPORT TIMES AND COSTS.

E.G. FIRE BOX FOR LPG CYLINDERS



A.4 SHEDS FOR MANAGEMENT SERVICE ACTIVITIES (ENGINEERS AND MANAGERS);

DEFINITION AND SIZING

THE MANAGEMENT AREAS CONSIST OF OFFICES. THE AREA OF THESE SPACES DEPENDS ON NUMBER OF WORKERS AND EMPLOYEES PRESENT ON THE SITE.

THE FOLLOWING STANDARDS CAN BE APPLIED.

- OFFICES: 15 SQM / EMPLOYEE;
- TOTAL AREA OF 15/20 SQM/ AVERAGE EMPLOYEE PRESENT

LOCATION

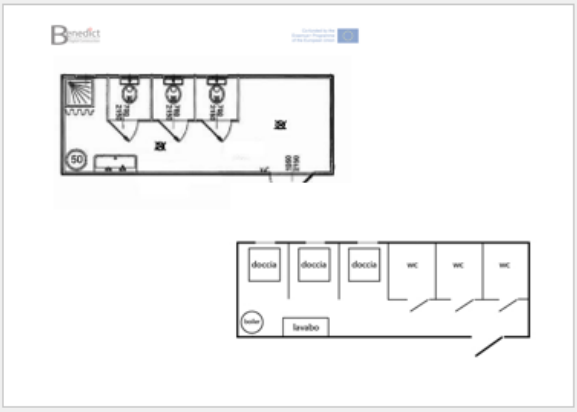
THE MANAGEMENT AREAS MUST BE CLOSELY LOCATED TO THE GATES OF THE CONSTRUCTION SITE.

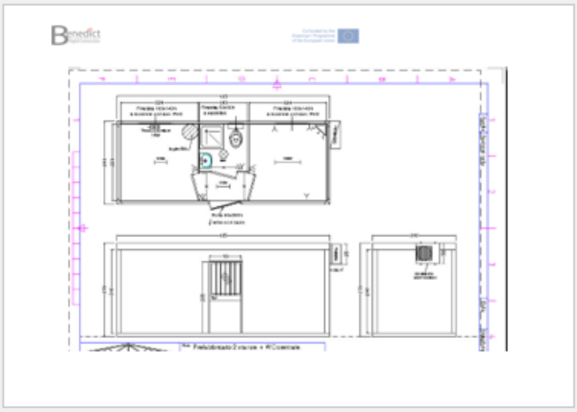
A.5. STAFF SERVICE SHEDS

DEFINITION, SIZING, AND POSITION

THESE AREAS ARE USED AS CANTEEN, REFECTORY, LIVING ROOMS, LOCKER ROOMS, INFIRMARY, HOUSING, IMPOSED BY COMPANY NEEDS AND RULES OF OCCUPATIONAL HEALTH AND SAFETY. NORMALLY THEY ARE LOCATED NEAR THE ENTRANCES OF THE CONSTRUCTION SITE. THE AVERAGE DIMENSIONAL INDEXES ARE AS FOLLOWS:

- **CANTEEN:** 5 SQM /PERSON; ON CONSTRUCTION SITES WITH MORE THAN **50 WORKERS (BY ITALIAN DPR 320/56)**
- **LOCKER ROOMS AND** TOILETS: 2 SQM/USER, 1 **TOILET AND 1 SHOWER** FOR EVERY **10 PEOPLE AND 1 SINK FOR EVERY 5 (BY ITALIAN D.LGS.81/08)**
- **HOUSINGS**: 10 SQM PER PERSON;
- **INFIRMARY:** 10 SQM/PERSON PRESENT AT THE SAME TIME (SPECIAL ROOM WITH FIRST AID FACILITIES IF <100 WORKERS, PLUS INFIRMARY IF > 500 WORKERS))
- TOTAL AVERAGE AREA 1.5-2 SQM/PERSON X SHIFT.



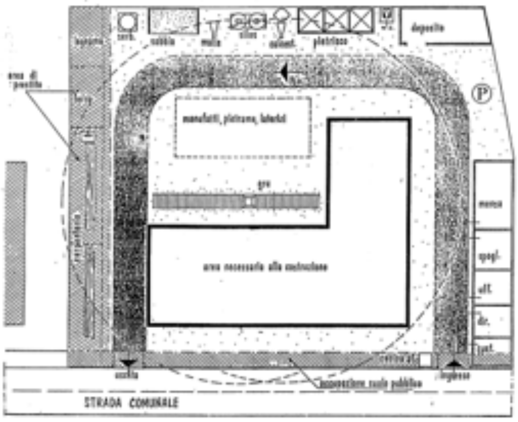


A.6. THE STATIONS OF PRODUCTION SUPPORT ACTIVITIES.

DEFINITION AND POSITION

THEY ARE **INTENDED FOR THE VEHICLE REPAIR** SHOP, THE TOOL AND CLOTHING WAREHOUSE AND THE SPARE PARTS WAREHOUSE.

PRESENT ON LARGE SITES AND IN THOSE LOCATED IN AREAS WHICH ARE DIFFICULT TO ACCESS OR WHERE TECHNICAL ASSISTANCE IS DIFFICULT TO FIND, PRODUCTION SUPPORT STATIONS HAVE NORMALLY PERIPHERAL LOCATION BECAUSE THEIR USE IS OCCASIONAL.



A.7 WASTE STORAGE STATIONS – TEMPORARY STORAGE (ITALIAN STANDARDS)

INERT BUILDING AND DEMOLITION WASTE IS CLASSIFIED IN ITALY AS SPECIAL WASTE

WASTE MUST BE RECOVERED OR DISPOSED OF WITHOUT ENDANGERING HUMAN HEALTH AND WITHOUT HARMING THE ENVIRONMENT.

THE DISPOSAL OF INERT WASTE FROM THE CONSTRUCTION AND DEMOLITION SECTOR MUST TAKE PLACE THROUGH THE TRANSFER TO **SECOND-CLASS LANDFILLS.**

THE TEMPORARY STORAGE OF WASTE

TEMPORARY STORAGE OF WASTE IS THE GROUPING OF WASTE CARRIED OUT, PRIOR TO COLLECTION, AT THE PLACE WHERE IT IS PRODUCED, UNDER THE FOLLOWING CONDITIONS:

1) THE WASTE DEPOSITED MUST NOT CONTAIN PARTICULAR TOXIC SUBSTANCES;
2) WASTE MUST BE COLLECTED AND INITIATED FOR RECOVERY OR DISPOSAL ON A QUARTERLY BASIS (WITHOUT QUANTITATIVE LIMIT, OR ANNUALLY DEPENDING ON THE QUANTITY OF STORAGE; (MAX **30 MC OF WHICH MAX 10 OF HAZARDOUS WASTE**);
3) TEMPORARY STORAGE MUST BE CARRIED OUT BY HOMOGENEOUS CATEGORIES OF WASTE;
4) THE RULES GOVERNING THE PACKAGING AND LABELLING OF DANGEROUS SUBSTANCES MUST BE RESPECTED;
5) FOR SPECIAL CATEGORIES OF TOXIC WASTE, SPECIFIC PROCEDURES FOR TEMPORARY STORAGE OF WASTE MUST BE APPLIED.

TEMPORARY STORAGE MAY BE CARRIED OUT ONLY BY THE PRODUCER AT THE PLACE OF PRODUCTION

FOR THE CONSTRUCTION SITE, WASTE STORAGE AREAS SHOULD BE LOCATED IN PERIPHERAL AREAS OF THE SITE NEAR ROADS AND GATES.

TEMPORARY WASTE DUMPS MAY BE:

- **RUBBLE FROM CONSTRUCTION AND DEMOLITION ACTIVITIES**
- **FERROUS WASTE**
- **TIMBER AND PACKAGING**

CONTENTS IN DISCARDABLE BOXES.

NOTE. DISCARDABLE BOXES MUST BE APPROVED BY LOCAL AUTORITY

*IN ADDITION TO THE CONSTRUCTION SITE STATIONS ON NETWORK, **INFRASTRUCTURE AND CIVIL WORKS CONSTRUCTION SITES**,* THE FOLLOWING STATIONS CAN BE *PRESENT.*

A.8 TECHNOLOGY PLANT POWER STATIONS

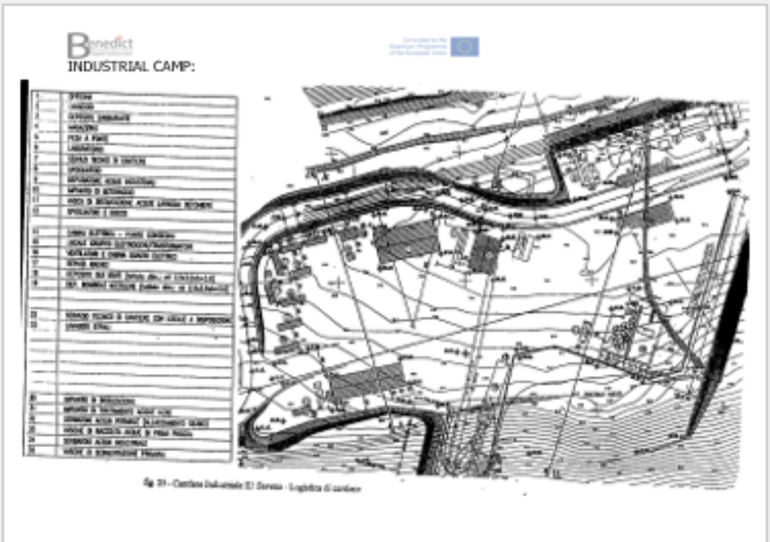
THEY CONSIST OF ELECTRICAL PANELS, TUNNEL VENTILATION UNITS, COMPRESSED AIR PRODUCTION PLANTS FOR MACHINES AND EQUIPMENT, WATER PUMPING UNITS, INDUSTRIAL WASTEWATER TREATMENT PLANTS.

A.9 PARKING AREAS FOR VEHICLES

GIVEN THE EXTENT AND SIZE OF CIVIL WORKS CAN BE VERY EXTENSIVE.

A.10 BASE CAMPS

IN CONTRAST TO **THE INDUSTRIAL CAMP,** WHERE THE ACTUAL PRODUCTION TAKES PLACE, THE BASE CAMPS ARE THE VILLAGES FOR THE HOUSING OF THE WORKERS INVOLVED IN THE CONSTRUCTION OF THE WORK, OFTEN ALSO EQUIPPED WITH BASIC SERVICES.



A.11 PRODUCTION STATIONS FOR RAW MATERIALS AND PRODUCTS FOR CIVIL WORKS

THESE ARE THE STATIONS RELATED **TO EXCAVATING, QUARRYING,** AND INERT PRODUCING AREAS, CONCRETE PLANTS FOR THE PRODUCTION OF BITUMINOUS CONGLOMERATES, REAL PLANTS FOR THE PRODUCTION OF PREFABRICATED PRODUCTS.

A.12 INTERMODALITY STATIONS FOR TRANSPORT SYSTEMS:

THE INTERMODALITY STATIONS OF TRANSPORT SYSTEMS ARE INTENDED TO MITIGATE THE IMPACT OF VEHICLE FLOWS OF ROAD TRANSPORT OF RESULTING MATERIAL FROM THE EXCAVATION AND PRODUCTION OF RAW MATERIALS

CONNECTION SYSTEMS:

B.1. THE HORIZONTAL AND VERTICAL HANDLING SYSTEM.

IT IS THE KINEMATIC COMPONENT OF THE LAYOUT.

IT CONSISTS OF:

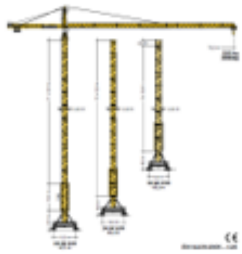
- *INFRASTRUCTURE SUBSYSTEM;*
- *TRANSPORT SUBSYSTEM.*

THE INFRASTRUCTURE SYSTEM

THE INFRASTRUCTURE SYSTEM CONSISTS OF THE COMPLEX OF THE ROAD, RAIL AND AIR NETWORK (TOWER CRANES, CABLE CAR) WHICH ALLOWS THE MOBILITY OF RESOURCES (MANPOWER, MATERIALS, COMPONENTS) WITHIN THE CONSTRUCTION SITE.

THE SIZE AND CONFIGURATION OF THE INFRASTRUCTURE SUBSYSTEM ARE LINKED TO THE TYPE OF WORK, THE SIZE OF THE CONSTRUCTION SITE, THE OROGRAPHY OF THE TERRITORY, THE TYPE OF TRANSPORT CHOSEN.

TOWER CRANE:



THE TRANSPORT SYSTEM

IN THE CHOICE OF TRANSPORT TECHNIQUES, MUCH IMPORTANCE IS ATTACHED TO THE DEVELOPMENT OF SYSTEMS CAPABLE OF INTEGRATING AND COORDINATING THE VARIOUS METHODS.

B.2. THE ELECTRICAL SYSTEM.

IT CONSISTS OF THE FOLLOWING ELEMENTS.

- **TRANSFORMATION BOOTH FROM MV (MEDIUM VOLTAGE) TO LV (LOW VOLTAGE)** FOR UTILITIES ABOVE 100 KW. IT CONSISTS OF A PREFABRICATED STEEL OR A.C. ARTIFACT OR PILE PROCESSING BOOTHS.
- **GENERAL ELECTRICAL** PANEL, DOWNSTREAM OF THE CONNECTION, FROM WHICH DERIVE ALL THE PRIMARY POWER LINES, EACH PROTECTED BY A DIFFERENTIAL SWITCH.
- PRIMARY **POWER LINES, WHICH** CAN BE AERIAL OR UNDERGROUND WITH SPECIFIC CHARACTERISTICS ACCORDING TO CURRENT LEGISLATION.
- **AREA ELECTRICAL CABINETS,** WHICH SERVE A SERIES OF EQUIPMENT (CRANES, CEMENT PLANTS) OR AN AREA OF THE CONSTRUCTION SITE.
- **SECONDARY LINES** THAT POWER THE INDIVIDUAL EQUIPMENT.
- **USAGE CABINETS WHERE** THE SOCKETS FOR SMALL EQUIPMENT OR THE LIGHTING SYSTEM ARE LOCATED.
- **EQUIPMENT WIRING.** THE PLUG SOCKETS OF THE WIRING MUST BE OF THE INTERLOCKED TYPE.
- **EARTHING SYSTEM THAT** CONNECTS ALL EQUIPMENT AND MASSES.
- **AUTONOMOUS GENERATOR** GENERALLY CONSISTING OF A DIESEL ELECTRICAL POWER FORCE GENERATOR, POSITIONED NEAR THE GENERAL ELECTRICAL PANEL.

STANDARD FOR SIZING

INDOOR AND OUTDOOR LIGHTING:

- OFFICE LIGHTING, CANTEEN ETC.:4 KW/100SQM;
- LIGHTING WAREHOUSES, WORKSHOP (INCLUDING FEM ELECTRIC DRIVING FORCE): 8 KW/100SQM;
- OUTDOOR LIGHTING WITH LIGHT POLES:1 KW/200SQM.

ELECTRICAL POWER FORCE:

THE INSTALLED POWER WILL BE EQUAL TO THE SUM OF THE POWER FORCE UTILITIES OF CONSTRUCTION MACHINERY AND EQUIPMENT, MULTIPLIED BY A COEFFICIENT OF CONTEMPORANEITY RANGING FROM 0.75 TO 1.00, AND OF THE INDOOR AND OUTDOOR LIGHTING.

$$P_{TOT} = P\Sigma_i \times C_{CONT} + P\ LIGHTING_{ILLUMINAZIONE}$$

B.3. SANITARY AND INDUSTRIAL WATER SYSTEM.

THE WATER AND SANITARY SYSTEM CONSISTS OF:

- DRINKING WATER SUPPLY **FACILITY AND/OR NON-POTABLE WATER SUPPLY;**
- BLACK **AND WHITE WATER** SEWERAGE SYSTEM.

THE DRINKABLE AND NON-POTABLE WATER SUPPLY FACILITY - FOR INDUSTRIAL USE

THE WATER SUPPLY SYSTEM CONSISTS OF:

- AQUEDUCT CONNECTION;

Or

- COLLECTION WELL;
- STORAGE TANK;

AND, IN ANY CASE,

- DISTRIBUTION NETWORK.

IN **GENERAL, NETWORKS** FOR INDUSTRIAL USE ARE OF TWO TYPES:

- HIGH FLOW RATE AND LOW PREVALENCE (CONCRETE AND CRUSHING PLANTS);
- LOW FLOW RATE AND HIGH PREVALENCE (CURING OF CONCRETE AT HEIGHT, ETC.).

THE TANK CAN BE MADE OF REINFORCED CONCRETE OR FIBERGLASS OF THE "FOOD" TYPE, POLYETHYLENE OR PVC, IF THE WATER IS INTENDED FOR DRINKING OR CIVIL USES (DRINKING WITH ACTIVATED CARBON FILTERS OR SALTS).

THE DISTRIBUTION OF WATER IS CARRIED OUT WITH FLEXIBLE POLYETHYLENE, MULTILAYER PIPES. IF GALVANIZED STEEL AND UNDERGROUND PLACED MUST BE PROTECTED AGAINST ACCIDENTAL EXCAVATIONS AND CONNECTED TO THE GROUNDING PLANT.

THE WATER CONSUMPTION FOR EACH SITE VARIES ACCORDING TO THE TYPE OF INSTALLATIONS, THE NUMBER OF PERSONNEL AND THE CLIMATE *(CURING OF CONCRETE)*.

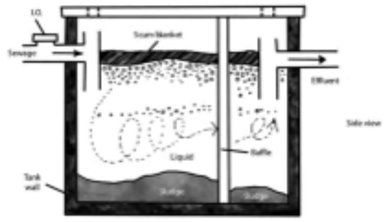
AS AN INDICATION, SOME CONSUMPTION IS REPORTED:

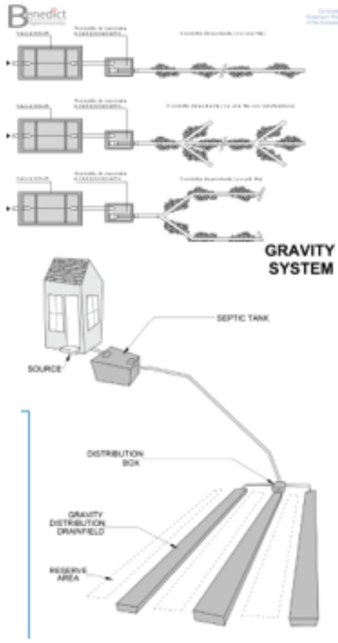
- CEMENT PLANT: 0.200 MC OF H_2O/MC OF CLS;
- INERT TREATMENT PLANT: 2,000 MC OF H_2O/MC OF INERT;
- INERT TREATMENT PLANT WITH WATER RECOVERY: 0.500 MC OF H_2O/MC OF INERT;
- CLAY/LOAM COMPACTION: 12% OF THE WEIGHT OF THE MATERIAL TO BE COMPACTED;
- TOUT-VENANT COMPACTION: 8% OF THE WEIGHT OF THE MATERIAL TO BE COMPACTED;
- CONCRETE CURING: 0.300 MC OF H_2O/MC CLS;
- STAFF: 0.100 MC/PERSON PER DAY.

THE BLACK AND WHITE WATER SEWER SYSTEM

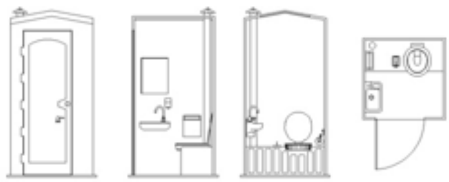
THE SEWERAGE SYSTEM, TO BE BUILT WITH UNDERGROUND CONCRETE OR PVC PIPES, MUST ENSURE THE DISPOSAL OF METEORIC AND BLACK WATER.

- IN THE CASE OF RAINWATER, PROVISION SHOULD ALSO BE MADE FOR GARRISON WORKS AGAINST POSSIBLE FLOODING OF RIVERS.
- IN THE CASE OF BLACK WATER, PROVISION SHOULD BE MADE FOR A **SEPTIC TANK** OF THE IMHOFF TYPE IN ORDER TO AVOID POLLUTION OF AQUIFERS OR RETURN WATER COURSES.





ALTERNATIVELY: CHEMICAL TOILET



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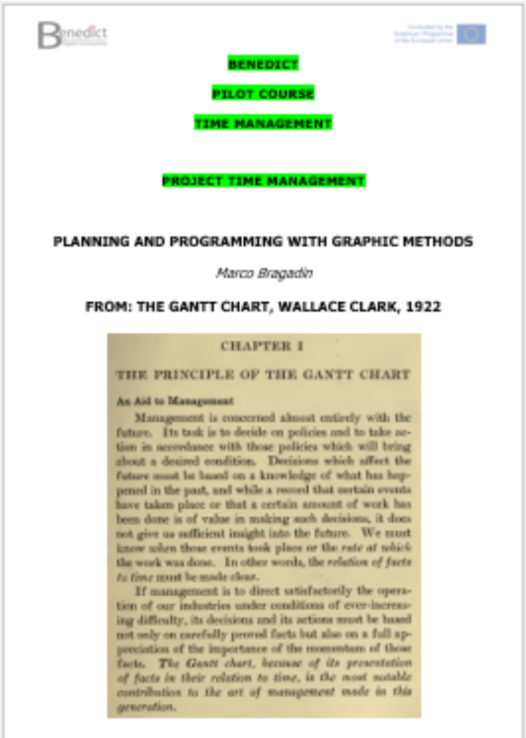
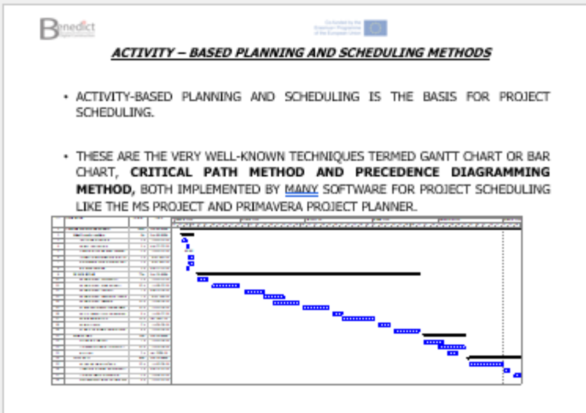
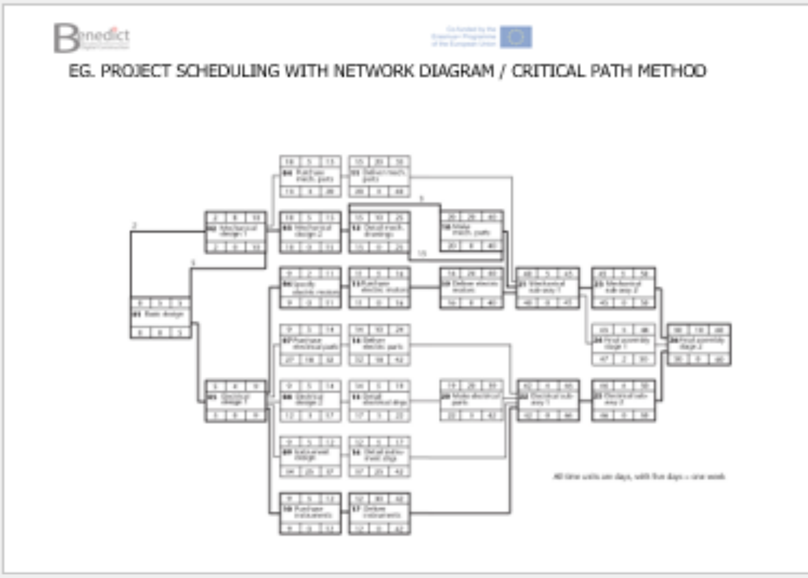
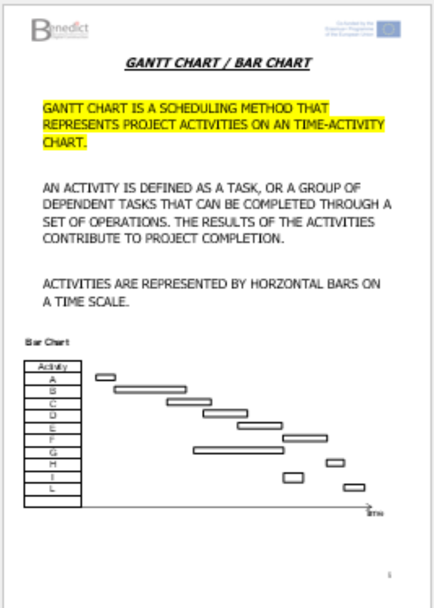
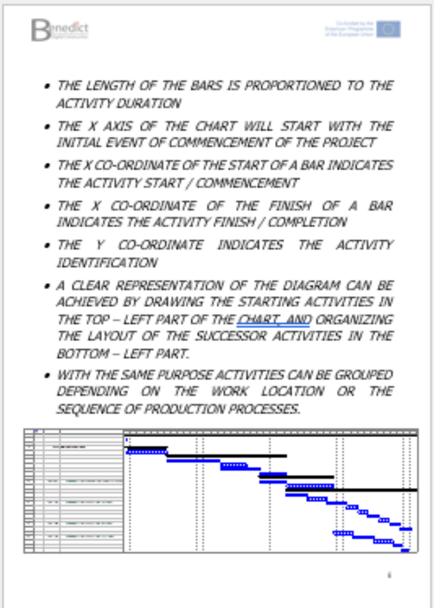
A.4. Workshop 3 lecture Slides

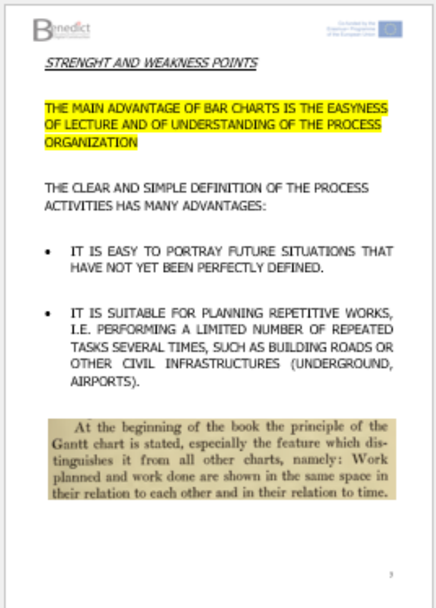




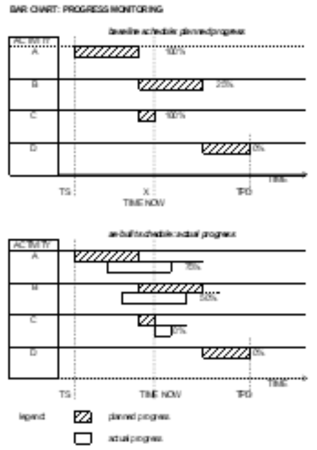

EG. PROJECT SCHEDULING WITH NETWORK DIAGRAM / CRITICAL PATH METHOD


GANTT CHART / BAR CHART
GANTT CHART IS A SCHEDULING METHOD THAT REPRESENTS PROJECT ACTIVITIES ON AN TIME-ACTIVITY CHART.
AN ACTIVITY IS DEFINED AS A TASK, OR A GROUP OF DEPENDENT TASKS THAT CAN BE COMPLETED THROUGH A SET OF OPERATIONS. THE RESULTS OF THE ACTIVITIES CONTRIBUTE TO PROJECT COMPLETION.
ACTIVITIES ARE REPRESENTED BY HORZONTAL BARS ON A TIME SCALE.
Bar Chart
Activity
A
B
C
D
E
F
G
H
I
L


THE LENGTH OF THE BARS IS PROPORTIONED TO THE ACTIVITY DURATION
THE X AXIS OF THE CHART WILL START WITH THE INITIAL EVENT OF COMMENCEMENT OF THE PROJECT
THE X CO-ORDINATE OF THE START OF A BAR INDICATES THE ACTIVITY START / COMMENCEMENT
THE X CO-ORDINATE OF THE FINISH OF A BAR INDICATES THE ACTIVITY FINISH / COMPLETION
THE Y CO-ORDINATE INDICATES THE ACTIVITY IDENTIFICATION
A CLEAR REPRESENTATION OF THE DIAGRAM CAN BE ACHIEVED BY DRAWING THE STARTING ACTIVITIES IN THE TOP – LEFT PART OF THE CHART AND ORGANIZING THE LAYOUT OF THE SUCCESSOR ACTIVITIES IN THE BOTTOM – LEFT PART.
WITH THE SAME PURPOSE ACTIVITIES CAN BE GROUPED DEPENDING ON THE WORK LOCATION OR THE SEQUENCE OF PRODUCTION PROCESSES.


STRENGHT AND WEAKNESS POINTS
THE MAIN ADVANTAGE OF BAR CHARTS IS THE EASYNESS OF LECTURE AND OF UNDERSTANDING OF THE PROCESS ORGANIZATION
THE CLEAR AND SIMPLE DEFINITION OF THE PROCESS ACTIVITIES HAS MANY ADVANTAGES:
IT IS EASY TO PORTRAY FUTURE SITUATIONS THAT HAVE NOT YET BEEN PERFECTLY DEFINED.
IT IS SUITABLE FOR PLANNING REPETITIVE WORKS, I.E. PERFORMING A LIMITED NUMBER OF REPEATED TASKS SEVERAL TIMES, SUCH AS BUILDING ROADS OR OTHER CIVIL INFRASTRUCTURES (UNDERGROUND, AIRPORTS).
At the beginning of the book the principle of the Gantt chart is stated, especially the feature which distinguishes it from all other charts, namely: Work planned and work done are shown in the same space in their relation to each other and in their relation to time.

UPDATING PROJECT SCHEDULE: IN-PROGRESS MONITORING



ON THE OTHER HAND, THE SIMPLICITY OF BAR CHARTS DOES NOT ALLOW THE PLANNER TO KNOW:

- THE GRAPHIC REPRESENTATION OF LINKS OF LOGICAL DEPENDENCE BETWEEN DIFFERENT ACTIVITIES;
- THE GRAPHIC REPRESENTATION OF THE CONSTRAINTS TO BE RESPECTED THAT ALLOW THE START OF A TASK;
- AN INDICATION OF THE STRATEGIC ACTIVITIES OF THE PROGRAMME, I.E. THOSE WHICH MUST BE CARRIED OUT AS A MATTER OF PRIORITY IN ORDER TO ALLOW THE END OF THE PROGRAMME BY SUCH A DATE
- ANY EXTENSIONS THAT MAY BE GRANTED AT THE BEGINNING AND/OR END OF A GIVEN ACTIVITY WITHOUT DELAYING THE DATE OF PROJECT COMPLETION.

IN ADDITION TO THIS, THE FOLLOWING CRITICAL ASPECTS:

- IF THE NUMBER OF TASKS TO BE PROGRAMMED BECOMES HIGH AND THE DIAGRAM DEVELOPS OVER SEVERAL PAGES IT BECOMES DIFFICULT TO READ AND UNDERSTAND DATA, IN PARTICULAR IT IS DIFFICULT TO "SEE" THE RELATIONSHIPS BETWEEN THE TASKS;
- IT DOES NOT ALLOW THE PLANNER TO IDENTIFY CHANGES IN THE PROGRAMME THAT MAY OCCUR AS A RESULT OF CHANGES IN DURATION OR RESOURCES OF AN ACTIVITY;
- IT IS DIFFICULT TO USE IT AS A TOOL FOR MONITORING THE PROGRESS OF LARGE PROJECTS.
- IT IS DIFFICULT TO INTRODUCE MATHEMATICAL METHODS FOR RESOURCE MANAGEMENT;
- THE PLANNING AND SCHEDULING FUNCTIONS ARE PERFORMED AT THE SAME TIME.

PROJECT CONTROL -

THE MEASURING OF THE WORK IN-PROGRESS

THE PROGRESS OF THE WORK CAN BE MEASURED OBJECTIVELY WITH THE DEFINITION OF PERFORMANCE INDICATORS (**KEY PERFORMANCE INDICATORS – KPIS)** THAT ENABLE THE EVALUATION OF WHAT HAS ALREADY BEEN ACHIEVED RELATED TO THE FORECAST.

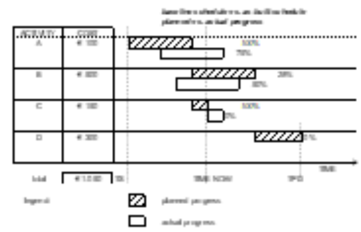
INDICATORS ARE ALSO CALLED "WEIGHTS" OF ACTIVITIES. WEIGHING MAKES IT POSSIBLE TO EVALUATE THE OVERALL PROGRESS OF THE PROJECT RELATED TO THE ENTIRE WORK TO BE CARRIED OUT, AT ANY INTERMEDIATE TIME OF THE EXECUTION, ON THE BASIS OF THE DATA COLLECTED ON SITE.

THE MOST IMPORTANT CATEGORIES OF INDICATORS ARE THE FOLLOWING:

- **MONEY;**
- **LABOUR EFFORT MEASURED IN MAN - HOURS OR LABOR - DAYS;**
- **TIME REQUIRED FOR THE PERFORMANCE (DURATION);**
- **QUANTITY OF PRODUCT TO BE PRODUCED;**

FOR EXAMPLE, THE ESTIMATE OF THE PERCENTAGE OF WORK CARRIED OUT IS DETERMINED ON THE BASIS OF:

- (COST OF ACTIVITY "A" / TOTAL AMOUNT OF CONTRACT) X 100
- (MAN-HOURS OF WORK OF ACT. "A" / ACTUAL MAN HOURS OF PERIOD) X 100
- (DURATION OF ACT. "A" / TOT. PROJECT DURATION) X 100
- (QUANTITY OF ACT. "A" / TOT Q [MC, KM, TON, ETC) X 100
- SCORE ASSIGNED TO EACH ACTIVITY



planned progress
baseline project status

activity	cost	% pct	amount
A	€ 100,00	100%	€ 100,00
B	€ 500,00	25%	€ 125,00
C	€ 150,00	100%	€ 150,00
D	€ 300,00	0%	€ -
total	€ 1.050,00		€ 375,00

36% base line progress

actual progress
as-built project status

activity	cost	% pct	amount
A	€ 100,00	75%	€ 75,00
B	€ 500,00	50%	€ 250,00
C	€ 150,00	0%	€ -
D	€ 300,00	0%	€ -
total	€ 1.050,00		€ 325,00

31% actual progress

NETWORK DIAGRAMS FOR PLANNING AND SCHEDULING

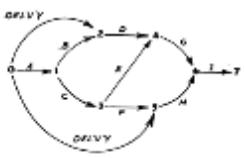
M. Bragadin

CPM-PDM NETWORK DIAGRAMS

THE CRITICAL PATH METHOD CPM

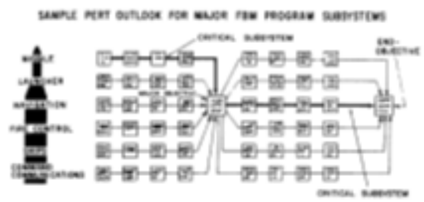
THE **CRITICAL PATH METHOD WAS** DEVELOPED FROM **1956** TO **1959** BY **E.I. DU PONT DE NEMOURS (DUPONT)**, FOLLOWING THE PURCHASE OF ONE OF THE FIRST COMPUTERS MADE FOR FREE SALE TO PRIVATE INDIVIDUALS BY **UNIVAC** (REMINGTON RAND).

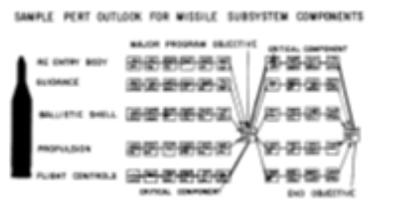
KELLEY AND WALKER'S WORK PRODUCED THE CPM, WHICH WAS CALLED " BECAUSE OF THE CENTRAL POSITION THAT CRITICAL ACTIVITIES IN A PROJECT PLAY IN THE **METHOD**" (KELLEY, WALKER, 1959).



PROGRAMME EVALUATION AND REVIEW TECHNIQUE PERT

"AT THE SAME TIME" OF CPM DEVELOPMENT, THE U.S. NAVY SPECIAL PROJECTS OFFICE **DEVELOPED THE PERT - PROJECT EVALUATION AND REVIEW TECHNIQUE** FOR **THE POLARIS MISSILE PROJECT** (MALCOM, ROSEBOOM, CLARK, FAZAR, 1959) WITH A PROBABILISTIC APPROACH.





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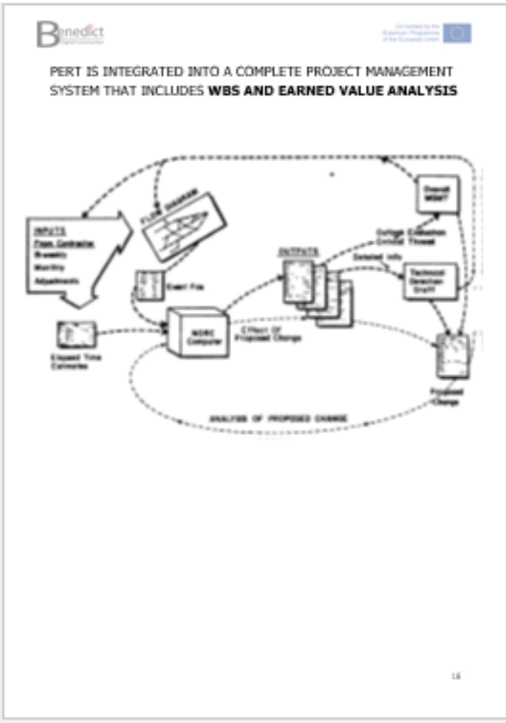
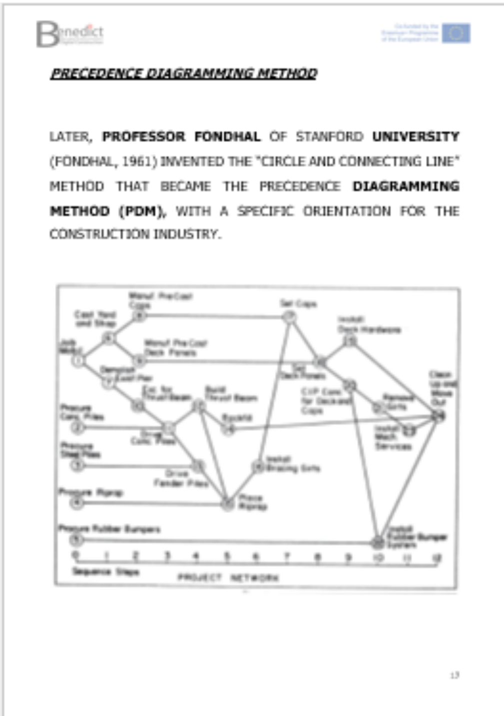
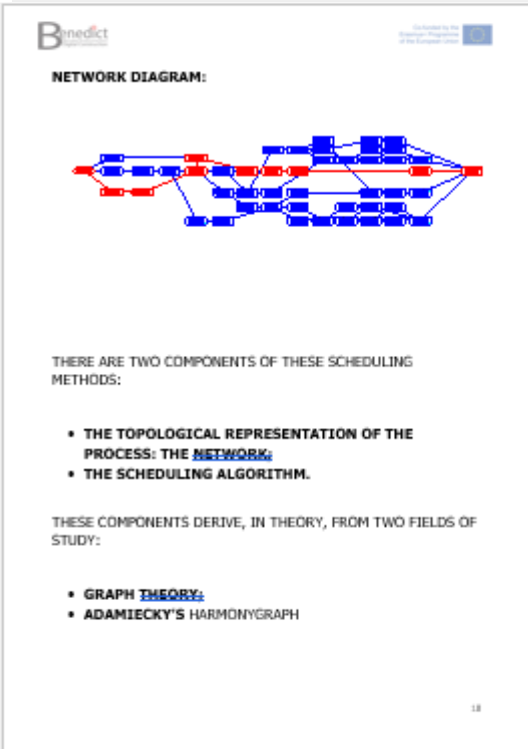
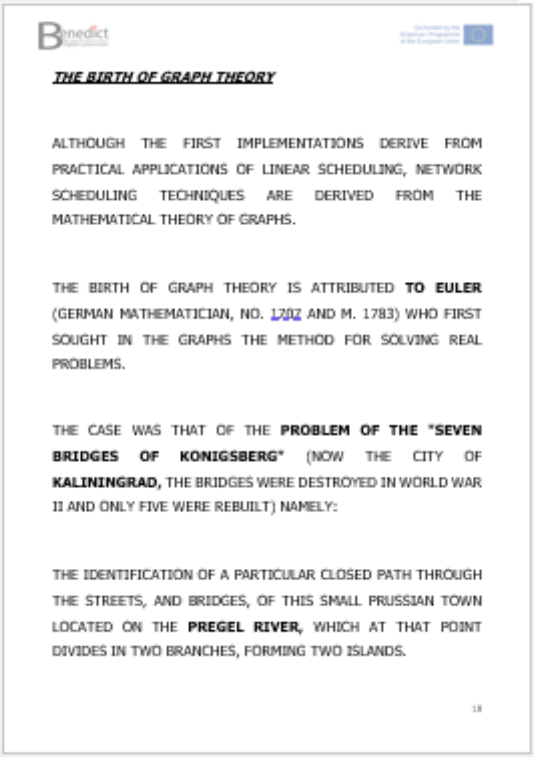
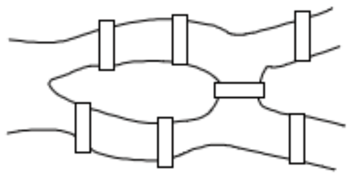

PERT IS INTEGRATED INTO A COMPLETE PROJECT MANAGEMENT SYSTEM THAT INCLUDES **WBS AND EARNED VALUE ANALYSIS**
ANALYSIS OF PROPOSED CHANGE


PRECEDENCE DIAGRAMMING METHOD
LATER, PROFESSOR FONDHAL OF STANFORD UNIVERSITY (FONDHAL, 1961) INVENTED THE "CIRCLE AND CONNECTING LINE" METHOD THAT BECAME THE PRECEDENCE DIAGRAMMING METHOD (PDM), WITH A SPECIFIC ORIENTATION FOR THE CONSTRUCTION INDUSTRY.
PROJECT NETWORK


NETWORK DIAGRAM:
THERE ARE TWO COMPONENTS OF THESE SCHEDULING METHODS:
THE TOPOLOGICAL REPRESENTATION OF THE PROCESS: THE NETWORK;
THE SCHEDULING ALGORITHM.
THESE COMPONENTS DERIVE, IN THEORY, FROM TWO FIELDS OF STUDY:
GRAPH THEORY;
ADAMIECKY'S HARMONYGRAPH


THE BIRTH OF GRAPH THEORY
ALTHOUGH THE FIRST IMPLEMENTATIONS DERIVE FROM PRACTICAL APPLICATIONS OF LINEAR SCHEDULING, NETWORK SCHEDULING TECHNIQUES ARE DERIVED FROM THE MATHEMATICAL THEORY OF GRAPHS.
THE BIRTH OF GRAPH THEORY IS ATTRIBUTED TO EULER (GERMAN MATHEMATICIAN, NO. 1707 AND M. 1783) WHO FIRST SOUGHT IN THE GRAPHS THE METHOD FOR SOLVING REAL PROBLEMS.
THE CASE WAS THAT OF THE PROBLEM OF THE "SEVEN BRIDGES OF KONIGSBERG" (NOW THE CITY OF KALININGRAD, THE BRIDGES WERE DESTROYED IN WORLD WAR II AND ONLY FIVE WERE REBUILT) NAMELY:
THE IDENTIFICATION OF A PARTICULAR CLOSED PATH THROUGH THE STREETS, AND BRIDGES, OF THIS SMALL PRUSSIAN TOWN LOCATED ON THE PREGEL RIVER, WHICH AT THAT POINT DIVIDES IN TWO BRANCHES, FORMING TWO ISLANDS.

THE SEVEN BRIDGES OF KONIGSBERG ON THE PREGEL RIVER



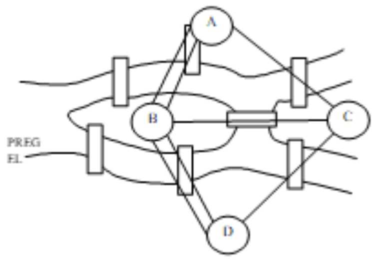
THE PROBLEM OF THE SEVEN BRIDGES OF KONIGSBERG CAN BE STATED IN THE FORM:

<u>"IS IT POSSIBLE TO CROSS EACH BRIDGE ONLY ONCE AND RETURN TO THE STARTING SHORE?"</u>

EULER MATHEMATICALLY DEFINED THE PROBLEM AND SOLVED IT, FOUNDING THEORY OF GRAPH ***CONDITION OF EULER, PRESENTED AT THE ACADEMY OF SCIENCES IN ST. PETERSBURG, 1736.***

THE FIRST STEP WAS TO ABSTRACT THE MODEL BY SYNTHESIZING THE PROBLEM WITH A GRAPH, WHICH IS A DIAGRAM CONSISTING OF NODES AND LINKING ARCS.

GRAPH EQUIVALENT TO THE MAP:



THE PROBLEM IS REFORMULATING:

"IS THERE A CLOSED PATH THAT CROSSES ALL THE ARCHES OF THE GRAPH ONCE AND ONLY ONCE?"

IT IS EASY TO PROVE, EVEN BY TRIAL AND ERROR, THAT THE PROBLEM HAS NO SOLUTION.

LA GENERALIZZAZIONE DEL PROBLEM (FROM DETAIL TO GENERAL) THROUGH GRAPHS LED EULER TO THE DEFINITION OF A GENERAL RULE.

"THE CLOSED CIRCUIT EXISTS IF THERE ARE AN EVEN NUMBER OF INCIDENT SIDES FOR EACH NODE."

(EULER'S CONDITION)

IN THE SPECIFIC CASE OF THE SEVEN KONINGSBERG BRIDGES, THE REPRESENTATIVE GRAPH HAS NODES A, B, C, AND D:

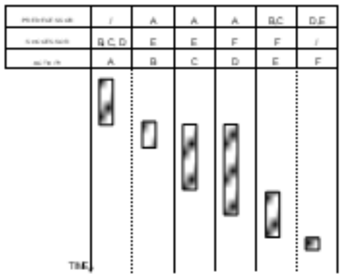
- 3 INCIDENT SIDES
- 3 INCIDENT SIDES
- 3 INCIDENT SIDES
- 5 ACCIDENT SIDES

FOR THE KONINGSBERG PROBLEM THERE IS NO SOLUTION, THAT IS, THERE IS NO CLOSED CIRCUIT, ALSO CALLED THE EULER CIRCUIT.

SINCE THEN, WITH THE EVOLUTION OF **OPERATIONAL RESEARCH STUDIES,** GRAPHS HAVE BEEN USED:

- *IN THE MILITARY FIELD (E.G. DEFINITION OF HIERARCHY);*
- *IN THE INDUSTRIAL FIELD (E.G. COMPANY ORGANIZATION CHART OR FUNCTIONAL LAYOUT OF PRODUCTION PLANTS, WBS);*
- *IN THE FIELD OF TRANSPORT;*
- *FOR THE PLANNING OF THE ACTIVITIES OF A PROJECT AND THEREFORE OF CONSTRUCTION WORK;*
- *FOR MANY OTHER APPLICATIONS.*

ADAMIECKY'S HARMONYGRAPH (1896–1931)



ACTIVITY NETWORKS

- **"ACTIVITY NETWORKS" OR "NETWORK DIAGRAMMING"**, ARE GRAPHS THAT ALLOW TO CREATE A SIMPLE MODEL OF THE CONSTRUCTION PROCESS, OR OF ANY PROCESS THAT INVOLVES ACTIVITIES THAT CONTRIBUTE TO THE ACHIEVEMENT OF THE INTENDED PURPOSE BY A CO-ORDINATED ORDER OF SEQUENCE.

- **PROJECT PLANNING AND SCHEDULING CAN BE DEVELOPED THROUGH NETWORKING TECHNIQUES.**

THESE TECHNIQUES ADDRESSES PROJECT PLANNING BY A SUBDIVISION OF THE COMPLEX PROJECT INTO ELEMENTARY ACTIVITIES THAT ARE INTERCONNECTED LOGICALLY. THEREFORE, THE UPDATING OF THE STATUS OF PROJECT ACTIVITIES ALLOWS TO KNOW IMMEDIATELY THE CONSEQUENCES OF ACTUAL PROJECT PERFORMANCE ON THE FINAL PROJECT COMPLETION DATA, I.E. TIME AND COSTS.

EVENTS AND ACTIVITIES

A PROJECT IS COMPOSED BY DIFFERENT ELEMENTS, EVENTS AND ACTIVITIES.

- **EVENT:** A SITUATION OCCURRING WHEN ONE OR MORE ACTIVITIES ARE COMPLETED. EVENTS HAVE NO DURATION (SEE MILESTONES)
- **ACTIVITY/TASK:** AN OPERATION CARRIED OUT WITH THE CONSUMPTION OF RESOURCES AND CHARACTERIZED BY A DURATION

SCHEDULING PHASES

PLANNING

THE FIRST STEP OF PROJECT CONTROL IS PROJECT PLANNING. PROJECT PLANNING INDICATES ALL THE FORESEEABLE ELEMENTARY ACTIONS AND THEIR LOGIC SEQUENCE.

PLANNING DETECTS THE TASKS WHOSE COMPLETION MUST NECESSARILY PRECEDE THE START OF EACH CONSIDERED TASK (PREDECESSORS), THOSE THAT CANNOT BEGIN IF THIS TASK HAS NOT BEEN COMPLETED (SUCCESSORS), AND FINALLY THOSE TASKS THAT CAN BE PERFORMED AT THE SAME TIME.

PROGRAMMING / SCHEDULING AND CONTROLLING

THE DURATION OF TIME OF AN ACTIVITY OR TASK CAN BE ESTIMATED BY A DETERMINISTIC OR PROBABILISTIC METHOD.

ONCE THE DURATION OF ACTIVITIES AND THEIR LOGIC LINKS HAVE BEEN INDICATED, IT IS POSSIBLE TO DETERMINE THEIR START AND END DATES AND TO MONITOR THEM DURING WORK IN-PROGRESS.

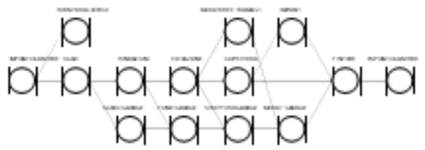
PLANNING METHODS

TYPE OF ACTIVITY NETWORKS:

- **STOCHASTIC** FOR THE STRATEGIC LEVEL (**PROBABILISTIC ACTIVITY NETWORK = PAN**)
- **DETERMINISTIC** FOR THE OPERATIONAL LEVEL (**DETERMINISTIC ACTIVITY NETWORK = DAN**)

IN THE PAN CASE, **ONLY ACTIVITY ON ARC (AOA) NETWORKS CAN BE USED,** I.E. THE NETWORK ARCS PORTRAY THE SINGLE ACTIVITIES AND THEIR LOGICAL – CHRONOLOGICAL SEQUENCE, WHILE THE NODES PORTRAY THE START AND END EVENTS OF THE SAME ACTIVITIES.

IN THE DAN CASE, BOTH AOA AND **ACTIVITY ON NODE (AON) NETWORKS CAN BE USED,** WHERE ELEMENTARY ACTIVITIES ARE REPRESENTED BY NODES AND ARCS DETERMINE THEIR SEQUENCE.



SCHEDULING AND CONTROLLING METHODS

AT THE SCHEDULING STAGE, THE METHODS ARE DIFFERENT IN RELATION TO THE LEVEL OF DECISION-MAKING IN WHICH THEY OPERATE. IN GENERAL, THE FOLLOWING ARE INDICATED:

- **DETERMINISTIC METHODS (DETS)** WITH DETERMINISTIC ALGORITHMS FOR THE OPERATING LEVEL, SUCH **AS CRITICAL PATH METHOD (CPM)** AND **PRECEDENCE DIAGRAMMING METHOD (PDM)**#

- **STOCHASTIC METHODOLOGIES (STOCS)** WITH STOCHASTIC ALGORITHMS FOR THE STRATEGIC LEVEL SUCH AS GENERALIZED ACTIVITY NETWORK (GAN); **GRAPHIC EVALUATION REVIEW TECHNIQUE (GERT)** AND GERT FOR SIMULATION (GERTS)#

- **PERT (PROGRAM EVALUATION REVIEW TECHNIQUE)** IT IS A METHODS THAT USES A DETERMINISTIC NETWORK (AND THEREFORE SUITABLE FOR THE OPERATIONAL LEVEL FOR PLANNING), BUT SUPPORTED BY A STOCHASTIC ALGORITHM, FOR THE TIME ANALYSIS PHASE - SCHEDULING.

NETWORK PROJECT PLANNING: APPLICATION HYPOTHESES AND NETWORK LOGIC

THERE ARE FOUR APPLICATION HYPOTHESES FOR NETWORK TECHNIQUES USED TO PLAN AND MANAGE A CONSTRUCTION PROJECT:

1. **THE NETWORK REPRESENTS THE REALITY OF THE CONSTRUCTION PROCESS, THAT** IS, THE REALITY OF THE CONSTRUCTION PROCESS: IT REPRESENTS ALL THE ACTIVITIES THAT TAKE PLACE ON SITE;
2. **EACH ARC, IN THE CASE OF THE AOA REPRESENTATION, OR EACH** NODE, IN THE CASE OF THE **AON** REPRESENTATION, **CORRESPONDS TO A WELL-DEFINED** ACTIVITY. WORK ACTIVITIES MUST HAVE A UNIQUE CORRESPONDENCE WITH THE ELEMENTS (ARCS OR NODES) OF THE NETWORK, WITHOUT MISUNDERSTANDING.
3. **ACTIVITIES ARE CHARACTERIZED BY A REPRESENTATIVE VALUE OF THE DURATION OF** THE ACTIVITY ITSELF, EXPRESSED IN DETERMINISTIC FIGURES (I-J, CPM, PDM) OR PROBABILISTIC (PERT)#

4. **THE RELATIONSHIPS BETWEEN THE ACTIVITIES ON SITE ARE LOGICAL AND CHRONOLOGICAL.** THEY IMPLY THE TIME FLOW, AND SINCE IN OUR REALITY TIME CANNOT GO BACK, WITHIN THE NETWORK THERE CAN BE NO LOGICAL LOOPS OR **FEED-BACKS PROCESSES.** TASKS ARE PERFORMED ACCORDING TO THEIR TIME ALLOCATION ACCORDING TO THE LOGIC OF THE PROCESS. *THERE ARE NO ACTIVITIES THAT CAN GO BACK IN TIME.*

IN NETWORK PROJECT PLANNING TWO STEPS NEED TO BE PERFORMED BY THE PROJECT PLANNER / PROJECT SCHEDULER:

- **FIRSTLY, A PLANNING STEP**, IN WHICH THE NETWORK LOGIC OF SINGLE **ACTIVITIES** IS IDENTIFIED
- THEN, A **SCHEDULING STEP**, BASED ON THE CALCULATION ALGORITHM IMPLEMENTED BY THE SCHEDULING METHOD.

NETWORK LOGIC

LOGICAL / CHRONOLOGICAL LINKS DEFINE BETWEEN TWO OR MORE ACTIVITIES A RELATIONSHIP OF SUCCESSION, PARTIAL CONTEMPORANEITY, OR TOTAL CONTEMPORANEITY.

"NETWORK LOGIC" IS THE SET OF LOGICAL-CHRONOLOGICAL RELATIONSHIPS BETWEEN THE ACTIVITIES THAT BUILDS THE STRUCTURE OF THE NETWORK.

IT'S THE SEQUENCE OF EXECUTION OF ACTIVITIES.

NETWORK LOGIC IS REPRESENTED BY THE STRUCTURE COMPOSED BY THE LINKS BETWEEN THE ACTIVITIES IN THE NETWORK IN DIFFERENT WAYS DEPENDING ON THE NETWORK TYPE (ACTIVITY ON ARC OR ACTIVITY ON NODE) AND THE SCHEDULING METHOD:

- FOR AN ACTIVITY **ON NODE NETWORK,** GIVEN A LOGIC, **ONLY ONE NETWORK IS UNIQUELY** FOUND.
- FOR AN **ACTIVITY ON ARC NETWORK,** GIVEN A LOGIC, MULTIPLE DIFFERENT NETWORKS ARE POSSIBLE BECAUSE THE AOA REPRESENTATION IS NOT **UNIQUE.**

WHEN BUILDING THE NETWORK, **IMPLEMENTATION CHOICES OF THE PROCESS ARE MADE.**

A CONSTRUCTION PROCESS DEVELOPS ACCORDING TO FEW BASIC GENERAL RULES AND SOME MORE SPECIFIC RULES, TERMED CONSTRAINTS, THAT ARE DRIVEN FROM TECHNOLOGY, CONTRACT AND REGULATIONS, PROJECT SPECIFIC POLICIES OR CONSTRUCTIVE TRADITIONS, AVAILABLE RESOURCES, OR ANY OTHER CONDITIONING PROJECT ELEMENT.

A FUNDAMENTAL RULE OF PROJECT PLANNING AND SCEHDULING IS TERMED THE **RULE OF 3 "S":**

- **SAFETY**
- **SPACE**
- **STRUCTURE**

THAT IDENTIFIES THE FUNDAMENTAL REQUIREMENTS OF THE CONSTRUCTION PROCESS.

- **THE SAFETY OF PSYCHOPHYSICAL WORKING CONDITIONS OF OPERATORS ON SITE** IS A FUNDAMENTAL REQUIREMENT OF THE CONSTRUCTION PROCESS. ***IT IS WELL KNOWN THAT THE SUCCESSION OF ACTIVITIES IS FUNDAMENTAL IN ENSURING THE SAFETY OF WORK OPERATIONS.***
- THE **AVAILABILITY OF** SPACE NEEDED TO CARRY OUT CONSTRUCTION ACTIVITIES IS A NECESSARY CONDITION FOR CARRYING OUT PROCESS OPERATIONS (AND TO ENSURE THEIR SAFETY)
- THE **CONSTRUCTION OF THE BUILIDING STRUCTURE IS THE BACKBONE OF THE PROCESS TO** BE CARRIED OUT ON SITE. THE STRUCTURE IS ALWAYS THE FIRST STEP TO BE CARRIED OUT ON THE CONSTRUCTION SITE AND IS THE CONDITIONING PROCESS FOR ALL THE REMAINING ONES. GENERALLY SPEAKING, THE CHAIN OF ACTIVITIES THAT

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REPRESENTS THE LOAD CARRING STRUCTURE OF A BUILDING IS A FUNDAMENTAL COMPONENT OF THE NETWORK LOGIC.

LOGIC – LINKS AND CONSTRAINTS BETWEEN NETWORK ACTIVITIES

LOGICAL-CHRONOLOGICAL DEPENDENCY CONSTRAINTS BETWEEN **TASKS CAN REPRESENT DIFFERENT CAUSAL TYPOLOGIES** THAT CAN BE:

- **NATURAL;**
- **RESOURCE - BASED;**
- **PROCESS - BASED.**

THERFORE, ACTIVITY RELATIONSHIPS CAN BE CLASSIFIES AGAINST THESE CATEGORIES.

- **NATURAL CONSTRAINTS ARE PHYSICAL OR TECHNOLOGICAL CONSTRAINTS AND DEPEND ON THE TECHNOLOGIES USED.** THESE ARE THE ACTIVITIES THAT WE MUST DO IN ORDER OF BEING ABLE OF DOING OTHER ACTIVITIES AFTER, DEPENDING ON THE TECHNOLOGY CHOSEN::
  - *E.G. BEFORE POURING CONCRETE, THE FORMWORKS NEED TO BE MADE AND STEEL REBARS NEED TO BE LAID*

  OR LEAD TIMES REQUIRED TO DEVELOP CERTAIN PROCESSES WHICH ARE DIFFICULT TO CONDITION:
  - *E.G. THE DEVELOPMENT OF CHEMICAL REACTIONS SUCH AS CONCRETE CURING OR PAINT DRYING.*

- **RESOURCE-BASED CONSTRAINTS ARE CONSTRAINTS DUE TO THE CONTINUED USE OF THE SAME RESOURCES TO PERFORM MULTIPLE TASKS SEQUENTIALLY.** THIS IMPLIES THAT WHEN THERE IS A NEED FOR A CERTAIN RESOURCE, IT WILL BE AVAILABLE ON-SITE. THE BENEFITS OF IMPLEMENTING NETWORK TECHNIQUES IN RESOURCE SCHEDULING CAN BE ACHIEVED IN THE FOLLOWING TWO STEPS.
  - 1st STEP - ASSUMPTION OF UNLIMITED RESOURCES
  - 2nd STEP - PERFORM RESOURCE OPTIMIZATION:
    - BY STRUCTURING THE LOGIC OF THE NETWORK (I.E. BY DETERMINING A PRIORITY AMONG ACTIVITIES THAT USE THE SAME RESOURCES);
    - RESOURCE OPTIMIZATION ALGORITHMS.

  NOTE THAT, IN ANY CASE, THE INTRODUCTION OF CONSTRAINTS ON RESOURCES (AND IN PARTICULAR ON LABOUR) IS ALWAYS A DOUBLE-EDGED SWORD BECAUSE IT ACTUALLY BINDS SCHEDULING AND NOT RESOURCES.

  RESOURCE CONSTRAINTS CAN BE:
  - **LABOUR** FORCE, RELATING TO THE AVAILABILITY OF OPERATORS
  - **EQUIPMENT:** CONCERN THE AVAILABILITY OF EQUIPMENT (E.G. MACHINERY THAT IS NEEDED ON SITE, CRANES, FORKLIFT ….)
  - **PLANT** PRODUCTIVITY: CONCERN THE PRODUCTIVITY OF SITE INSTALLATIONS (E.G. DAILY OUTPUT OF A CONCRETE PLANT)

- **PROCESS OR PROJECT-BASED CONSTRAINTS, ARE CONSTRAINTS DUE TO OTHER CONDITIONAL ELEMENTS,** E.G. PARTICULAR CONSTRUCTION CHOICES, ENVIRONMENTAL, MANUFACTURING, REGULATORY OR CONTRACTUAL CONTEXT, ETC. CAN BE DIVIDED INTO CONSTRAINTS OF:
  - **CROWDING. THEY DERIVE** FROM THE SPACE AVAILABLE ON THE CONSTRUCTION SITE. EACH ACTIVITY NEEDS ITS OWN SPACE FOR EXECUTION, WHICH IF VIOLATED CAN CAUSE PROCESS CONFLICTS OR EVEN NEW HAZARDS;
  - **SEQUENCE. THEY** CAN BE GIVEN BY THE PLANNER ACCORDING TO COMPANY POLICIES OR SUBJECTIVE CHOICES;
  - **ACCESS. THESE ARE ACCESS CONSTRAINTS TO CERTAIN WORKSPACES.** FOR EXAMPLE, A BUILDING RENOVATION PROJECT OF AN INDUSTRIAL PREMISES WHERE MANUFACTURING PROCESSES ARE STILL WORKING, OR OF AN HOSPITAL BUILDING THAT CANNOT INTERRUPT SERVICES, OR A PARTICULARLY DISADVANTAGED LOCATION OF THE PRODUCTION SITE WHICH LIMITS ACCESSIBILITY, FOR EXAMPLE, TO LORRIES AND OTHER MACHINES;
  - **CONTRACTUAL** OBLIGATIONS. THESE ARE CONSTRAINTS IMPOSED BY THE CLIENT, I.E. THEY DERIVE FROM CONTRACTUAL COMMITMENTS, FOR EXAMPLE FOR THE PROCESS STEPS FOR CARRYING OUT

WORKING OPERATIONS OR THE SEQUENCE OF CONSTRUCTION OF SINGLE BUILDINGS OF A BLOCK;

- **ENVIRONMENTAL / METEOROLOGICAL CONSTRAINTS. THEY ARE RELATED TO CERTAIN TECHNOLOGIES USED ON SITE. FOR INSTANCE IT IS NOT POSSIBLE TO PREDICT WHAT THE CLIMATE WILL BE, BUT THERE ARE CERTAIN** WORKS THATA CANNOT BE PERFORMED IN CERTAING PERIODS OF THE YEAR (E.G. ASPHALTING IN THE WINTER MONTHS, CONCRETE POURING, ETC.). THESE ARE CONSTRAINTS RELATING TO THE FORESEEABLE CLIMATIC SITUATION, AND CERTAINLY NOT RELATED TO EXCEPTIONAL OR UNPREDICTABLE EVENTS
- **SAFETY PROVISIONS. THESES CONSTRAINTS ARE DUE TO THE IMPLEMENTATION OF SAFETY PROVISIONS** AGAINST HAZARDS AND OTHER THREATS TO THE HEALTH AND SAFETY OF WORKERS. **THEY ARE ALSO CALLED SITE CO-ORDINATION PROVISIONS AS THEY LINK ACTIVITIES TO A CERTAIN PROCESS MODEL PROVIDED IN THE SAFETY PLAN**

DUMMIES, SUMMARY AND MILESTONES ACTIVITIES

- **DUMMY ACTIVITY. A ZERO DURATION ACTIVITY THAT IS USED** TO SHOW A LOGICAL-CHRONOLOGICAL RELATIONSHIP IN THE CPM /IJ METHOD, ACTIVITY ON ARROW. *THE INTRODUCTION OF DUMMY ACTIVITIES COMPLICATES THE NETWORK, THEREFORE THE PLANNER SHOULD LIMIT DUMMY ACTIVITIES AS MUCH AS POSSIBLE. PLANNERS SHOULD NOT INCUR THE ERROR OF INSERTING TOO MANY OR UNNECESSARY CONSTRAINTS TO THE NETWORK MODEL.*
- **SUMMARY ACTIVITIES / HAMMOCK ACTIVITY:** ACTIVITIES THAT REPRESENT A WORKING CATEGORY, A GROUP OF ACTIVITIES, WORK ITEMS OR ELEMENTARY ACTIVITIES – WORK PACKAGES. ALSO CALLED SUMMARY ACTIVITY.
- **MILESTONE: THE SIGNIFICANT POINT OR EVENT OF A PROJECT.** SCHEDULE MILESTONE IS A SIGNIFICANT EVENT IN PROJECT SCHEDULE, SUCH AS AN EVENT RESTRAINING FUTURE WORK OR MARKING THE COMPLETION *(E.G. RESTRAINS FUTURE WORK OR MARKS THE COMPLETION OF A MAJOR DELIVERABLE).* A **SCHEDULE MILESTONE HAS ZERO DURATION**.

PHASES OF IMPLEMENTING A NETWORK MODEL FOR SCHEDULING

IT IS CLEAR THAT THE DRAFTING OF THE SCHEDULING NETWORK AND THEREFORE THE DEFINITION OF ITS LOGIC CAN BE CARRIED OUT IN THREE STEPS:

- STEP 1: DRAFTING OF THE NETWORK WITH THE HYPOTHESIS OF UNLIMITED RESOURCES AND ONLY NATURAL CONSTRAINTS;
- STEP 2: DRAFTING OF THE NETWORK WITH PROCESS - BASED CONSTRAINTS;
- STEP III: DRAFTING OF THE NETWORK WITH RESOURCE-BASED CONSTRAINTS.

IT IS EASY TO UNDERSTAND THAT THE FIRST STEP - NETWORK LOGIC CREATION - IS THE ONE THAT PROVIDES THE **GREATEST ADDED VALUE** FOR PROJECT CONTROL.

NETWORK LOGIC CREATIONG FORCES DECISION-MAKERS TO MAKE ANALYTICAL CHOICES, BASED ON OBJECTIVE AND QUANTIFIABLE DATA, WHICH REQUIRE AN IN-DEPTH ANALYSIS FOR THE EVALUATION OF THE NEEDED ACTIVITIES AND FOR FUNDAMENTAL CAUSE AND EFFECT RELATIONSHIPS BETWEEN THEM.

PRECEDENCE DIAGRAMMING METHOD (PDM)

ACTIVITY ON NODE. NODES OF THE NETWORK PORTRAY TASKS AND ARCS PORTRAY LOGICAL-CHRONOLOGICAL DEPENDENCY RELATIONSHIPS.

- THIS REPRESENTATION WAS CONCEIVED BY J.W. FONDHAL IN 1961. HE TERMED THIS METHOD "CIRCLE AND CONNECTING **LINE**", WHILE LATER SCIENTIFIC LITERATURE CALLED IT "**ACTIVITY ON NODE**" (AON) OR "**NODE DIAGRAMMING**" OR **PRECEDENCE DIAGRAMMING**.

A NON-COMPUTER APPROACH TO THE CRITICAL PATH METHOD FOR THE CONSTRUCTION INDUSTRY

Prof. John W. Fondhal

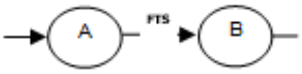
- GENERALIZATION OF THIS METHOD IS CALLED **PRECEDENCE DIAGRAMMING METHOD (PDM).**
- THE TERM PDM FIRST APPEARED IN THE 1964 USER MANUAL OF A PROGRAM FOR AN **IBM 1440 COMPUTER**, OF WHICH, AMONG OTHERS THE LEAD AUTHOR **WAS J. D. CRAIG**.
- CRAIG'S METHOD INCLUDES THE USE OF GENERALIZED LOGIC LINKS, SO WE CAN DISTINGUISH TWO VERSIONS

- **"SIMPLE" PRECEDENCE DIAGRAMMING METHOD**
-
- **GENERALIZED PRECEDENCE DIAGRAMMING METHOD**

THE LOGIC OF THE PDM WITH THE SIMPLE LOGIC LINK

THE LOGICAL DEPENDENCE BETWEEN ACTIVITIES IS ACHIEVED THROUGH **THE ONLY POSSIBLE LOGIC RELATIONSHIP OF THIS METHOD THAT IS THE FINISH TO START LINK (FTS OR THE SIMPLE LINK):**

- **FTS:** THE END OF THE PREVIOUS TASK (TERMED PREDECESSOR) ALLOWS THE START OF THE NEXT TASK (TERMED SUCCESSOR).



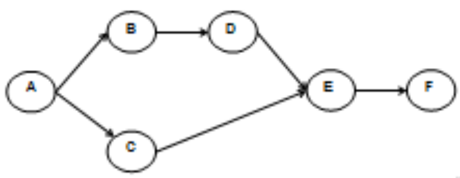
A PREDECESSOR ***B SUCCESSOR***

*THE SEQUENCE IN WHICH TASKS ARE PERFORMED IN THE NETWORK IS TERMED **NETWORK LOGIC**. THE LOGIC OF THE PROCESS IS PORTRAYED BY THE NETWORK BECAUSE ITS STRUCTURE INDICATES THE SEQUENCE OF EXECUTION OF THE TASKS. ACTIVITIES CAN BE CARRIED OUT IN SUCCESSION WITH EACH OTHER, SIMULTANEOUSLY OR WITH PARTIAL OVERLAP, WITHOUT DIRECT LINKS OR WITH DIRECT LINKS.*

LIST OF PREDECESSORS (IPA) AND SUCCESSORS (ISA) OF ACTIVITIES

Attività	Durata	Predecessore	Successore
A	0	/	B,C
B	2	A	D
C	3	A	E
D	2	B	E
E	3	D, C	F
F	2	E	/

EXAMPLE OF AN **AON NETWORK** WITH PRECEDENCE DIAGRAMMING METHOD:



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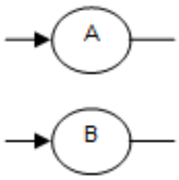
THE RULES OF REPRESENTATION OF NETWORK LOGIC

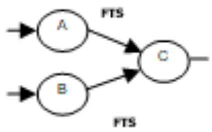
1) **INDEPENDENT ACTIVITIES.** WHEN TWO ACTIVITIES ARE INDEPENDENT, THEY WILL APPEAR IN THE NETWORK REPRESENTED BY SEPARATE NODES WITH NO CONNECTION LINKS.



2) **DEPENDENT ACTIVITIES.** IF THERE IS A FINISH-TO-START RELATIONSHIP BETWEEN TWO ACTIVITIES, THEY WILL BE CONNECTED BY A FTS CONSTRAINT.

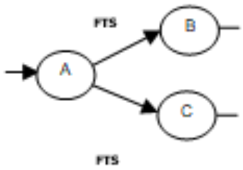
3) **CONVERGENCE ACTIVITIES**

WHEN TWO OR MORE PREDECESSOR TASKS NEED TO BE COMPLETED BEFORE A SUCCESSOR TASK CAN START, MULTIPLE PREDECESSORS WILL BE LINKED WITH FINISH-TO-START TO THE SUCCESSOR TASK. *C IS A SINK NODE.*



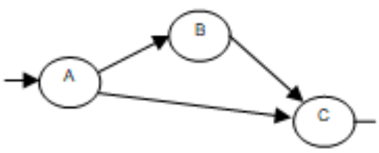
4) **DIVERGENCE ACTIVITIES**

WHEN A PREDECESSOR TASK NEEDS TO BE COMPLETED TO ALLOW THE START OF TWO OR MORE SUCCESSOR TASKS, THE PREDECESSOR IS LINKED TO SUCCESSORS WITH FINISH-TO-START RELATIONSHIPS. *A IS A SOURCE NODE.*



5) **REDUNDANT LOGIC LINKS**

THEY ARE SUPERABUNDANT LOGIC RELATIONSHIPS THAT DO NOT ADD ANY LOGIC MEANING TO THE NETWORK, ***ALTHOUGH IN REALITY THEY CAN REPRESENT PARTICULAR SITUATIONS.***



FTS REDUNDANT LINK (AC)

CORRECT LOGIC

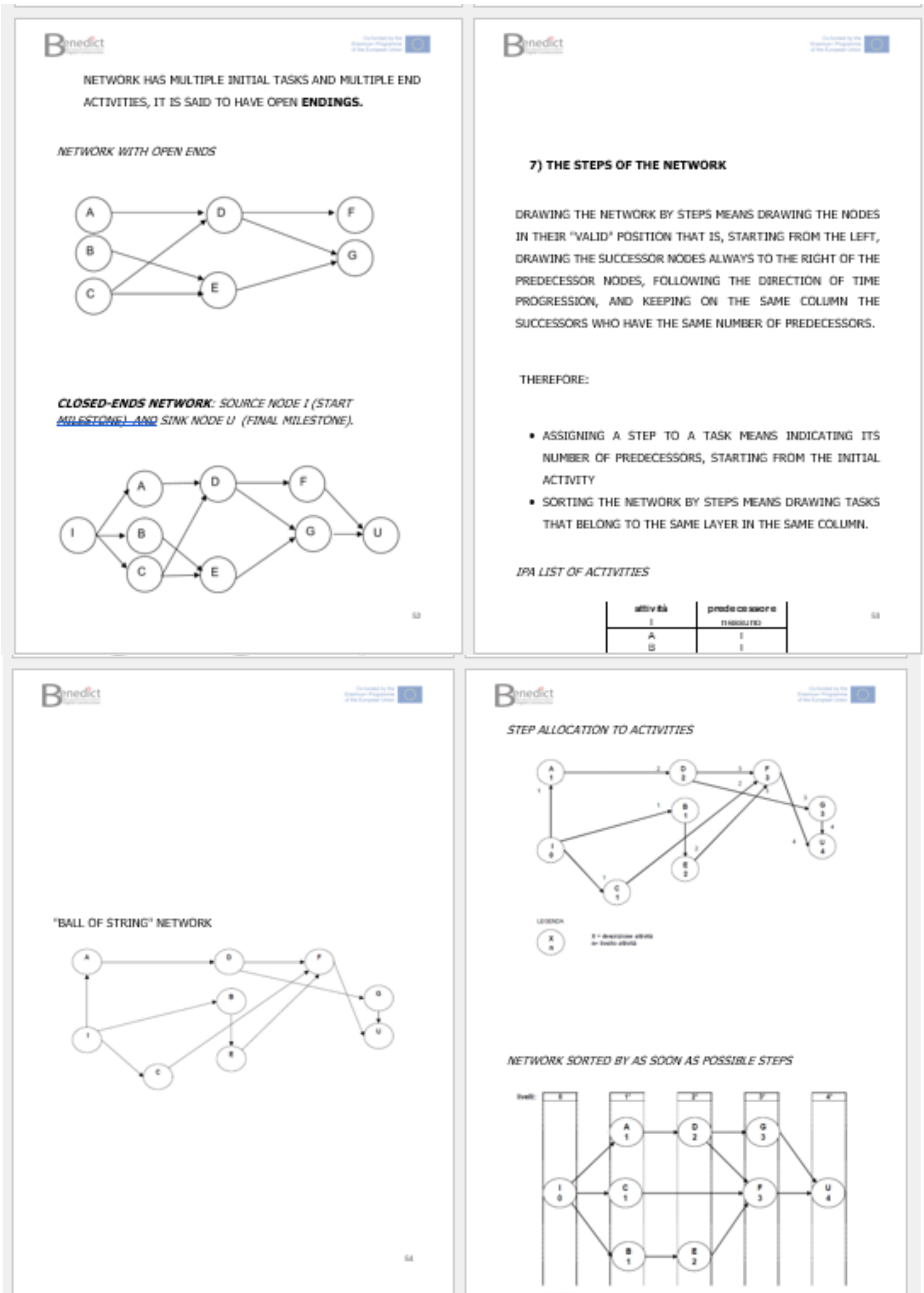
THIS IS THE CASE WHERE TWO ACTIVITIES, B AND C LINKED BY AN FTS(BC) RELATIONSHIP ARE AT THE SAME TIME SUCCESSORS TO THE SAME ACTIVITY A.

THE INTRODUCTION OF THE FTS(AC) LINK IS A LOGICAL FALLACY. THE FTS(AC) RELATIONSHIP IS OVERABUNDANT, AS THE ABC BRANCH ALREADY BINDS THE START OF ACTIVITY C TO THE END OF ACTIVITY A. THE FTS(AC) LINK IS SAID TO BE REDUNDANT.

6) **START AND END ACTIVITIES: OPEN ENDINGS**

PDM NETWORKS MUST HAVE A SINGLE INITIAL ACTIVITY (**SOURCE NODE**), WITHOUT PREDECESSORS, AND A SINGLE FINAL ACTIVITY **(SINK NODE),** WITHOUT SUCCESSORS.

- THIS ALLOWS THE ALGORITHM TO CORRECTLY PERFORM TIME CALCULATIONS.
- IT IS THEREFORE NECESSARY TO ALWAYS FIND A SINGLE INITIAL ACTIVITY AND A SINGLE FINAL ACTIVITY. IF THE



NETWORK HAS MULTIPLE INITIAL TASKS AND MULTIPLE END ACTIVITIES, IT IS SAID TO HAVE OPEN **ENDINGS.**

NETWORK WITH OPEN ENDS

CLOSED-ENDS NETWORK: *SOURCE NODE I (START MILESTONE) AND SINK NODE U (FINAL MILESTONE).*

7) THE STEPS OF THE NETWORK

DRAWING THE NETWORK BY STEPS MEANS DRAWING THE NODES IN THEIR "VALID" POSITION THAT IS, STARTING FROM THE LEFT, DRAWING THE SUCCESSOR NODES ALWAYS TO THE RIGHT OF THE PREDECESSOR NODES, FOLLOWING THE DIRECTION OF TIME PROGRESSION, AND KEEPING ON THE SAME COLUMN THE SUCCESSORS WHO HAVE THE SAME NUMBER OF PREDECESSORS.

THEREFORE:

- ASSIGNING A STEP TO A TASK MEANS INDICATING ITS NUMBER OF PREDECESSORS, STARTING FROM THE INITIAL ACTIVITY
- SORTING THE NETWORK BY STEPS MEANS DRAWING TASKS THAT BELONG TO THE SAME LAYER IN THE SAME COLUMN.

IPA LIST OF ACTIVITIES

attività	predecessore
I	nessuno
A	I
B	I

"BALL OF STRING" NETWORK

STEP ALLOCATION TO ACTIVITIES

NETWORK SORTED BY AS SOON AS POSSIBLE STEPS

NETWORK LOGIC AS A REPRESENTATION OF ACTUAL CONSTRUCTION PROCESSES

THE OVERLAPPING OF ACTIVITIES

IN CASE OF TWO PARTIALLY OVERLAPPING T AND C ACTIVITIES, THE PROJECT SHOULD BE REPRESENTED AS FOLLOWS.

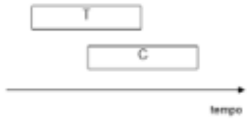
CHAIN OF TWO ACTIVITIES IN LOGICAL – CHRONOLOGICAL SUCCESSION

INSTALLING ELECTRICAL WIRING BY "CHASING" GROOVES INTO THE MASONRY STRUCTURE OF THE WALLS OF A BUILDING

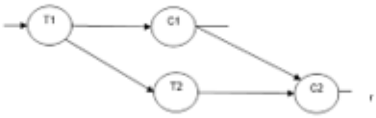
T = CHASING GROOVES

C = INSTALLING ELECTRICAL WIRING

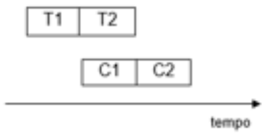
IF, ON THE OTHER HAND, A SITUATION OF PARTIAL CONTEMPORANEITY SHOULD BE REPRESENTED AS INDICATED IN THE BAR DIAGRAM, THE TASKS SHOULD BE DIVIDED INTO SEVERAL PARTS, LINKED WITH FINISH-TO-START RELATIONSHIPS.



SIMPLE PDM NETWORK WITH SUBDIVIDED AND PARTIALLY OVERLAPPING T AND C



CONTEMPORARY T2 AND C1 OF EQUAL DURATION



WORKFLOW AND RESOURCES

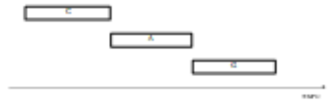
NOW CONSIDER THREE ACTIVITIES IN THREE BUILDINGS:

C = TRADITIONAL TIMBER FORMWORK BUILDING

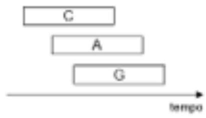
A = LAYING REINFORCING STEEL REBARS.

G = POURING CONCRETE

SIMPLE PDM NETWORK AND GANTT: CHAIN OF C, A AND G

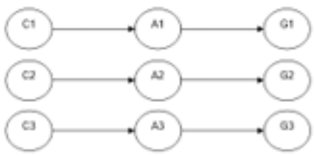


WHEREAS IF THE THREE ACTIVITIES ARE CARRIED OUT IN THREE BUILDINGS, 1, 2, 3, IT IS POSSIBLE TO WORK IN PARTIAL OR IN TOTAL CONTEMPORANEITY



PARTIALLY OVERLAPPING BAR DIAGRAM OF C, A, AND G

IN THE SIMPLE PDM THREE CHAINS OF ACTIVITY C, A AND G ARE DEVELOPED IN BUILDINGS 1, 2, 3, WITH ONLY **PHYSICAL/TECHNOLOGICAL LINKS**

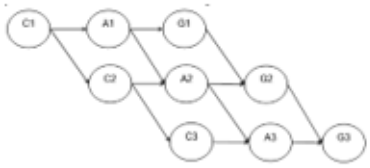


AT THIS POINT THE RESOURCES / TRADES OF THE ACTIVITIES SHOULD BE CONSIDERED:

- C1, C2, C3 ARE MADE BY THE CARPENTERS' CREW,
- A1, A2, A3 ARE MADE BY REBARS CREW,
- G1, G2, G3 ARE MADE BY CONCRETE PLACING CREW.

IF A SINGLE CREW IS USED FOR EACH TRADE FOR ALL THE THREE BUILDINGS, IT IS NECESSARY TO INSERT LOGIC LINKS REPRESENTING THE SUCCESSION BETWEEN ACTIVITIES ACCORDING TO THE MOVEMENT OF RESOURCES FROM ONE ACTIVITY TO ANOTHER. I.E. ***THE MOVEMENT OF EACH CREW FROM ONE BUILDING TO ANOTHER.***

THE FLOW OF RESOURCES IS REPRESENTED BY THE RELATIONSHIPS THAT LINK THE THREE CHAINS TO FORM THE NETWORK IN **FIGURE (RESOURCE-BASED LOGIC LINKS).**



SIMPLE PDM NETWORK WITH WORKFLOW

TIME ANALYSIS IN THE SIMPLE PDM METHOD

THE FOUR ACTIVITY TIMES

THE EARLY TIMES OR MINIMUM TIMES, I.E. AS SOON AS POSSIBLE (ASAP):

- **EARLY START ESI OR MINIMUM START TIME.** IT IS THE CLOSEST MOMENT TO TIME S, I.E. THE BEGINNING OF CONSTRUCTION PROJECT, IN WHICH THE ACTIVITY I CAN BEGIN.
- **EARLY FINISH EFI OR MINIMUM FINISH TIME.** IT IS THE CLOSEST MOMENT TO TIME S, I.E. THE BEGINNING OF THE CONSTRUCTION PROJECT, IN WHICH THE ACTIVITY I CAN END.

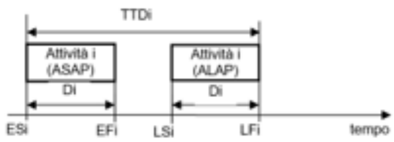
THE LATE TIMES OR MAXIMUM TIMES, I.E. AS LATE AS POSSIBLE (ALAP):

- **LATE START LSI MAXIMUM START TIME.** IT IS THE CLOSEST MOMENT TO TIME T, THE END OF THE CONSTRUCTION PROJECT, IN WHICH THE ACTIVITY I CAN BEGIN, WITHOUT

DELAYING T IN TURN

- **LATE FINISH LFI MAXIMUM FINISH TIME.** IT IS THE CLOSEST MOMENT TO TIME T, THE END OF THE CONSTRUCTION PROJECT, IN WHICH THE ACTIVITY I CAN END, WITHOUT DELAYING T IN TURN.

ASAP AND ALAP TIMES HAVE NOT THE SAME IMPORTANCE.
IN PRACTICE, MOST USED TIMES ARE EARLY TIMES.



THE TOTAL AVAILABLE TIME

THE ACTUAL EXECUTION OF THE TASK I CAN BE CARRIED OUT WITHIN THE TIME WINDOW THAT STARTS FROM THE ESI AND ENDS AT THE LFI.

TOTAL AVAILABLE TIME FOR ACTIVITY I

TTAI = LFI – ESI

AS SOON AS POSSIBLE (ASAP) SCHEDULE AND AS LATE AS POSSIBLE (ALAP) SCHEDULE

- *THE ACTIVITY I IN THE MINIMUM TIME POSITION, I.E. SCHEDULED WITH EXECUTION FROM THE EARLY START TIME TO THE EARLY FINISH TIME IS SAID TO BE SCHEDULED* ***"AS SOON AS POSSIBLE - ASAP"***, AND THE PROGRAMME THAT SHOWS ALL PROJECT ACTIVITIES IN THE EARLY POSITION IS THE **ASAP SCHEDULE** OF THE PROJECT.

- *THE ACTIVITY I IN THE MAXIMUM TIME POSITION, I.E. SCHEDULED WITH EXECUTION FROM THE LATE START TIME TO THE LATE FINISH TIME IS SAID TO BE SCHEDULED* ***"AS LATE AS POSSIBLE - ALAP"***, AND THE PROGRAMME THAT SHOWS ALL PROJECT ACTIVITIES IN THE LATE POSITION IS THE **ALAP SCHEDULE** OF THE PROJECT.

THE TIME CALCULATION ALGORITHM CONSISTS OF TWO PARTS, FORWARD PASS AND BACKWARD PASS AND IS THE CPM-BASED TRADITIONAL ALGORITHM.

THE FORWARD PASS

THE FORWARD PASS CONSISTS OF THREE STEPS:

1. THE EARLY START ES0 OF THE INITIAL ACTIVITY A0 OF THE NETWORK IS EQUAL TO THE S START TIME OF THE PROJECT.

   ES0 = S

2. THE EARLY FINISH EFI OF THE ACTIVITY I OF THE NETWORK IS EQUAL TO THE EARLY START PLUS THE DURATION OF THE ACTIVITY.

   EFI = ESI + DI

3. SINCE NO SUCCESSOR J TASK CAN START UNTIL ALL PREDECESSOR I TASKS (LOGICAL CONNECTION "AND") HAVE ENDED, THE EARLY START OF ALL SUCCESSOR J ACTIVITIES IS EQUAL TO THE GREATER OF THE EARLY FINISH OF THE I TASKS THAT ARE PREDECESSORS OF THE J TASK.

ESJ = MAX(EFI)

*NOTE THAT THE VALUE S IS IMPOSED BY THE SCHEDULER AND NORMALLY THERE IS THE START TIME RULE OF **ZERO PROJECT START**, THAT IS:*

S=0

BACKWARD PASS

EVEN THE BACKWARD PASS CONSISTS OF THREE STEPS:

1. THE LATE FINISH LFN OF THE FINAL ACTIVITY OF THE NETWORK IS EQUAL TO THE COMPLETION TIME T OF THE PROJECT.

   LFN = T

2. THE LATE START LSI OF THE ACTIVITY I IS EQUAL TO ITS LATE FINISH LFI MINUS ITS DURATION.

   LSI = LFI – DI

3. SINCE NO ACTIVITY CAN START UNTIL ALL THE PREVIOUS ACTIVITIES HAVE BEEN FINISHED (LOGICAL CONNECTION "AND"), PROCEEDING BACKWARDS FROM THE PROJECT END TO THE PROJECT START, NO PREDECESSOR I ACTIVITY CAN FINISH AFTER THE START OF ANY SUCCESSOR J ACTIVITY. THE LATE FINISH LFI OF THE I ACTIVITY IS EQUAL TO THE LOWER OF THE LATE START LSJ OF ITS SUCCESSORS (OTHERWISE SUCCESSOR ACTIVITIES WOULD BE DELAYED).

   LFI = MIN(LSJ)

ZERO FLOAT RULE

THE T VALUE, THE LATE END TIME OF THE PROJECT IS A VALUE DECIDED BY THE PLANNER. IT IS COMMON RULE TO POSE:

T = EFN

THAT IS TO MAKE THE EARLY FINISH OF THE FINAL TASK N BEING EQUAL TO ITS LATE FINISH.

LFN = EFN

EXAMPLE

IPA LIST OF ACTIVITIES

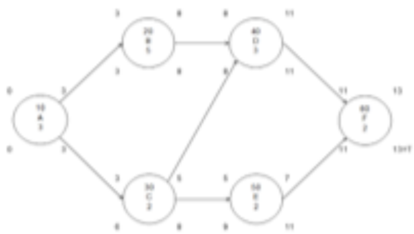
attività	predecessore
A	/
B	A
C	A
D	B, C
E	C
F	D, E

FROM THE LIST OF PREDECESSORS, PLEASE DRAW THE PDM NETWORK, SORTED BY STEPS

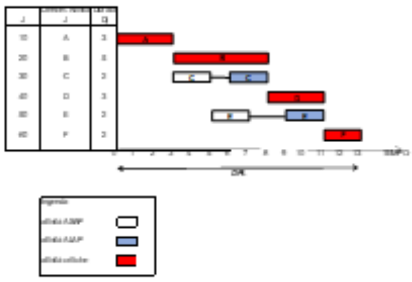
LIST OF NETWORK ACTIVITIES J AND CORRESPONDING DURATIONS.

J	Denominazione attività	Durata Dj
10	A	3
20	B	5
30	C	2
40	D	3
50	E	2
60	F	2

FORWARD AND BACKWARD PASSES:



BAR CHART



FINAL REMARKS

CRITICAL ACTIVITIES. IN THE NETWORK, **THERE** ARE SOME "SPECIAL" ACTIVITIES WHOSE EARLY AND LATE SCHEDULING COINCIDE.

- THESE TASKS HAVE NO FLOAT OPTIONS IF YOU DO NOT WANT TO DELAY THE COMPLETION DATE OF THE WHOLE PROJECT.
- THEREFORE, FROM A TIME-RELATED POINT OF VIEW THERE ARE SOME ACTIVITIES THAT ARE MORE IMPORTANT THAN OTHERS OF THE PROJECT, AND THESE ACTIVITIES ARE TERMED **TIME-CRITICAL**.
- OTHER SUBCRITICAL ACTIVITIES ARE TERMED NON-CRITICAL ACTIVITIES.

ASAP SCHEDULING

- THE ASAP SCHEDULE AIMS AT CONCENTRATING ACTIVITIES NEAR TO TIME ZERO. FROM A CONSTRUCTION COMPANY POINT OF VIEW FOR ACTUAL PROJECT IMPLEMENTATION, THIS OFTEN INVOLVES A CONSIDERABLE EFFORT OF RESOURCES WITH **MULTIPLE OVERLAPPING OF ACTIVITIES** IN THE VERY FIRST STEP OF THE PROJECT.
- HOWEVER, THE IMPLEMENTATION OF THE ASAP SCHEDULE IS FACILITATED BY THE **POSSIBILITY OF DELAYING** CERTAIN ACTIVITIES IN CASE OF NEED.

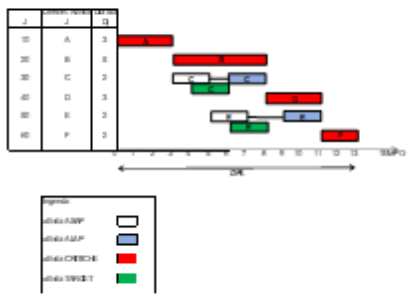
ALAP SCHEDULING

- THE ALAP SCHEDULE NORMALLY LEADS TO **A GREATER DISTRIBUTION OF ACTIVITIES** OVER THE TOTAL TIME OF PROJECT EXECUTION, WITH LESS OVERLAPPING BETWEEN ACTIVITIES.
- HOWEVER, **ALL ACTIVITIES ARE NOW CRITICAL** AND ANY DELAY IN CARRYING OUT AN ACTIVITY RESULTS IN AN EQUAL DELAY OF THE PROJECT COMPLETION.

BASELINE OR TARGET ACTIVITIES AND SCHEDULE

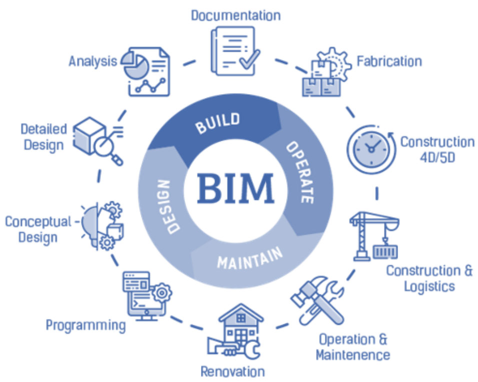
THEREFORE, FROM THE POINT OF VIEW OF A CONSTRUCTION CONTRACTOR THE CHOSEN SCHEDULE WILL BE THE ONE THAT SCHEDULES THE SUBCRITICAL ACTIVITIES IN AN **"INTERMEDIATE"** POSITION BETWEEN THE EARLY START AND LATE FINISH OF THE TIME WINDOW, WITH THE AIM OF BETTER ALLOCATING PROJECT RESOURCES AND OPTIMIZING THE WORK AN COST EFFORT OF THE EXECUTION STEP.

THIS "INTERMEDIATE" SCHEDULE THAT OPTIMIZES PRODUCTION NEEDS IS REFERRED TO AS **THE "TARGET" OR "BASELINE" SCHEDULE,** AS IT DEFINES THE OBJECTIVE TO BE PURSUED AND THE REFERENCE FOR MEASURING DEVIATIONS BY THE IN-PROGRESS PROJECT CONTROL PROCESS.



BIM 4D

Eng. Arch. Caterina Morganti



BIM, which stands for Building Information Modeling, is a digital representation of the physical and functional characteristics of a building or infrastructure project. It is a collaborative process that involves the creation and management of a comprehensive 3D model with detailed information about every aspect of the project.

BIM goes beyond traditional 2D drawings by incorporating additional dimensions such as time (4D), cost (5D), and even sustainability factors (6D). It allows architects, engineers, contractors, and other stakeholders to work together in a coordinated manner, sharing and exchanging information throughout the project lifecycle.

One of the key advantages of BIM is its ability to improve project visualization and communication. The 3D model provides a clear and realistic representation of the building, enabling stakeholders to better understand the design intent and make informed decisions. It also facilitates better coordination and clash detection, reducing errors and conflicts during construction.

BIM also enhances project efficiency and productivity. It enables the generation of accurate quantity takeoffs and cost estimates, helping in better cost control and budget management. Additionally, BIM allows for the simulation and analysis of various design alternatives, optimizing performance and reducing waste.

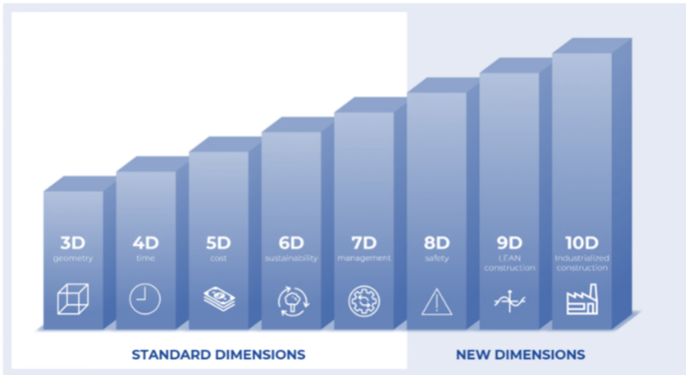
Furthermore, BIM supports the integration of various building systems and technologies. It can incorporate data from different sources, such as structural, mechanical, and electrical systems, enabling a more holistic and integrated approach to building design and construction.

Overall, BIM is a transformative technology that revolutionizes the way buildings and infrastructure are designed, constructed, and operated. It improves collaboration, visualization, and decision-making, leading to more efficient, sustainable, and cost-effective projects.

BIM dimensions

BIM dimensions are the use of data for specific BIM objectives:

3D (model)
4D (time)
5D (cost)
6D (sustainability)
7D (operation&maintenance)
8D (safety)
9D (lean construction)
10D (industrialized construction)



The .IFC (Industry Foundation Classes) exchange format is an open and neutral file format used for the exchange of building information models (BIM) between different software applications. It is a standardized file format developed by buildingSMART International, a non-profit organization focused on improving the interoperability of BIM software.

The purpose of the .IFC exchange format is to enable seamless collaboration and data exchange among various stakeholders in the construction industry, including architects, engineers, contractors, and facility managers. It allows for the transfer of geometric and non-geometric information about building elements, such as walls, doors, windows, and HVAC systems, in a structured and standardized manner.

One of the key benefits of the .IFC format is its ability to preserve the integrity and richness of the BIM data during the exchange process. It ensures that important information, such as object properties, relationships, and classifications, is accurately transferred between different software platforms. This helps to maintain the consistency and accuracy of the BIM model, regardless of the software used.

The .IFC format also promotes interoperability and avoids vendor lock-in. Since it is an open standard, any software application can implement support for .IFC files, allowing users to freely exchange BIM data without being limited to a specific software ecosystem. This promotes competition, innovation, and flexibility in the industry.

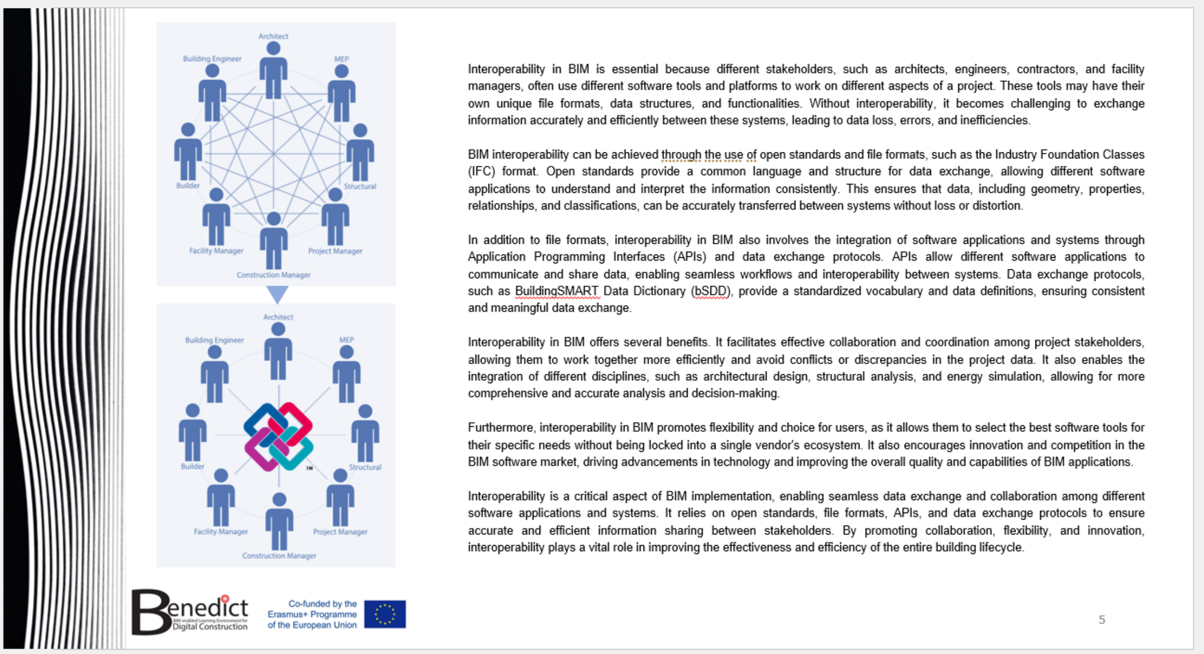
Furthermore, the .IFC format supports the exchange of not only geometric information but also other important aspects of a building project, such as time, cost, and sustainability data. This allows for a more comprehensive and integrated approach to BIM, enabling better decision-making and analysis throughout the project lifecycle.

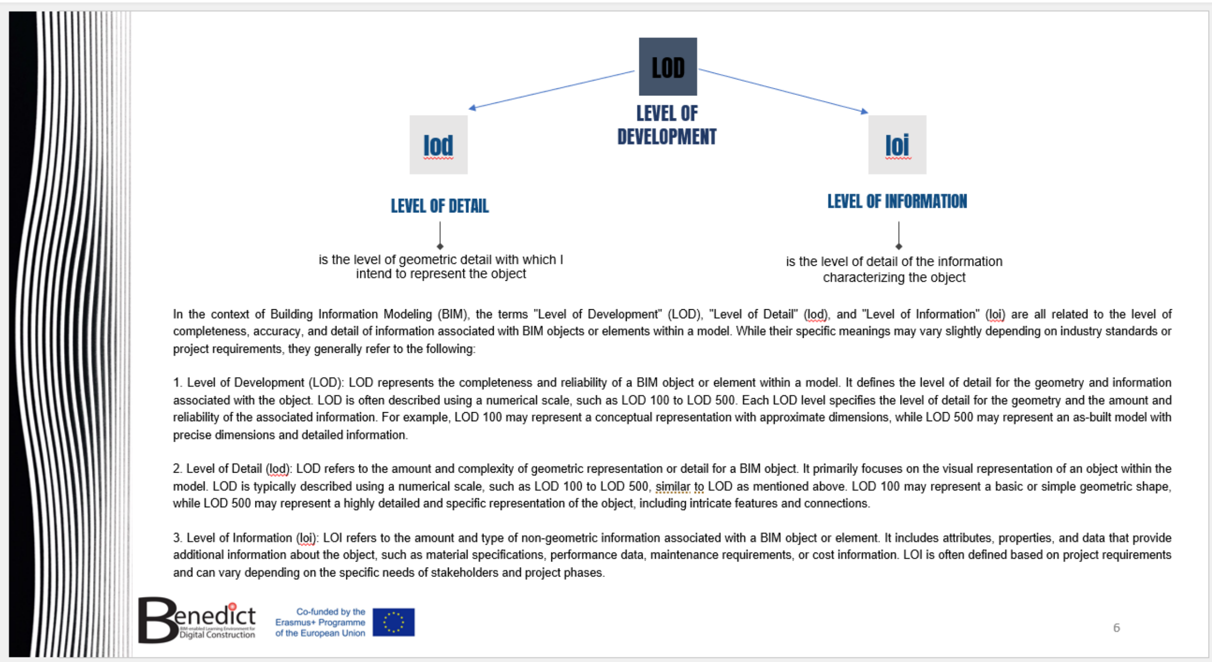
The .IFC exchange format plays a crucial role in facilitating the seamless exchange of BIM data between different software applications. It promotes interoperability, data integrity, and collaboration among stakeholders, ultimately enhancing the efficiency and effectiveness of the construction industry.

TM

.ifc

Industry Foundation Classes


Architect
Building Engineer
MEP
Builder
Structural
Facility Manager
Project Manager
Construction Manager
Interoperability in BIM is essential because different stakeholders, such as architects, engineers, contractors, and facility managers, often use different software tools and platforms to work on different aspects of a project. These tools may have their own unique file formats, data structures, and functionalities. Without interoperability, it becomes challenging to exchange information accurately and efficiently between these systems, leading to data loss, errors, and inefficiencies.
BIM interoperability can be achieved through the use of open standards and file formats, such as the Industry Foundation Classes (IFC) format. Open standards provide a common language and structure for data exchange, allowing different software applications to understand and interpret the information consistently. This ensures that data, including geometry, properties, relationships, and classifications, can be accurately transferred between systems without loss or distortion.
In addition to file formats, interoperability in BIM also involves the integration of software applications and systems through Application Programming Interfaces (APIs) and data exchange protocols. APIs allow different software applications to communicate and share data, enabling seamless workflows and interoperability between systems. Data exchange protocols, such as BuildingSMART Data Dictionary (bSDD), provide a standardized vocabulary and data definitions, ensuring consistent and meaningful data exchange.
Interoperability in BIM offers several benefits. It facilitates effective collaboration and coordination among project stakeholders, allowing them to work together more efficiently and avoid conflicts or discrepancies in the project data. It also enables the integration of different disciplines, such as architectural design, structural analysis, and energy simulation, allowing for more comprehensive and accurate analysis and decision-making.
Furthermore, interoperability in BIM promotes flexibility and choice for users, as it allows them to select the best software tools for their specific needs without being locked into a single vendor's ecosystem. It also encourages innovation and competition in the BIM software market, driving advancements in technology and improving the overall quality and capabilities of BIM applications.
Interoperability is a critical aspect of BIM implementation, enabling seamless data exchange and collaboration among different software applications and systems. It relies on open standards, file formats, APIs, and data exchange protocols to ensure accurate and efficient information sharing between stakeholders. By promoting collaboration, flexibility, and innovation, interoperability plays a vital role in improving the effectiveness and efficiency of the entire building lifecycle.
Benedict
Co-funded by the Erasmus+ Programme of the European Union
5


LOD
LEVEL OF DEVELOPMENT
lod
LEVEL OF DETAIL
is the level of geometric detail with which I intend to represent the object
loi
LEVEL OF INFORMATION
is the level of detail of the information characterizing the object
In the context of Building Information Modeling (BIM), the terms "Level of Development" (LOD), "Level of Detail" (lod), and "Level of Information" (loi) are all related to the level of completeness, accuracy, and detail of information associated with BIM objects or elements within a model. While their specific meanings may vary slightly depending on industry standards or project requirements, they generally refer to the following:
1. Level of Development (LOD): LOD represents the completeness and reliability of a BIM object or element within a model. It defines the level of detail for the geometry and information associated with the object. LOD is often described using a numerical scale, such as LOD 100 to LOD 500. Each LOD level specifies the level of detail for the geometry and the amount and reliability of the associated information. For example, LOD 100 may represent a conceptual representation with approximate dimensions, while LOD 500 may represent an as-built model with precise dimensions and detailed information.
2. Level of Detail (lod): LOD refers to the amount and complexity of geometric representation or detail for a BIM object. It primarily focuses on the visual representation of an object within the model. LOD is typically described using a numerical scale, such as LOD 100 to LOD 500, similar to LOD as mentioned above. LOD 100 may represent a basic or simple geometric shape, while LOD 500 may represent a highly detailed and specific representation of the object, including intricate features and connections.
3. Level of Information (loi): LOI refers to the amount and type of non-geometric information associated with a BIM object or element. It includes attributes, properties, and data that provide additional information about the object, such as material specifications, performance data, maintenance requirements, or cost information. LOI is often defined based on project requirements and can vary depending on the specific needs of stakeholders and project phases.
Benedict
Co-funded by the Erasmus+ Programme of the European Union
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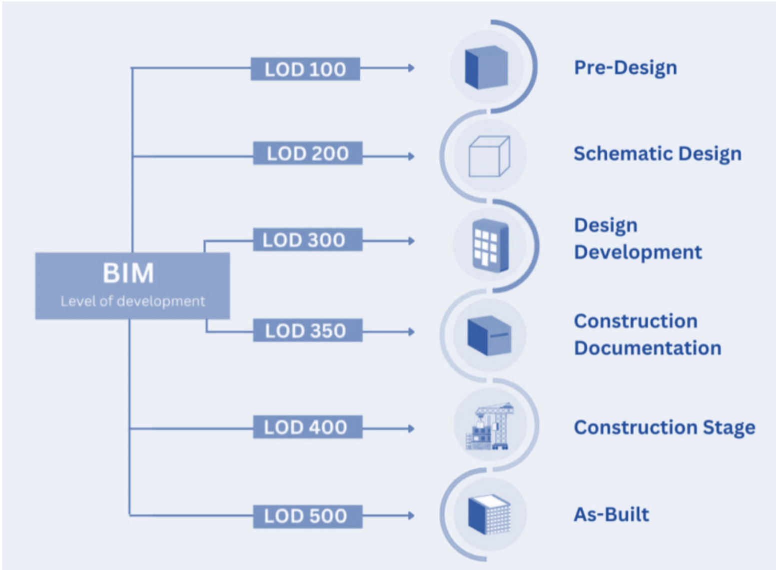


Building Information Modeling 4D (BIM 4D), is an advanced technology that combines the benefits of 3D modeling with the element of time. It allows stakeholders in the construction industry to visualize and simulate the construction process over time, creating a dynamic and interactive model.

In BIM 4D, the 3D model of a building or infrastructure project is integrated with scheduling information, such as task durations, dependencies, and resource allocation. This integration enables the creation of a virtual construction timeline, where each task is linked to its corresponding location in the 3D model.

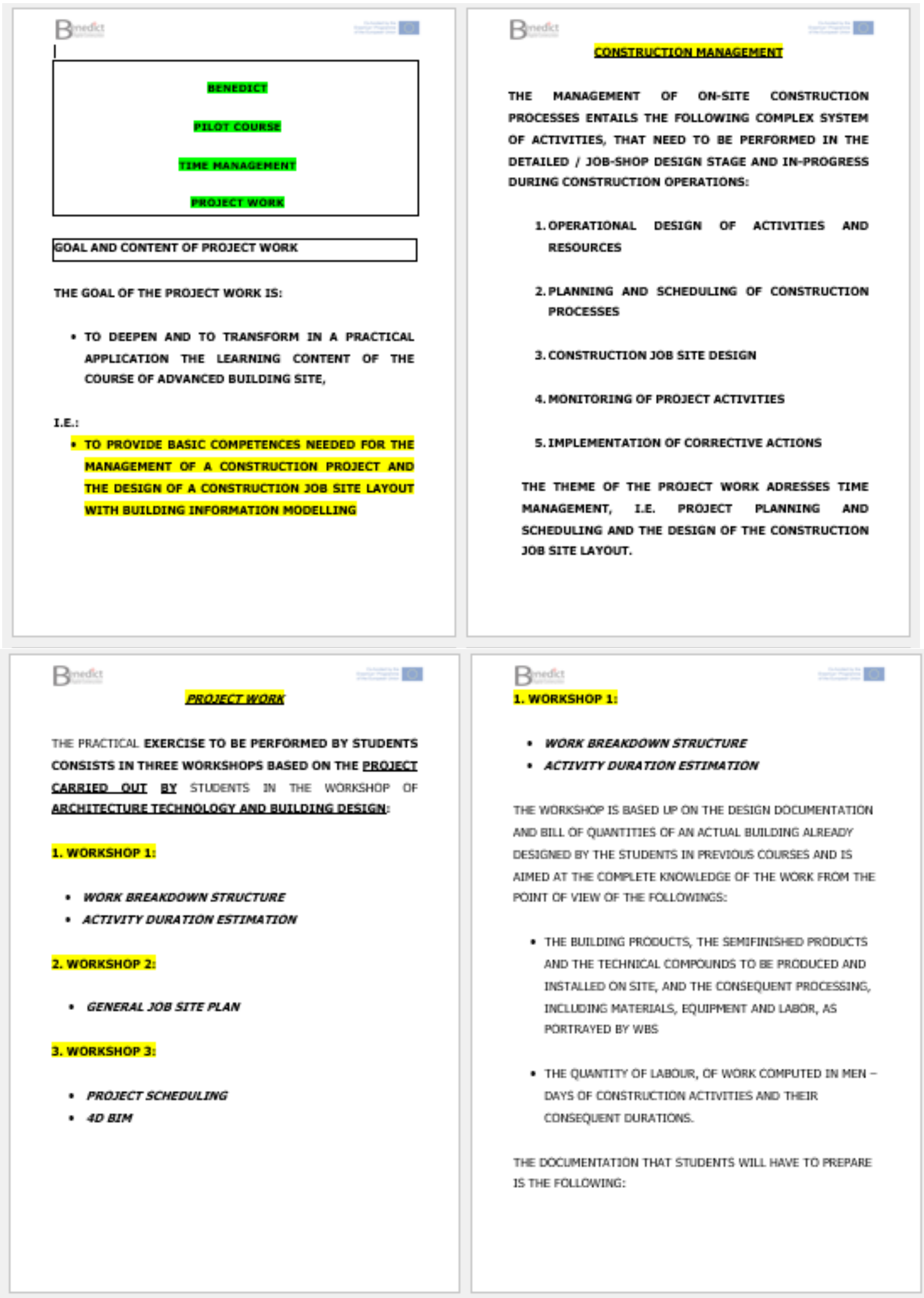
By incorporating time into the BIM model, project teams can better understand the sequencing and phasing of construction activities. This helps in identifying potential clashes, optimizing schedules, and improving overall project coordination. It also allows for better communication and collaboration among project stakeholders, as everyone can visualize the construction process in a more comprehensive and intuitive manner.

BIM 4D has several benefits for construction projects. It helps in identifying and resolving design and construction conflicts before they occur on-site, reducing rework and saving time and costs. It also improves project planning and scheduling accuracy, allowing for better resource allocation and optimization. Additionally, BIM 4D enhances project visualization, enabling stakeholders to make informed decisions and anticipate potential issues during the construction process.

Overall, BIM 4D is a powerful tool that enhances project efficiency, coordination, and communication. It brings together the spatial and temporal aspects of construction projects, enabling stakeholders to better plan, simulate, and manage the entire construction process.

Appendix B – Activity Materials

B.1. Project work



BENEDICT

PILOT COURSE

TIME MANAGEMENT

PROJECT WORK

GOAL AND CONTENT OF PROJECT WORK

THE GOAL OF THE PROJECT WORK IS:

- TO DEEPEN AND TO TRANSFORM IN A PRACTICAL APPLICATION THE LEARNING CONTENT OF THE COURSE OF ADVANCED BUILDING SITE,

I.E.:

- TO PROVIDE BASIC COMPETENCES NEEDED FOR THE MANAGEMENT OF A CONSTRUCTION PROJECT AND THE DESIGN OF A CONSTRUCTION JOB SITE LAYOUT WITH BUILDING INFORMATION MODELLING

CONSTRUCTION MANAGEMENT

THE MANAGEMENT OF ON-SITE CONSTRUCTION PROCESSES ENTAILS THE FOLLOWING COMPLEX SYSTEM OF ACTIVITIES, THAT NEED TO BE PERFORMED IN THE DETAILED / JOB-SHOP DESIGN STAGE AND IN-PROGRESS DURING CONSTRUCTION OPERATIONS:

1. OPERATIONAL DESIGN OF ACTIVITIES AND RESOURCES
2. PLANNING AND SCHEDULING OF CONSTRUCTION PROCESSES
3. CONSTRUCTION JOB SITE DESIGN
4. MONITORING OF PROJECT ACTIVITIES
5. IMPLEMENTATION OF CORRECTIVE ACTIONS

THE THEME OF THE PROJECT WORK ADRESSES TIME MANAGEMENT, I.E. PROJECT PLANNING AND SCHEDULING AND THE DESIGN OF THE CONSTRUCTION JOB SITE LAYOUT.

PROJECT WORK

THE PRACTICAL EXERCISE TO BE PERFORMED BY STUDENTS CONSISTS IN THREE WORKSHOPS BASED ON THE PROJECT CARRIED OUT BY STUDENTS IN THE WORKSHOP OF ARCHITECTURE TECHNOLOGY AND BUILDING DESIGN:

1. WORKSHOP 1:

- *WORK BREAKDOWN STRUCTURE*
- *ACTIVITY DURATION ESTIMATION*

2. WORKSHOP 2:

- *GENERAL JOB SITE PLAN*

3. WORKSHOP 3:

- *PROJECT SCHEDULING*
- *4D BIM*

1. WORKSHOP 1:

- *WORK BREAKDOWN STRUCTURE*
- *ACTIVITY DURATION ESTIMATION*

THE WORKSHOP IS BASED UP ON THE DESIGN DOCUMENTATION AND BILL OF QUANTITIES OF AN ACTUAL BUILDING ALREADY DESIGNED BY THE STUDENTS IN PREVIOUS COURSES AND IS AIMED AT THE COMPLETE KNOWLEDGE OF THE WORK FROM THE POINT OF VIEW OF THE FOLLOWINGS:

- THE BUILDING PRODUCTS, THE SEMIFINISHED PRODUCTS AND THE TECHNICAL COMPOUNDS TO BE PRODUCED AND INSTALLED ON SITE, AND THE CONSEQUENT PROCESSING, INCLUDING MATERIALS, EQUIPMENT AND LABOR, AS PORTRAYED BY WBS
- THE QUANTITY OF LABOUR, OF WORK COMPUTED IN MEN – DAYS OF CONSTRUCTION ACTIVITIES AND THEIR CONSEQUENT DURATIONS.

THE DOCUMENTATION THAT STUDENTS WILL HAVE TO PREPARE IS THE FOLLOWING:

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WBS - WORK BREAKDOWN STRUCTURE - OF THE PROJECT:

TO BE REALIZED IN GRAPHIC FORM.

ESTIMATION OF THE DURATION OF THE ACTIVITIES

IT WILL BE CARRIED OUT THROUGH THE PRODUCTION SCHEME, WHICH IDENTIFIES THE DURATION OF THE PROCESSES BASED ON THE ASSIGNED RESOURCES. A WBS – BASED ACTIVITY LIST WITH WP DURATIONS.

THE PRODUCTION SCHEME WILL BE BASED ON THE BILL OF QUANTITIES OF THE PROJECT

MAN-DAY: ESTIMATED AMOUNT OF WORK OF AN ACTIVITY REPRESENTED BY THE SUM OF THE WORKING DAYS WORKED BY THE WORKERS FOR THE PROCESSING OF THE ACTIVITY

THROUGH THE STUDY OF THE QUANTITY OF WORK REPRESENTED BY MEN – DAY OF WORK, GIVEN THE NUMBER OF COMPONENTS OF THE WORKING CREW, IT IS POSSIBLE TO COMPUTE THE DURATION OF THE ACTIVITIES AS IDENTIFIED BY THE WBS WITH THE FOLLOWING EQUATION:

DURATION = MAN-DAY / NUMBER OF UNITS

AND THE ACTIVITY DURATION SHEET AND LIST

2. WORKSHOP 2:

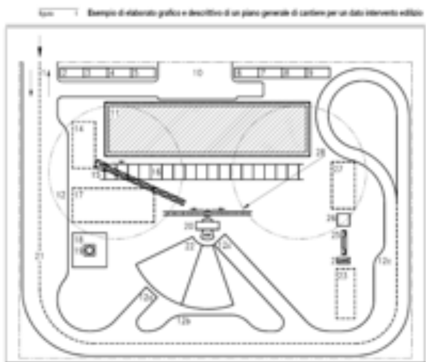
- ***GENERAL JOB SITE PLAN***

2. CONSTRUCTION JOB SITE LAYOUT:

"***THE DESIGNERS*** OF *WORKPLACES AND WORKSTATIONS AND PLANTS* RESPECT THE GENERAL PRINCIPLES OF PREVENTION IN THE FIELD OF HEALTH AND SAFETY AT WORK AT THE TIME OF THE DESIGNING OF PROCESSES AND TECHNICAL ***CHOICES***, AND CHOOSE EQUIPMENT, COMPONENTS AND PROTECTIVE EQUIPMENT THAT COMPLY WITH THE RELEVANT LAWS AND REGULATIONS" (*BY ITALIAN ART. 22 LEGISLATIVE DECREE NO. 81/08 CODE OF OHS)*

BOTTOM - UP

TOP - DOWN



THE PROJECT OF THE CONSTRUCTION JOB SITE LAYOUT **AIMS AT MINIMIZING OR ELIMINATING HAZARDS FOR WORKERS THAT CAN BE FOUND ON-SITE AND IN-PROGRESS:**

A) HAZARDS OF CONSTRUCTION SITE AREA AND SURROUNDINGS

B) HAZARDS OF PROCESS OPERATIONS PORTRAYED IN JOB SITE LAYOUT

AND AIMS AT INCREASING THE EFFICIENCY OF:

C) PRODUCTION PROCESSES AND LOGISTICS OF THE CONSTRUCTION SITE.

STUDENTS WILL DELIVER THE FOLLOWING:

- **JOB SITE LAYOUT PLANS, ADDRESSING AT LEAST THE FOLLOWING CONSTRUCTION STAGE**
  - **EXCAVATIONS,** FOUNDATIONS AND UNDERGROUND FLOORS
  - **ELEVATION** (ABOVE-GROUND WORKS - MANDATORY)
  - **ROOFING** (WORKS ON THE ROOF OF THE BUILDING) / **FINISHES** (INTERIOR AND FINISHING WORKS OF FACADES))

JOB SITE LAYOUT PLAN WILL ENTAIL THE FOLLOWING COMPONENTS:

- ***TEMPORARY WORKS (SCAFFOLDINGS)***
- ***WORKSTATIONS***
- *LOGISTIC AND WELFARE FACILITIES.*
- *CONSTRUCTION SITE SYSTEMS (ELECTRICAL, WATER) AND INFRASTRUCTURES (ROADS, ENTRANCE, ETC.)*
- *TOWER CRANE*
- *SITE FENCE*

THE JOB SITE LAYOUT WILL BE PREPARED WITH A 3D BIM – BUILDING INFORMATION MODEL

EXAMPLES OF 3D BIM OF CONSTRUCTION SITE

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SOFTWARES: EDIFICIUS, CERTUS HSBIM, SKETCHUP, REVIT AND NAVISWORKS

3. WORKSHOP 3:

- ***PROJECT SCHEDULING***
- ***4D BIM***

1. PROJECT SCHEDULE:

A PROJECT SCHEDULE CONTAINS THE PRODUCTION PLAN AND PROGRAMME OF THE CONSTRUCTION PROJECT, BASED ON A NETWORK MODEL. THE PROJECT SCHEDULE ENTAILS THE FOLLOWING INFORMATION:

A) THE SEQUENCE OF PROCESSES AND THE ORGANIZATION OF THE WORK STAGES

B) THE DURATION OF PROCESSES ON THE BASIS OF ASSIGNED RESOURCES (LABOUR, MACHINERY AND PLANT)

C) THE OVERALL COMMITMENT OF TIME, COST AND RESOURCES.

THE DOCUMENTS TO BE DELIVERED BY THE STUDENTS FOLLOWS:

- **GANTT CHART BASED ON A WORK BREAKDOWN STRUCTURE**
- **4D BIM OF THE CONSTRUCTION STAGE, WITH VIDEO ANIMATION OF THE WORKING PHASES**

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ORGANIZATIONAL ASPECTS

- **THE PROJECT WORK CAN BE DEVELOPED BY GROUPS OF STUDENTS, TEAMS**
- **THE PROJECT WORK MUST BE UPLOADED ON THE UNIBO VIRTUAL SERVER**, EACH WORKSHEET MUST CONTAIN THE HEADING WITH THE COURSE NAME AND THE NAME OF THE **STUDENTS**
- **THE PROJECT WORK MUST BE DELIVERED AT THE END OF THE COURSE AND WILL BE EVALUATED FOLLOWING THE ORAL PRESENTATION BY THE STUDENT.**
- **THE ORAL EXAM WILL CONSIST IN THE PRESENTATION OF THE PROJECT WORK, IN THE DISCUSSION OF THE ASSIGNMENT AND IN SOME ORAL QUESTIONS CONCERNING THE THEORETICAL FOUNDATION OF THE WORKSHOPS**

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Appendix C – Assessment Materials

C.1. Time management Course - Individual reflection questions

Please consider the following questions and enter your responses as short paragraphs.

1. Describe 1 new thing that you learned in this course.

2. Describe 1 thing that you found interesting in this course.

3. Describe 1 thing (from this course) that could be useful in your work or in (an)other course(s).

4. Do you have any other comments and/or observations about the time management course which you would like to share?