



8th INTERNATIONAL CONFERENCE
"CONSTRUCTION SAFETY & HEALTH"

26 & 27 May 2023

Hotel Hilton Nicosia,
Engomi, Cyprus

ECONOMIC ANALYSIS OF SAFETY RISKS
IN CONSTRUCTION USING BIM



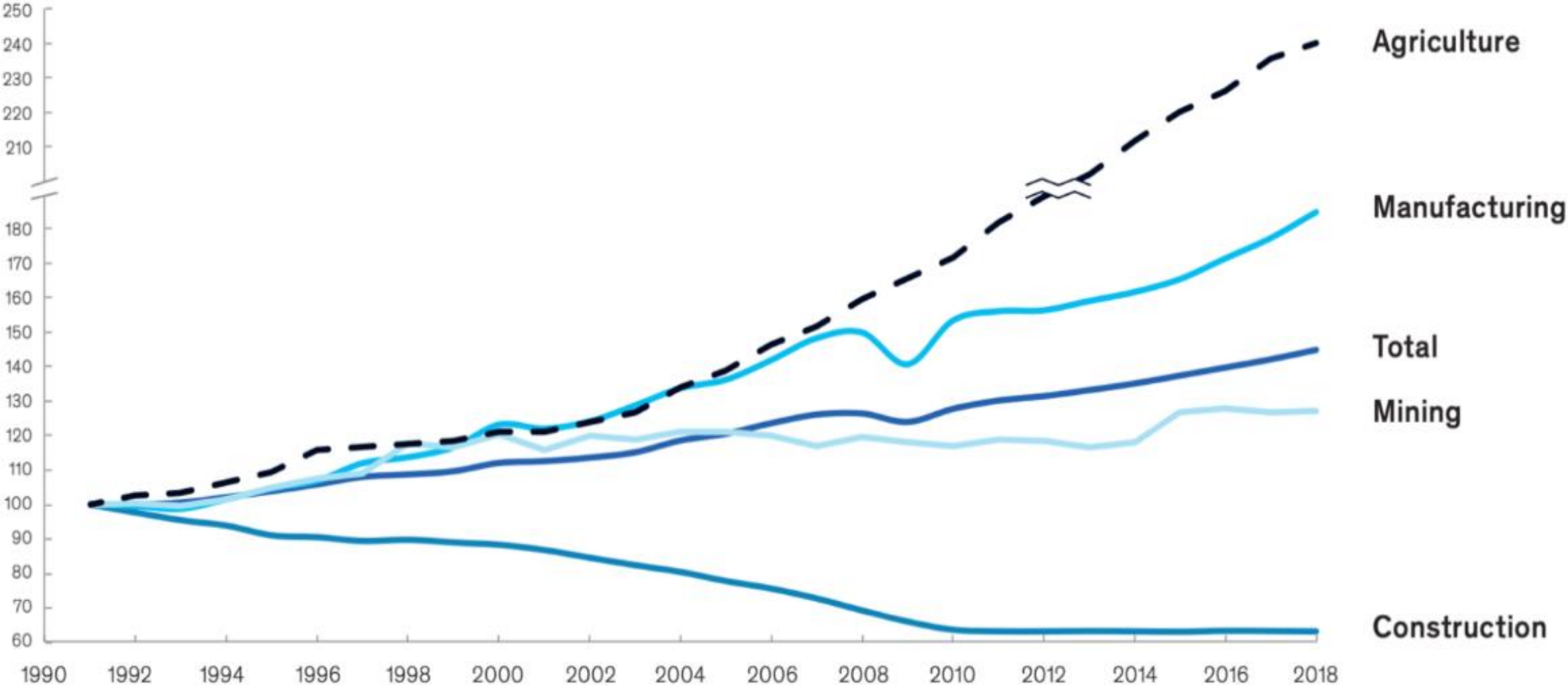
ORDEM
DOS
ENGENHEIROS

ECONOMIC ANALYSIS OF SAFETY RISKS IN CONSTRUCTION USING BIM

FERNANDO DE ALMEIDA SANTOS & RICARDO DA CUNHA REIS

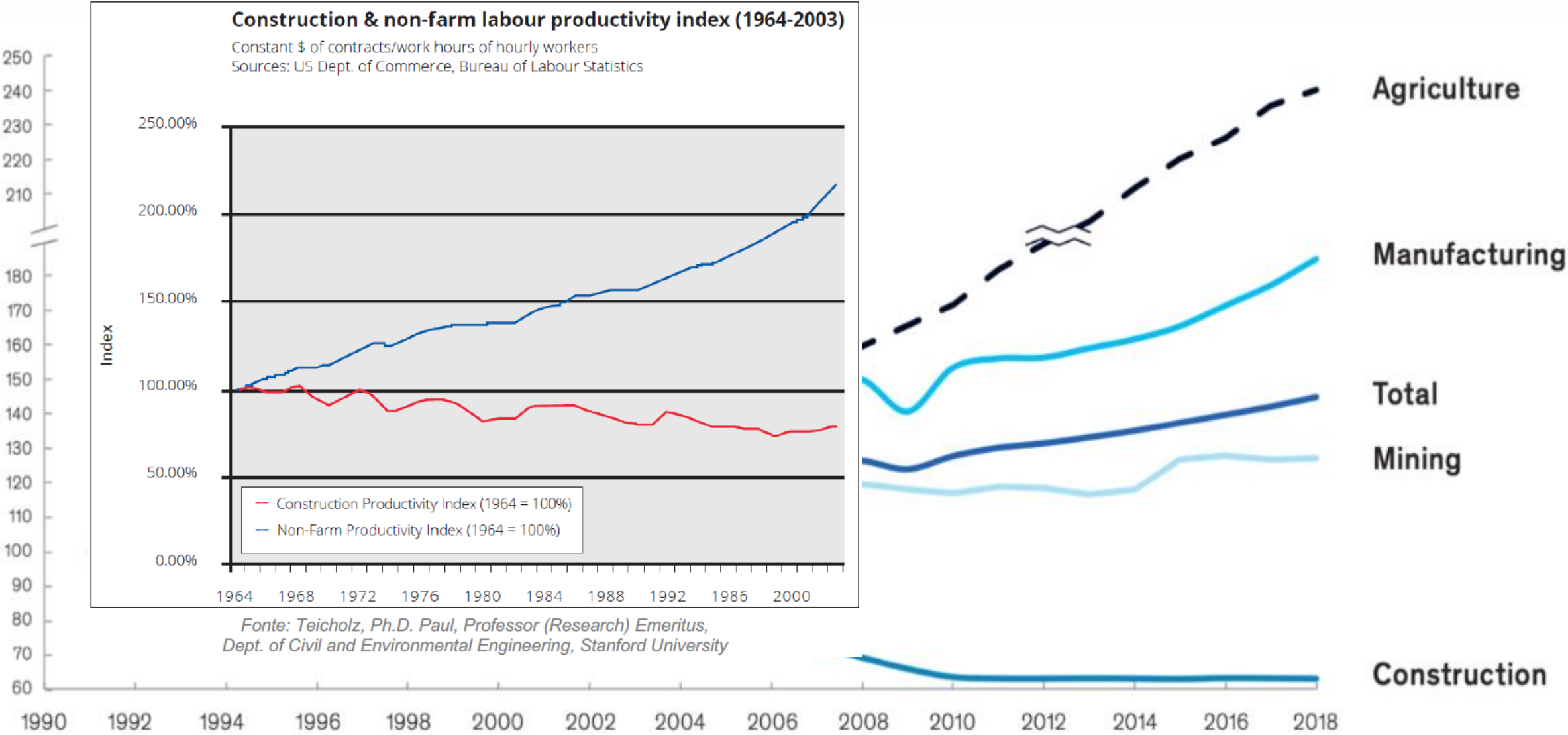
**ORDEM DOS ENGENHEIROS
PORTUGAL**

PRODUCTIVITY IN THE CONSTRUCTION & OTHERS SECTORS



Source: World Bank, IHS, International Labour Organization

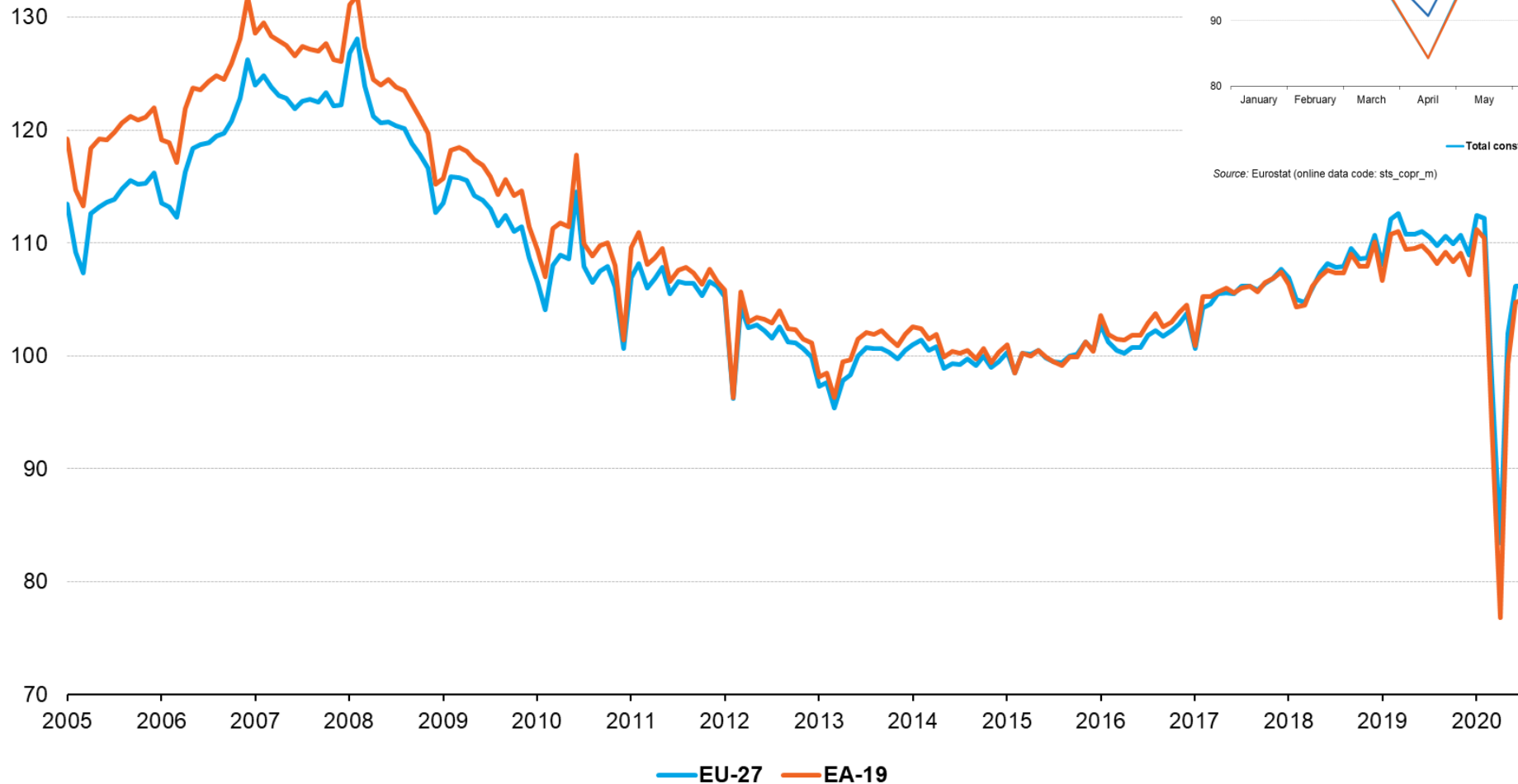
PRODUCTIVITY IN THE CONSTRUCTION & OTHERS SECTORS



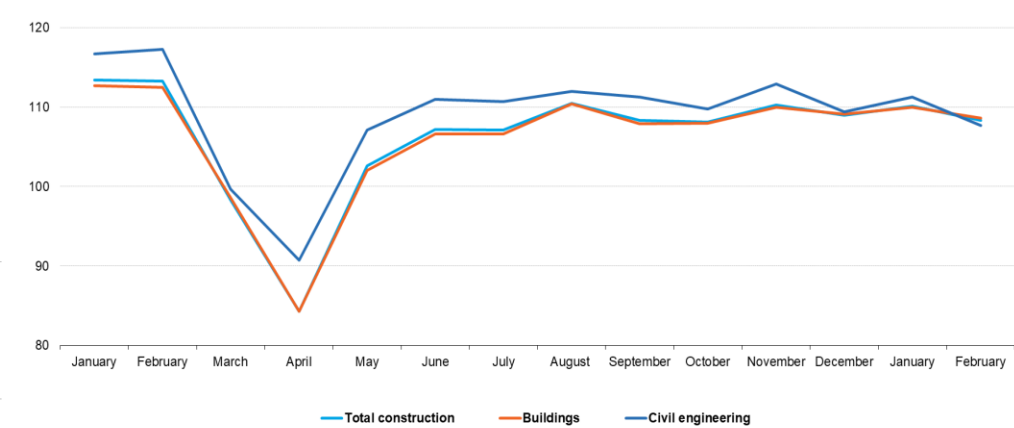
Source: World Bank, IHS, International Labour Organization

PRODUCTIVITY IN THE CONSTRUCTION (COVID TIME)

EU-27 and EA-19 construction production 2005 - 2020, calendar and seasonally adjusted data (2015 = 100)



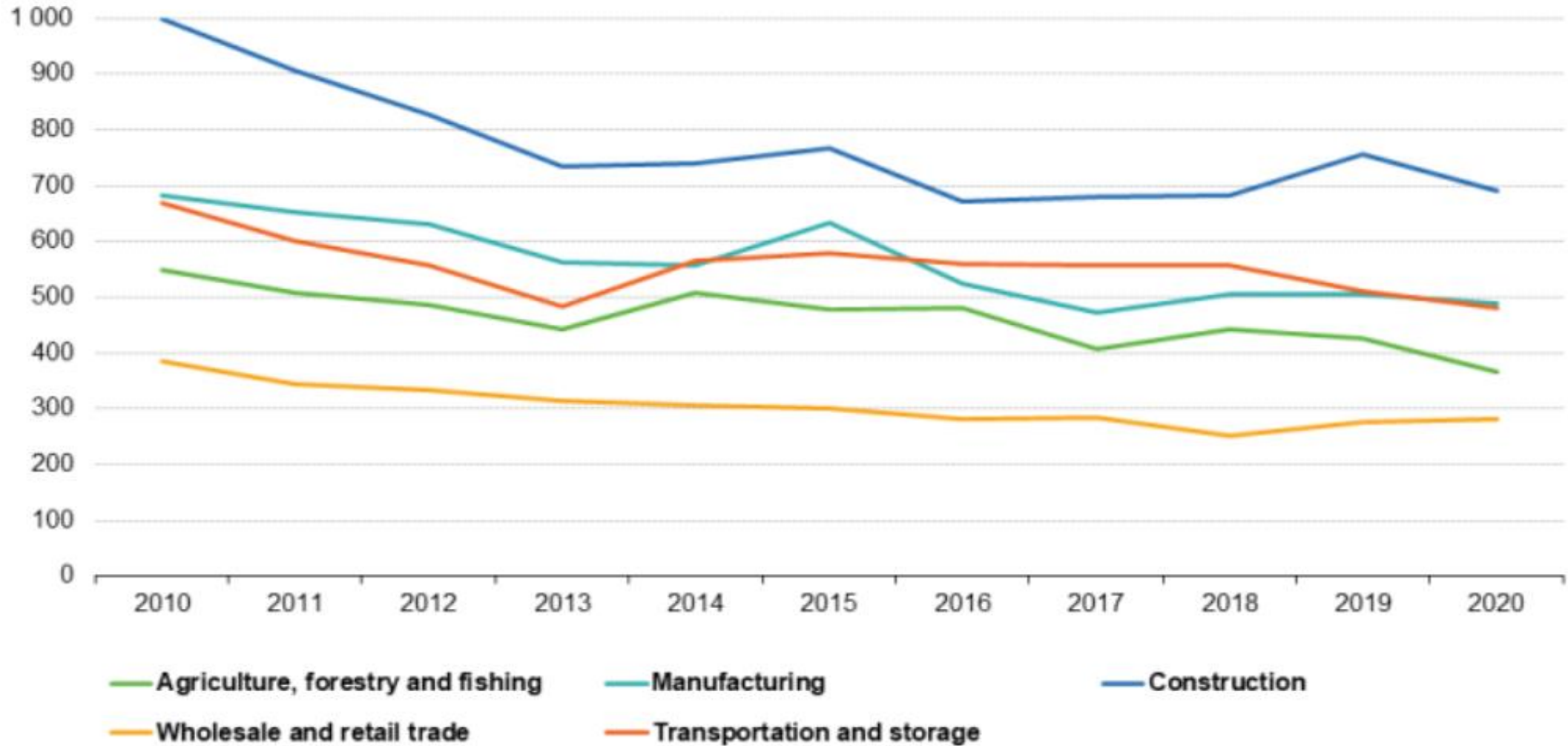
EU, development of construction production, January 2020 - February 2021
2015=100



Source: Eurostat (online data code: sts_copr_m)

eurostat

FATAL ACCIDENTS AT WORK IN THE CONSTRUCTION & OTHERS SECTORS WITH THE HIGHEST RISK LEVELS (PERSONS)



Source: Eurostat (online data code: hsw_n2_07)

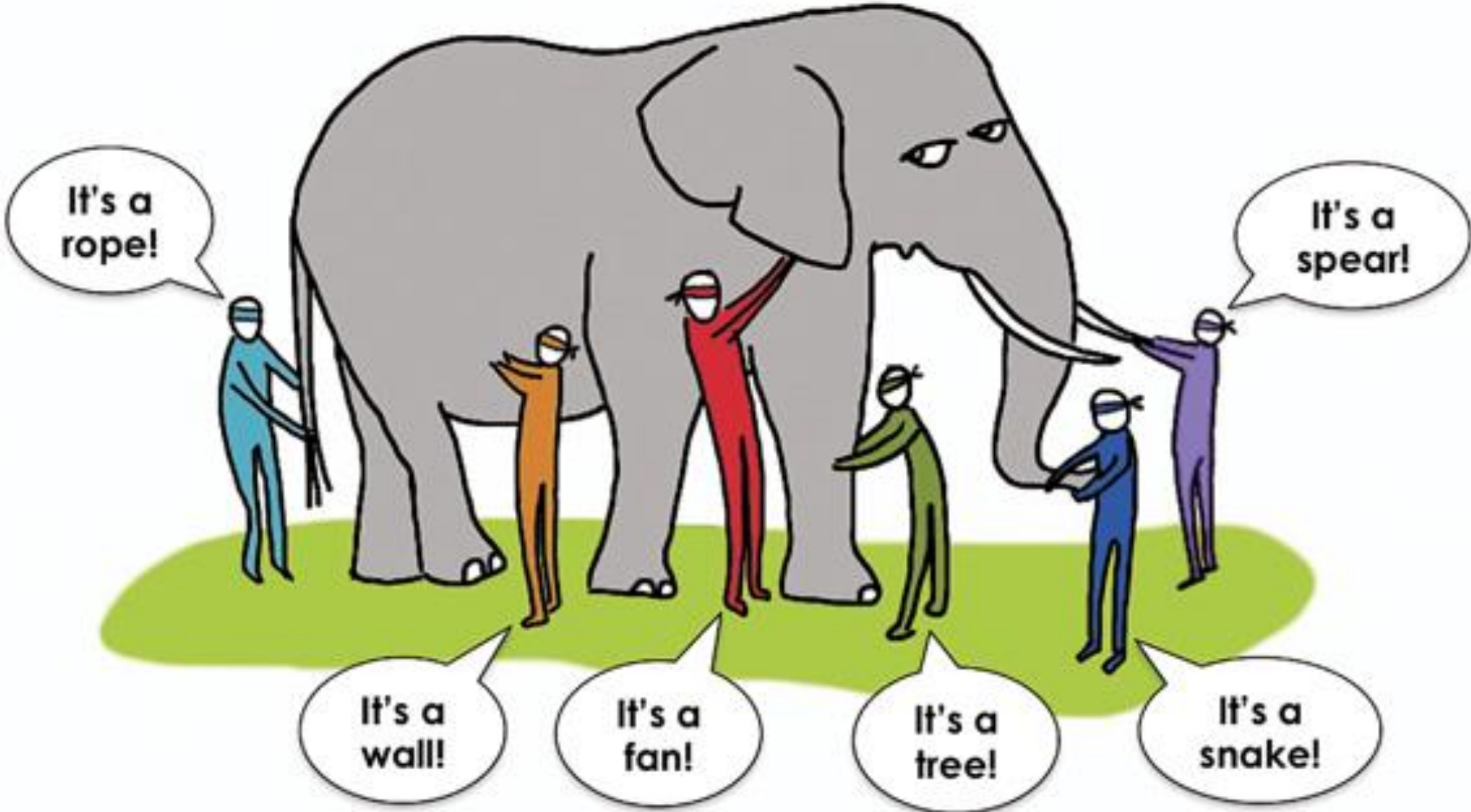
**I'M SURE
SAFETY BRINGS PRODUCTIVITY**

PRODUCTIVITY BRINGS SAFETY

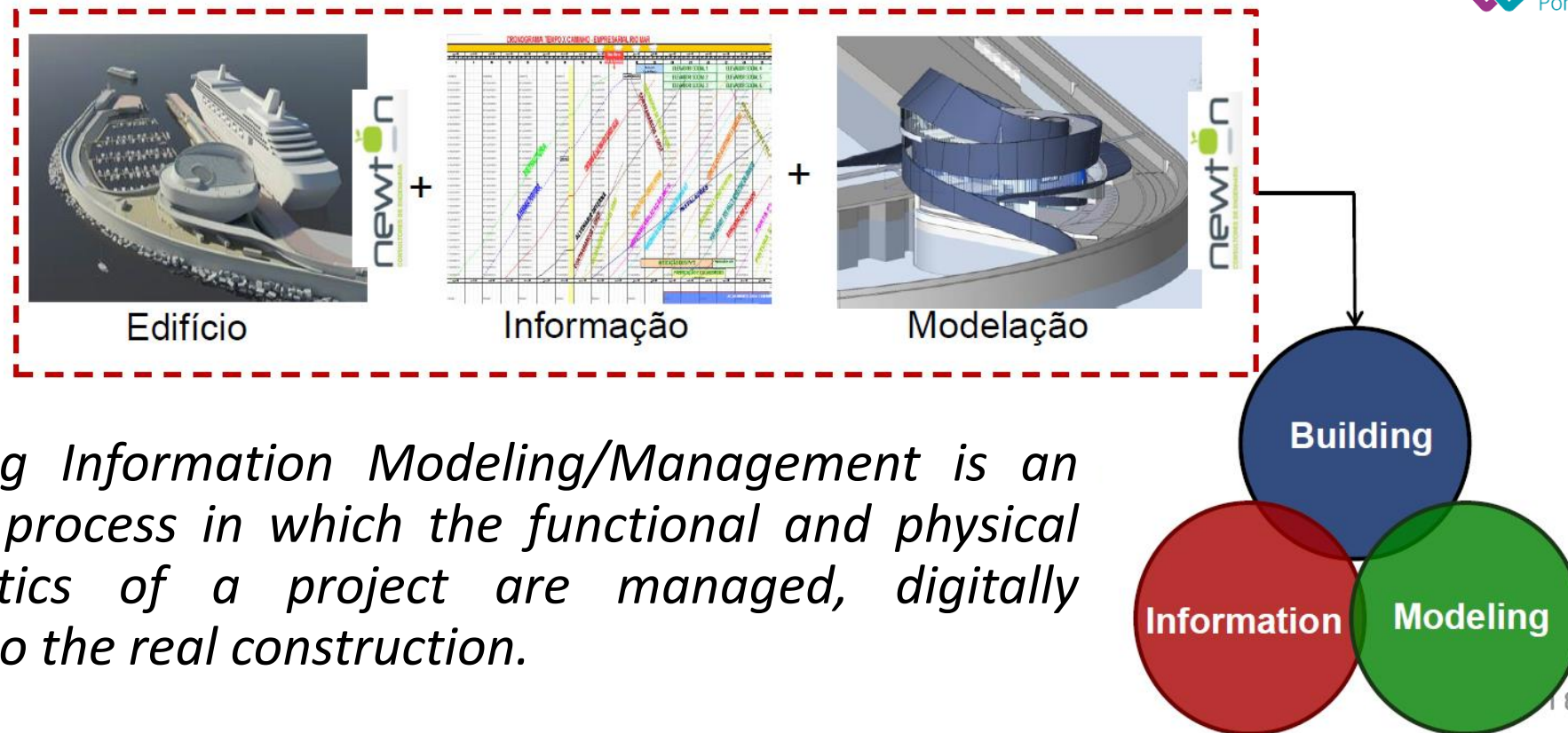
?

LET'S DISCUSS ABOUT IT...

WHAT IS BIM ?



BIM is a methodology for sharing information and communication between all stakeholders, during all stages of the life cycle of a construction that is supported by a digital model, accessible by software which allows the virtual manipulation of that same construction.

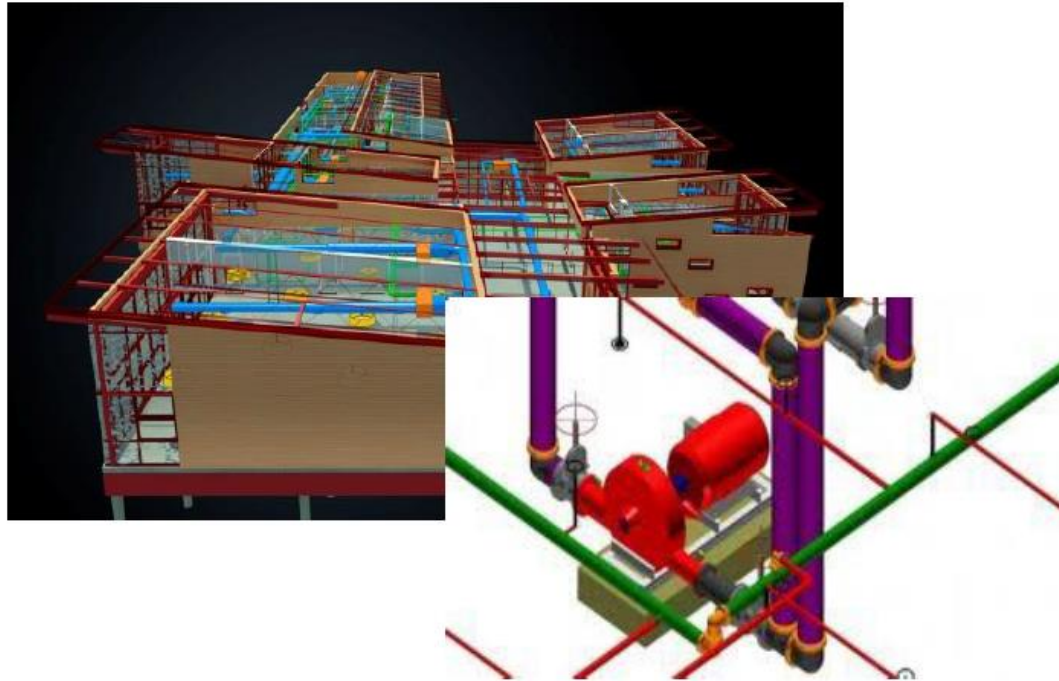
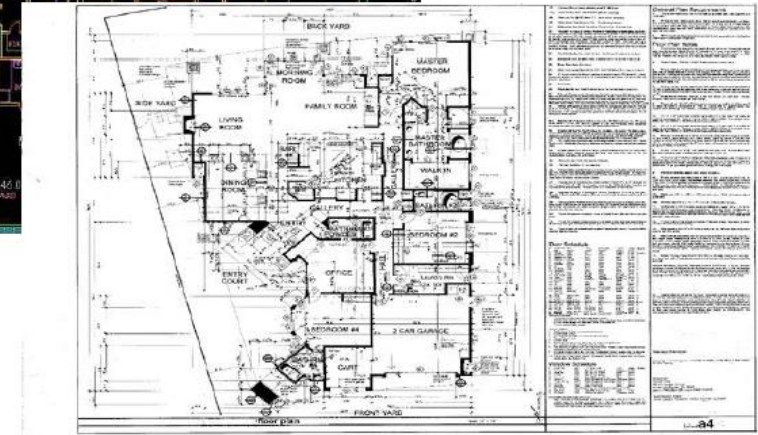
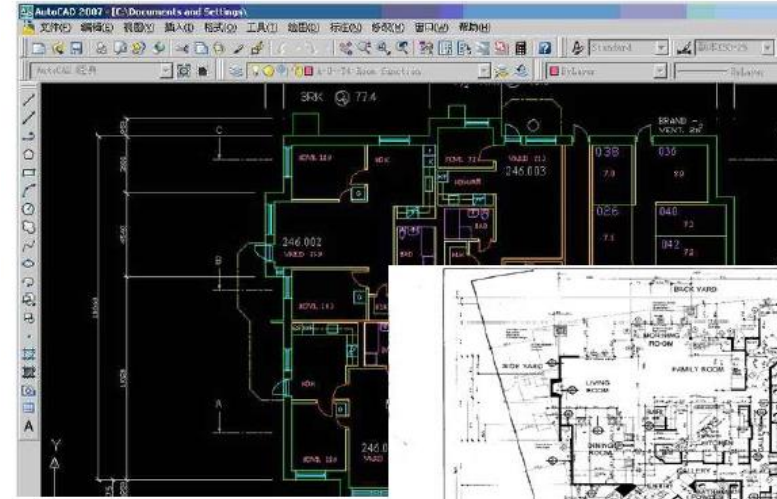


So, Building Information Modeling/Management is an integrated process in which the functional and physical characteristics of a project are managed, digitally simulated to the real construction.

OBJECT ORIENTED MODELING

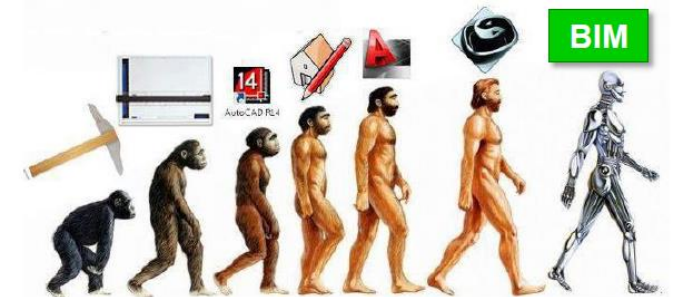
ENTITY-BASED: Geometric Modeling (Traditional Methodology)

- It is a simple geometric representation incapable of assigning any type of semantic information to the modeled element;
- This drawing tool allows you to display any type of element using points, lines and areas.



OBJECT ORIENTED: Object Oriented Modeling

- This representation allows to present the building through its components;
- It was only recently implemented;
- Requires high performance hardware.



PRODUCT (OBJECTS) DATA TEMPLATES

WHY DICTIONARIES ?



USE OF PDT

INTERNATIONAL
STANDARD

ISO
23387

First edition
2020-07

Building information modelling
(BIM) — Data templates for
construction objects used in the life
cycle of built assets — Concepts and
principles



ISO/TC 59/SC 13 N 666

ISO/TC 59/SC 13
Organization and digitization of information about buildings and civil engineering works,
including building information modelling (BIM)

Email of secretary: lia@standard.iso
Secretariat: SN (Norway)

Presentation Beijing prEN ISO 23386 and 23387

Document type: Other committee document

Date of document: 2018-10-24

Expected action: INFO

Background:

Committee URL: <https://iso.tc.iso.org/livelihood/open/tc59sc13>



prEN ISO 23387 – TERMINOLOGY

ricardo.reis@isopoll.eu - 2023-05-20 18:01:09



DATA TEMPLATE

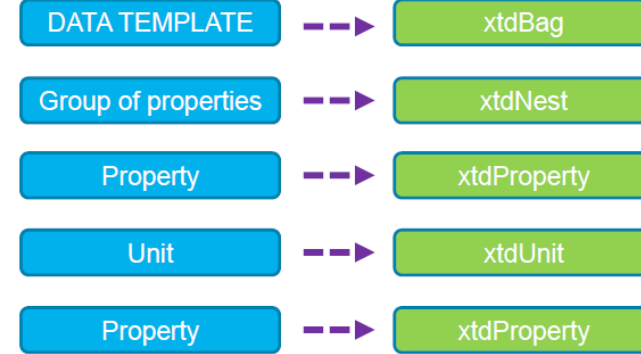
digital template, using a standardized data structure, providing the information needs for describing the characteristics of construction works entities

NOTE 1 The relevant use of the data template should be used together with the term “data template”. E.g. a data template for a product should be named “product data template”. A data template for a system should be named “system data template”, etc.

NOTE 2 ISO 12006-3 concept type is xtdBag

USE OF ISO 12006-3

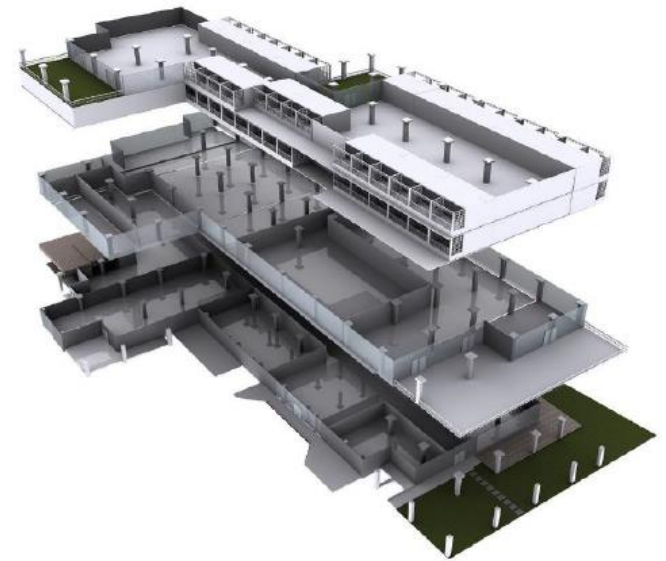
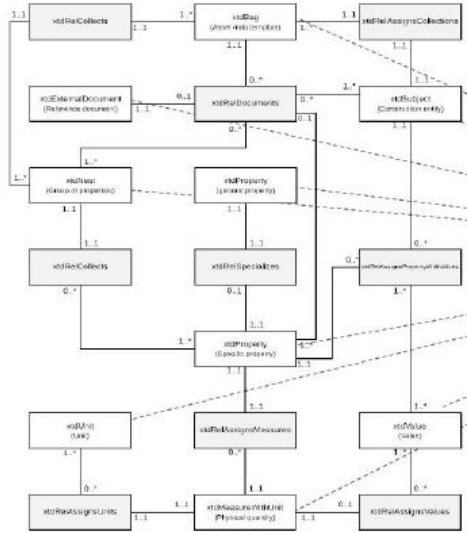
1§ to describe ISO 12006-3 CONCEPTS USED



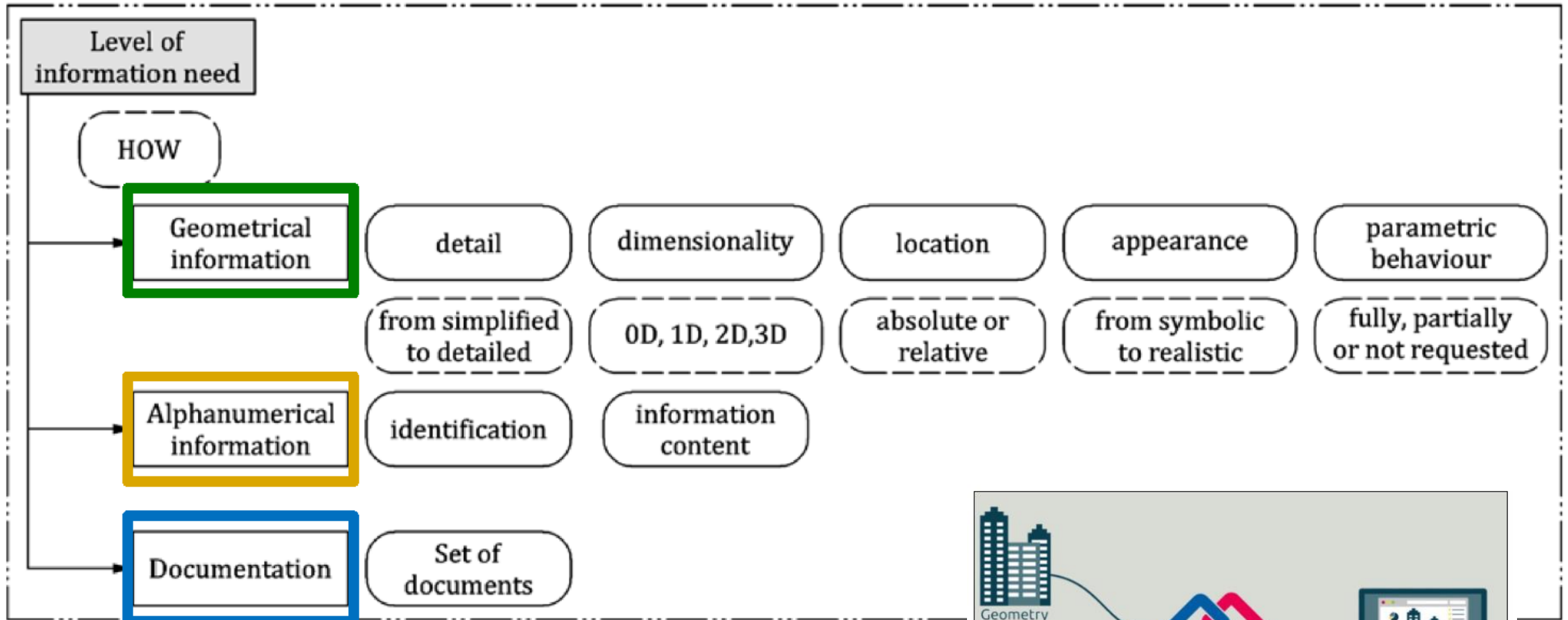
Data structure

Data exchange

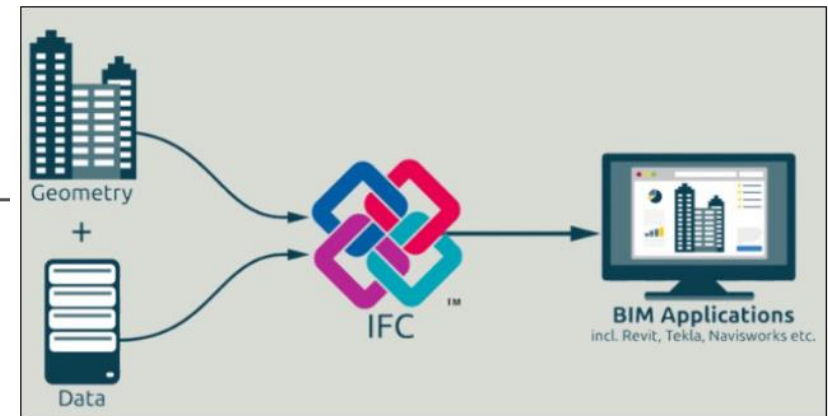
Model



LEVEL OF INFORMATION



Fonte: EN 17412-1:2020



Fonte: <https://www.buildingsmarkorea.org/what-is-ifc-and-open-source>

✓ Level of Information Need

Information delivery milestone:	Preliminary Design
Purpose:	Visualization
<i>Actor</i>	<i>Lead appointed party — Architect</i>
<ul style="list-style-type: none"> Object: 	"Site"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Geometrical information: 	Not requested
<ul style="list-style-type: none"> Alphanumerical information: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Identification: 	Site type
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Information content: 	Address, geo-location, ...
<ul style="list-style-type: none"> Documentation: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Set of documents: 	Survey drawing
<ul style="list-style-type: none"> Object: 	"Wall"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Geometrical information: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Detail: 	Simplified volume representation including openings
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Dimensionality: 	3D
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Location: 	Absolute
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Appearance: 	Realistic with texture of materials
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Parametric behaviour: 	Not requested
<ul style="list-style-type: none"> Alphanumerical Information: 	Not requested
<ul style="list-style-type: none"> Documentation: 	Not requested
<ul style="list-style-type: none"> Object: 	"Window"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Geometrical information: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Detail: 	Simplified volume representation of frames and panels
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Dimensionality: 	3D
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Location: 	Absolute
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Appearance: 	Realistic with texture and transparency of materials
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Parametric behaviour: 	Not requested

...	
Purpose:	Cost Estimation
<i>Actor</i>	<i>Appointed party — Quantity Surveyor</i>
<ul style="list-style-type: none"> Object: 	"Site"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Geometrical information: 	Not requested
<ul style="list-style-type: none"> Alphanumerical Information: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Identification: 	Site type
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Information content: 	Cost of site preparation
<ul style="list-style-type: none"> Documentation: 	Not requested
<ul style="list-style-type: none"> Object: 	"Wall"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Geometrical information: 	Not requested
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Alphanumerical Information: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Identification: 	Wall type (e.g. loadbearing exterior wall)
<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> Information content: 	Type, quantity, area, volume, composition/material (via type), classification
<ul style="list-style-type: none"> Documentation: 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Set of documents: 	Bill-of-materials, bill-of-quantities
<ul style="list-style-type: none"> Object: 	"Window"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> ... 	
<ul style="list-style-type: none"> <ul style="list-style-type: none"> Object: "Slab" 	"Slab"
<ul style="list-style-type: none"> <ul style="list-style-type: none"> ... 	
<ul style="list-style-type: none"> ... 	

BIM DIMENSIONS

3D



Modelling

4D



Scheduling

5D



Budgeting

6D



Sustainability

7D



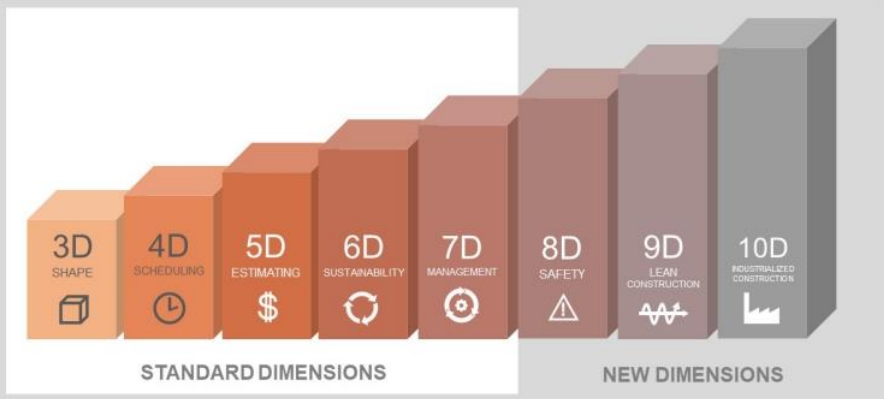
Facility Management

8D



Safety

DIMENSIONS OF BIM




Dimension	Label
3D	MODELAGEM
4D	CRONOGRAMA
5D	ORÇAMENTAÇÃO
6D	SUSTENTABILIDADE
7D	GESTÃO DAS INSTALAÇÕES
8D	SEGURANÇA
9D	LEAN CONSTRUCTION
10D	CONSTRUÇÃO INDUSTRIALIZADA

PRODUCT (OBJECTS) DATA HAZARDS

✓ ISO 19650 series

Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling

Part 1: Concepts and principles (EN ISO 19650-1:2018)

Part 2: Delivery phase of the assets (EN ISO 19650-2:2018)

Part 3: Operational phase of the assets (EN ISO 19650-3:2020)

Part 4: Information Exchange (EN ISO 19650-4:2022)

Part 5: Security-minded approach to Information management (EN ISO 19650-5:2020)

Part 6: Health and safety (em elaboração)

6.3.3 Risk management

The design team shall, based on their skills, knowledge and experience, as well as the Health and Safety information provided in the contract, determine and set out the design risk management tasks and other suitable design applications necessary to develop an inherently safer design solution. In both an iterative and progressive manner within the approach to design risk management the design team shall identify and evaluate the:

- **process and/or product hazards;**
- activity hazards;
- location hazards;
- hazards arising from temporary works, or permanent works in a temporary vulnerable state;
- hazards which may give rise to ill health, either on immediate exposure or after along latency period;
- hazards referenced by legislation; and
- hazards during an emergency event.

The design team shall identify the hazards and risks that **arise during an emergency event in construction, commissioning or end-use**, and mitigate them through the approach to design risk management.



ISO/TC 59/SC 13 "Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)"

Secretariat: SN

Committee manager: Landfald Lisbet Mrs

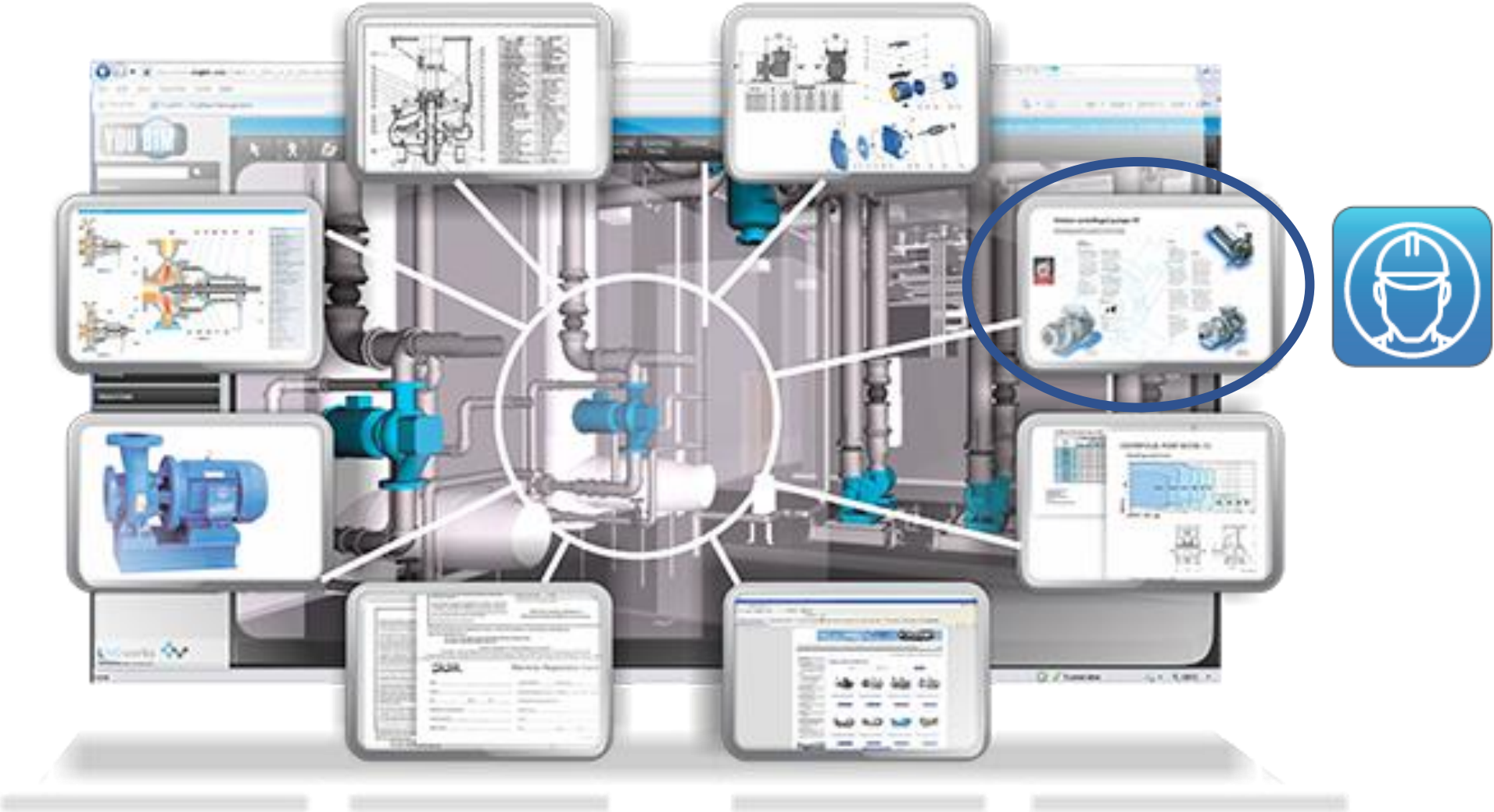


ISO/CD 19650-6 for comments




Document type	Related content	Document date	Expected action
Project / Draft	Project: ISO/CD 19650-6 Ballot: ISO/CD 19650-6 (restricted access)	2022-09-19	COMMENT/REPLY by 2022-11-15



PRODUCT (OBJECT) IS ALWAYS ASSOCIATED TO A TASK (ACTIVITY)



Economic analysis of safety risks in construction

Título Economic analysis of safety risks in construction   
Tipo Artigo em Livro de Atas de Conferência Internacional
Data 2007

Autores



Ata de Conferência Internacional

Título: SA Utilize este identificador para referenciar este registo: <https://hdl.handle.net/1822/70433>

Páginas: !

Safety an

T = 1/51lett:

Título: O impacto e utilidade do BIM no planeamento da segurança: análise realizada por especialistas

Autor(es): Lopes, Cátia Alexandrina Correia

Orientador(es): Couto, J. Pedro  
Tender, Manuel



Palavras-chave: Planeamento da segurança
BIM
Prevenção
Riscos
Gestão da construção
Safety planning
Prevention
Risks
Construction management

Data: 2017



Utilize este identificador para referenciar este registo: <https://hdl.handle.net/1822/59670>

Título: A integração do BIM na gestão da prevenção na construção

Autor(es): Reis, Ricardo da Cunha
Tender, Manuel
Couto, J. Pedro  
Lopes, Cátia
Cunha, Teima

Palavras-chave: BIM
BIMSafety
Compilação Técnica
Gestão da prevenção
PSS

Data: Mar-2018



Luana Coeli Santos Castelo Branco

Desenvolvimento de uma ferramenta baseada em BIM para apoiar a Avaliação de Riscos em projetos de construção

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment Points System

- It is intended to determine a **method that allows obtaining the risk value based on the statistical data** obtained from the survey of accident rates.
- A quick method of assessing risks and vulnerabilities is also theoretically developed, based on damage corresponding to the degree of risk. It is defined in advance that the degree of risk can only vary on a **scale of 1 to 5, with 1 being the minimum risk and 5 the maximum risk.**

		Severity/Consequence		
		Slightly harmful (1)	Harmful (2)	Extremely harmful (3)
Likelihood	Highly unlikely (1)	Trivial risk (Score 1)	Tolerable risk (Score 2)	Moderate risk (Score 3)
	Unlikely (2)	Tolerable risk (Score 2)	Moderate risk (Score 4)	Substantial risk (Score 6)
	Likely (3)	Moderate risk (Score 3)	Substantial risk (Score 6)	Intolerable risk (Score 9)

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment (NTP 330)

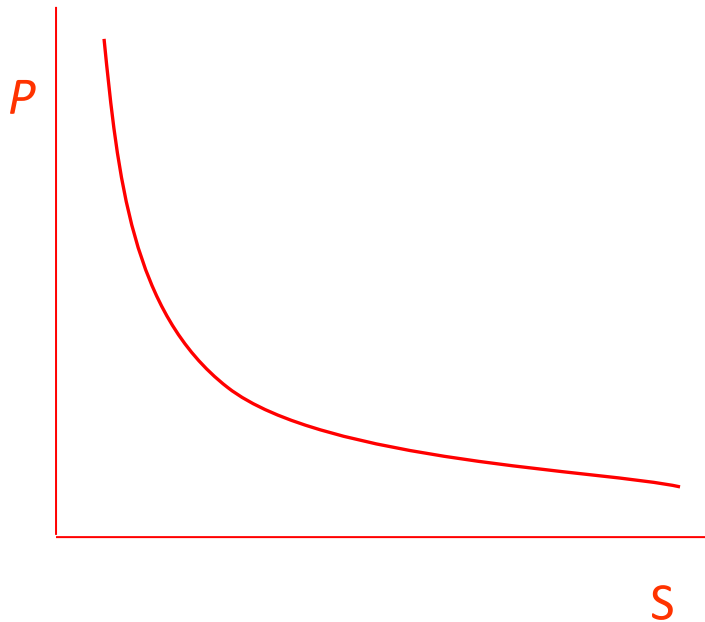
Risk Estimate is a function of the product of the probability of an accident occurring and its severity

$$R = P \times G$$

R – risk

P – probability

S – severity



Ajustment Risk (RA)

- To the **minimun** value obtain to the calculation of the risk – R, corresponde to a adjust risk value – AR equal to 1
- To the **maxium** value obtain to the calculation of the risk – R, corresponde to a adjust risk value – AR equal to 5
- Expression that aims to determine all adjusted values of the degree of risk:

$$A_{\text{risco}} = \frac{(R_{\text{máx}} + (AR_{\text{máx}} - AR_{\text{min}})) \times V_{\text{risco}} - AR_{\text{máx}} \times R_{\text{min}}}{R_{\text{máx}} - R_{\text{min}}}$$

- With:
 - AR_{min} = 1;
 - AR_{máx} = 5;
 - R_{min} = risk **minimun**;
 - R_{máx} = risco **maxium**;
 - V_{risco} = risk appreciation;
 - A_{risco} = ajustment risk

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment System (NTP 330)

Critério de valorização de risco

Danos sofridos:

Risco mínimo = 1

- Danos irrelevantes
- Sem danos físicos

Risco pequeno = 2

- Danos pequenos
- Sem danos físicos mas com assistência (paragem do sistema)

Risco médio = 3

- Danos algo relevantes
- Feridos ligeiros sem necessidade de internamento hospitalar
- Sem dias de baixa

Risco grande = 4

- Danos relevantes
- Feridos ligeiros com necessidade de internamento inferior a 10 dias
- Dias de baixa « 10 dias
- Doença profissional crónica

Família de riscos		R – risco	
		P x G	%
Quedas em altura	A	24,82	35,17 %
Quedas de nível	B	1,00	1,42 %
Soterramento	C	5,22	7,40 %
Esmagamento / estruturas	D	5,69	8,06 %
Esmagamento / máquinas	E	17,41	24,68 %
Electrocussão	F	1,63	2,31 %
Viação	G	1,30	1,84 %
In itinere	H	1,37	1,94 %
Outras causas / agressões	I	1,39	1,96 %
Lesões externas	J	4,29	6,08 %
Lesões internas	K	5,33	7,55 %
Causas desconhecidas	L	1,12	1,59 %
Doenças	M	---	---
			100,00 %

A_{risco}
$1 \leq A_R \leq 5$
5,00
1,00
1,71
1,79
3,76
1,11
1,05
1,06
1,06
1,55
1,73
1,02

Risco máximo = 5

- Grandes danos, destruição
- Feridos graves com necessidade de internamento hospitalar superior a 10 dias
- Dias de baixa » 10 dias
- Ferimentos ou doença incapacitante
- Morte

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment Points System in Model Application

- **The scale defined for risks is from 1 to 5**, assuming that no risk is equal to 0 (zero), since this always exists, even if it is residual.
- Taking into account the lack of prevention on site, a maximum value was defined for each risk, and in some cases this value reaches level 5, such as "falls from heights".
- Also, taking into account the use of prevention in its fullness, the valuation of risk was defined at 1, whatever the circumstance, since this is, as has already been focused on, the minimum value of risk assumed.

RISK POINTS	RISK FAMILY	MAXIMUM RISK	MAXIMUM RISK
TRAPPING	I	1,00	1,00
FALL FROM HEIGHT	A	5,00	1,00

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment Points System in Model Application

Example: Building a "Window" (BIM object/product)

In the first situation, where risk analysis is maximized, taking into consideration the fact that there is no prevention, the result is 20 points (**Risk Value Max.**);

In the second situation, assuming that there is full prevention of risks at all levels, the total of risk points is 5 points (**Risk Value Min.**).

Risco	Atividade / Contexto / Objeto / Produto	Local	Nível de detalhe do Produto				Nível de informação do Produto				Pontuação
			1	2	3	4	1	2	3	4	
Risco 1	Atividade 1	Local 1	1	2	3	4	1	2	3	4	20
Risco 2	Atividade 2	Local 2	1	2	3	4	1	2	3	4	5

Risk Assessment System (NTP 330)



Excel

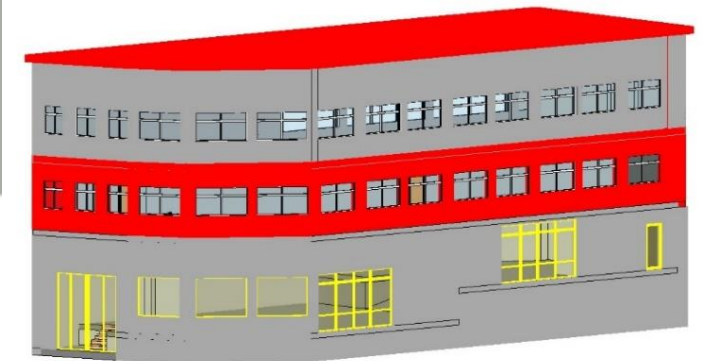
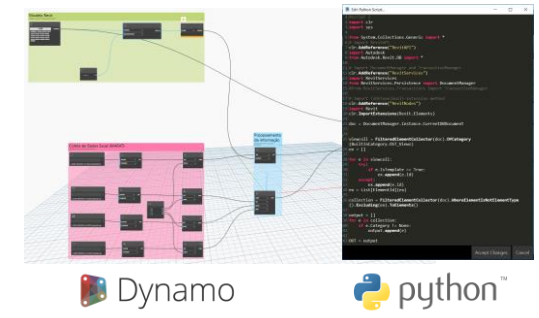
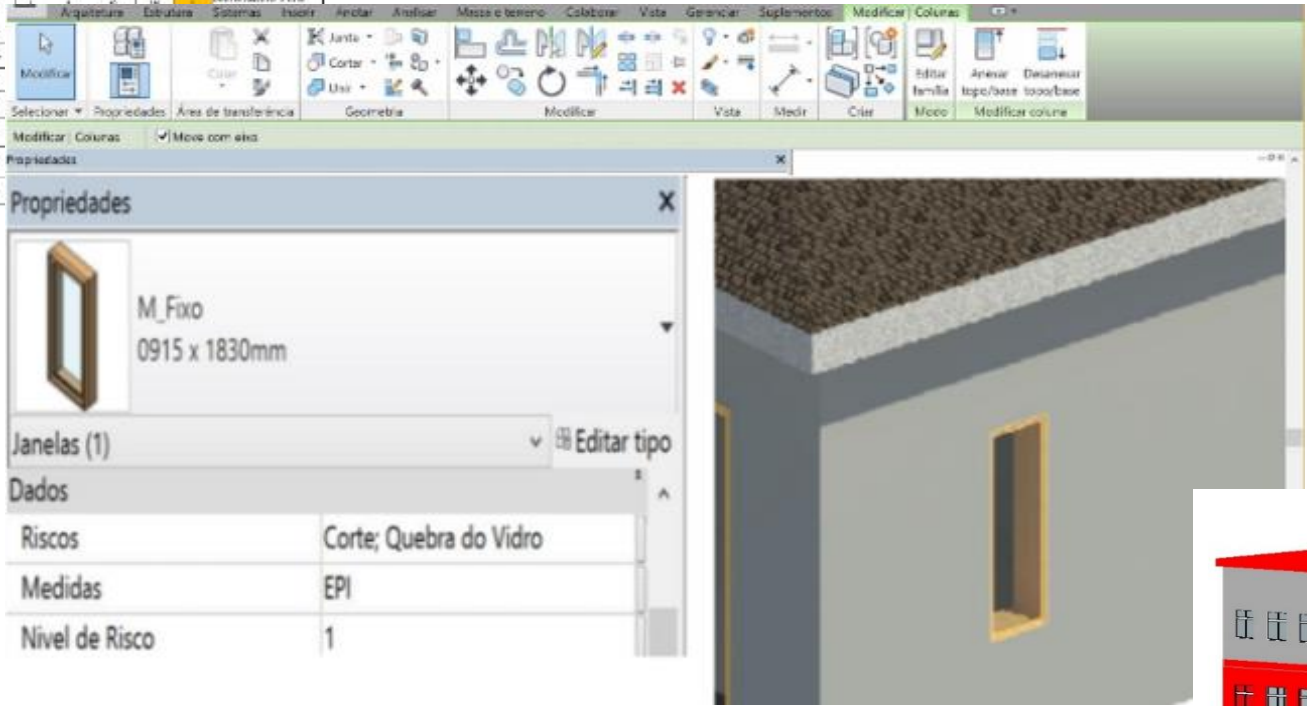
Umfang und Abgrenzung sind immer projektindividuelle Vereinbarungen

Beispiel Tur: 100, 200, 300, 400, 500

LoD Level of Detail: 1, 2, 3, 4, 5

LoI Level of Information: Name, Objektart und Nutzeranforderungen; Unterscheidung außen/innen und Brandschutzanforderungen; zusätzlich Angaben zu Material, Abmessungen, Standards und Zertifizierungen; Angaben über die Montage, Verfügbarkeit, und Wartung des Produktes; Sammlung aller Produktinformationen auf dem Niveau „as built“

Produktanforderungen → Produktausprägungen





Building:

DOURO CENTER

Located:

Vila Real – Portugal

Construction área:

150.000 m²

Floors:

- 3 (parking) + 2 (comercial)

Total value of construction:

35.000.000 €

Time estimated:

18 months

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment Points System in Model Application

Selection of Risks and Preventive Measures

- From the planning of the works, with **1.104 activities associated to objects**, the respective risk is analyzed by activity, particularly the Inspection and Prevention Procedures contained in the Health and Safety Plan;
- For each Inspection and Prevention Procedure, that is, for each activity, there are several associated risks.
- In order to optimize the use of this data, the procedures themselves became activities, associated to objects, in the work planning;
- Project planning by importing, editing and exporting schedules, using software:
 - the risks points have become incorporated as “resources” that make up the different activities;
 - the risk value is introduced as the “unit cost” of the risk (resource).

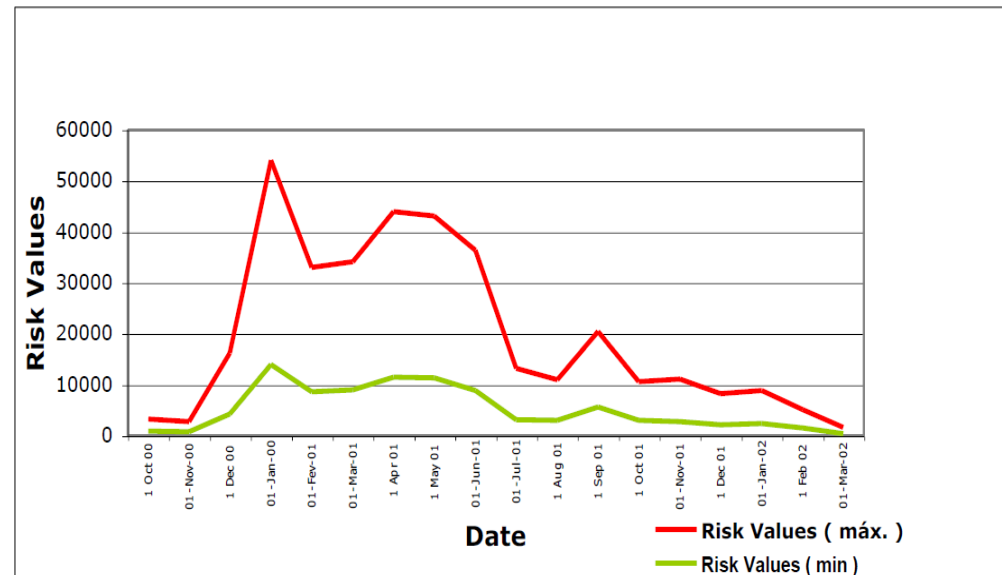
RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment Points System in Model Application

Model Simulation

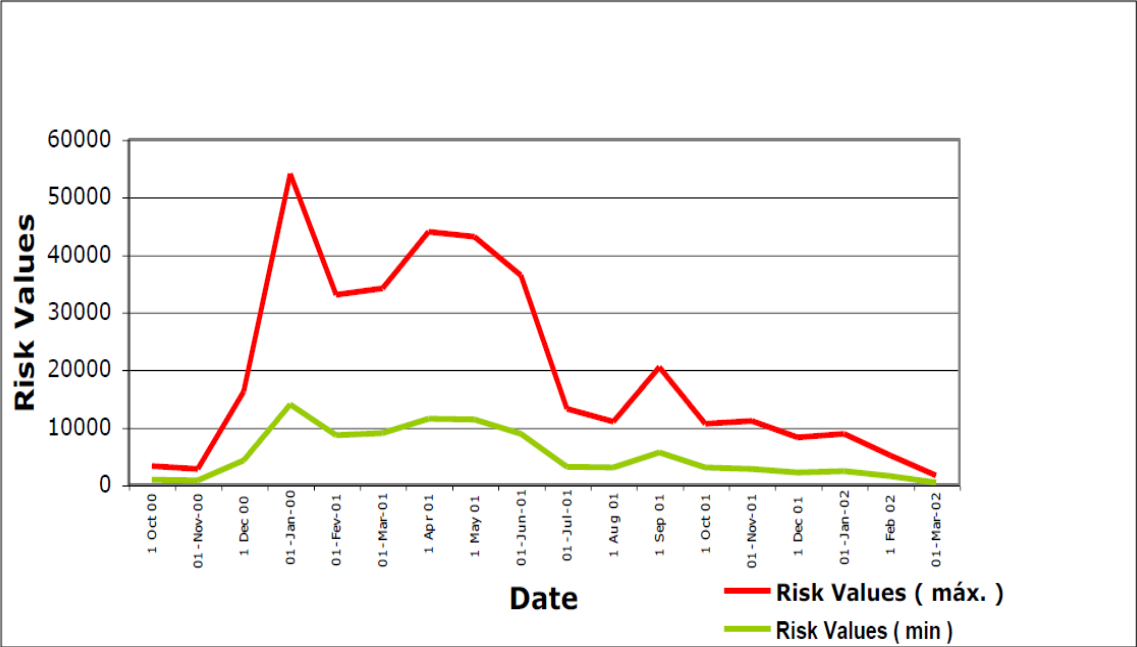
Risk histogram with **2 total results**:

- In the **first situation**, in which the valuation of the simulation is carried out through the application of **maximum risks**, that is, assuming that risk prevention is not carried out, an accumulated result of **356,663 risk points** is obtained, adding up all the inherent risks to activities;
- In the **second situation**, the valuation of the simulation is carried out by applying the minimum risks, that is, assuming that risk prevention is carried out at all levels, an accumulated result of **92,354 risk points** is reached;



RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Analysis of Safety Risks Value (8D) vs. Scheduling (4D)



(3D + 4D + 5D/8D)

RISK ASSESSMENT OF THE TASK (ACTIVITY) ASSOCIATED TO PRODUCT (OBJECT)

Risk Assessment Points System in Model Application

Model Simulation

Histogram analysis:

- The value **3.86** is determined as the average maximum risk reference point throughout the work, obtained by dividing the total maximum risks by the minimum risks (356,663 / 92,354);
- It quickly becomes clear that in certain stages of the same, the difference in risk incidence greatly exceeds these values, so that, in addition to the normal prevention situations, it is **urgent to act** in these risk "peaks".
- The difference in risk incidence may allow the location of **risk "peaks"**, priority situations for preventive action.

ECONOMIC ANALYSIS OF SAFETY RISKS

Risk Assessment Points System in Model Application

Model Simulation

Economic analogy in terms of risk:

- An analysis that can be elaborated, in a complementary way to this study, is the association of the total valuation of risks to monetary values, thus evaluating "**when it costs to provide safety**";
- Taking into consideration recent studies that show that **safety costs** for a similar work in Portugal, **rarely surpass 2%**.

DOURO CENTER	% VALUE	CALCULATION
TOTAL VALUE OF CONSTRUCTION:	35.000.000 €	
MAXIMUM RISK VALUATION RATE (NO PREVENTION BEING MADE)		3,86
COSTS OF IMPLEMENTING PREVENTION MEASURES	2,00 % 700.000 €	Approximate value obtained per study 2,00 % x 35.000.000 €
POTENTIAL COSTS OF "NOT SAFETY"	7,72 % 2.700.000 €	2,00 % x 3,86 7,72 % x 35.000.000 € ou 3,86 x 700.000 €
POTENTIAL RISK OF INCREASED COSTS BECAUSE PREVENTION IS NOT PERFORMED	5,72 % 2.000.000 €	7,72 % - 2,00 % 2.700.000 € - 2.000.000 €

CONCLUSIONS:

ECONOMIC ANALYSIS OF SAFETY RISKS

- The implementation of prevention and safety systems on site has costs, but what is proven, **through the attribution of costs to risks, is that safety has lower costs than non-safety.**
- All these measures are solutions, that bring security costs closer to the values practiced by those who are concerned with prevention and minimizing risk.

“REDUCING RISKS REDUCES PRODUCTION COSTS”

VISION ZERO
Safety.Health.Wellbeing.

developed by  **issa**

7 GOLDEN RULES FOR VISION ZERO

1. Take leadership – demonstrate commitment
2. Identify hazards – control risks
3. **Define targets – develop programmes**
4. Ensure a safe and healthy system – be well-organized
5. Ensure safety and health in machines, equipment and workplaces
6. Improve qualifications – develop competence
7. Invest in people – motivate by participation

CONCLUSIONS:

IDENTIFY AND EVALUATE PROCESS AND/OR PRODUCT HAZARDS



GENERAL PRINCIPLES OF PREVENTION (COUNCIL DIRECTIVE 89/391/EEC):

- (b) **evaluating the risks** which cannot be avoided;
- (e) **adapting to technical progress**;
- (g) developing a coherent overall **prevention policy which covers technology, organization of work, working conditions, social relationships and the influence of factors related to the working environment**;
- (i) giving appropriate **instructions to the workers**.



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PDTs



WHAT WE BELIEVE:

INVEST IN PREVENTION IS INVESTING IN PEOPLE (HAPPY PEOPLE = HAPPY COMPANY)



CONSTRUCTION
SEXY !!!





Thank you!



FERNANDO DE ALMEIDA SANTOS / RICARDO DA CUNHA REIS

ALFREDO SOEIRO / TERESA BOURBON / JOÃO COUTO / MANUEL TENDER / CATIA LOPES / TELMA CUNHA / LUANA BRANCO



MIGUEL AZENHA / JOSÉ CARLOS LINO / ANTONIO AGUIAR COSTA

