

DIGITIZATION AND INFORMATION SUPPORT FOR COST-EFFECTIVE AND SUSTAINABLE MANAGEMENT OF CONSTRUCTION PROJECTS



**Stavebná
fakulta**

**Technical University of Košice
Faculty of Civil Engineering**

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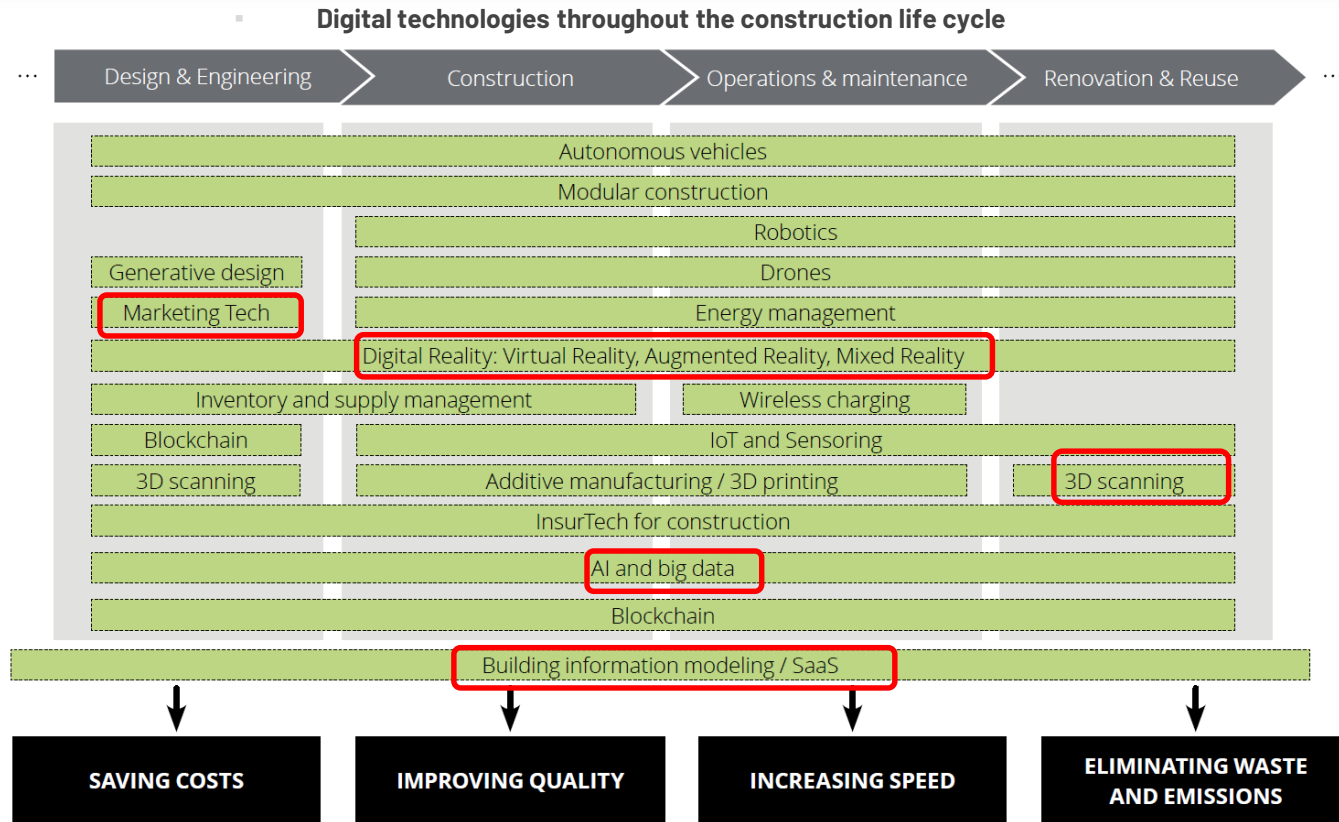


- 1. Introduction / Research motivation**
- 2. Information systems and digital tools for modeling cost and economic parameters within the life cycle of construction projects – state of art**
- 3. Research activities in the field of ICT and digital technologies in the construction projects – objectives, methodology, results, verification and application**
- 4. Education and research activities – contribution to study field „civil engineering“**
- 5. Study field „civil engineering“ at the Faculty of Civil Engineering TUKE – vision and perspectives**

General background - overview of the topic

- **Digitization, sustainability, efficiency in construction** – significant issue for researcher and practitioners
- Set of tools for **increasing the business performance and economic efficiency of construction projects** and activities (**cost, quality, time**) on global markets
- **Essential base for smart construction 4.0** – IoT, digital business platforms, cloud computing, AI
- Relation to **sustainability of construction project** (environmental, economic, social) and **circular economy** throughout the whole **life cycle** of construction project
- **Relation to EU policy** – digital transformation, Digital Europe programme (€7.6 billion), EU plan for the economic recovery supporting the EU's green transition and climate neutrality by 2050
- (...“**digital technologies could help to optimise production, reduce emissions and waste, boost companies' competitive advantages and bring new services and products to consumers**)

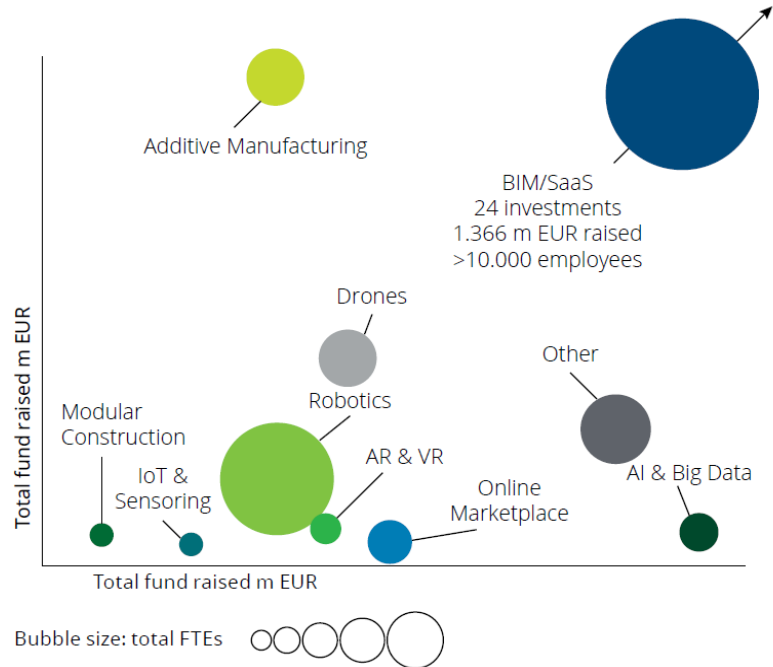
2. INFORMATION SYSTEMS AND DIGITAL TOOLS FOR MODELING COST AND ECONOMIC PARAMETERS WITHIN THE LIFE CYCLE OF CONSTRUCTION PROJECTS – STATE OF ART



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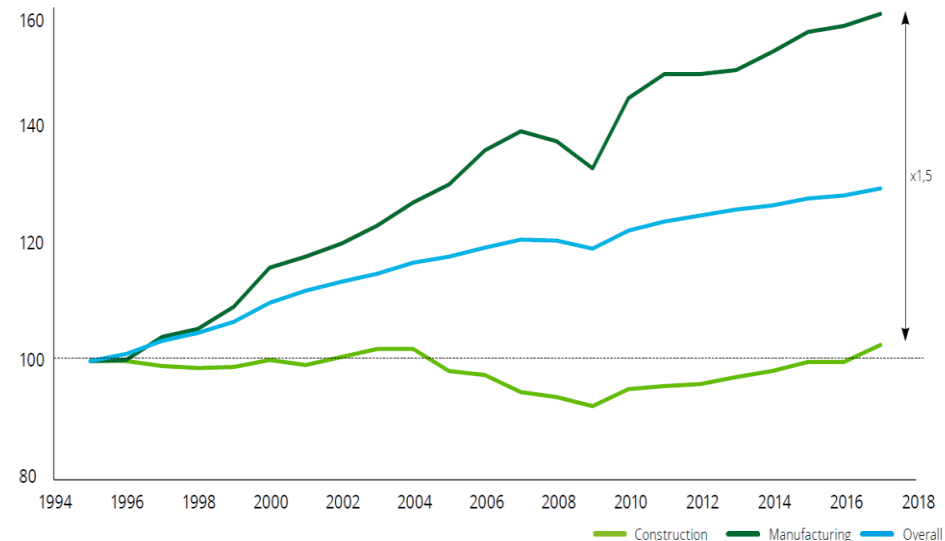


Top 70 start-ups by total fund raised between 2012-2018



Source: OECD, 2019

Standardized labour productivity growth 1995-2018



Source: Deloitte – Point of View on Digital Construction: The business case of incorporating digital technologies into the construction industry, 2020

3. RESEARCH ACTIVITIES IN THE FIELD OF ICT AND DIGITAL TECHNOLOGIES IN THE CONSTRUCTION PROJECTS



A)

Cost management of construction projects - cost controlling supported by ICT

B)

Automation of cost estimating in construction projects - 5D BIM

C)

Economic parameters in information modeling with emphasis on sustainability within the life cycle of buildings

3. RESEARCH ACTIVITIES IN THE FIELD OF ICT AND DIGITAL TECHNOLOGIES IN THE CONSTRUCTION PROJECTS

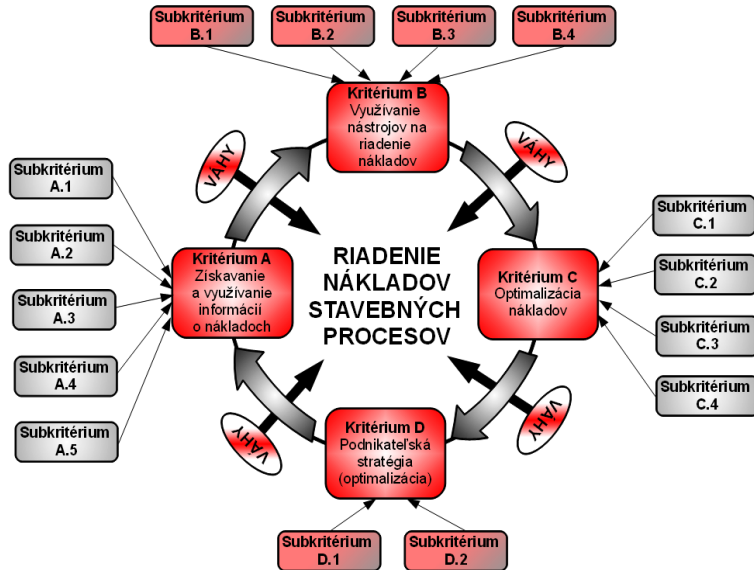


A) Cost management of construction projects - cost controlling supported by ICT

RESEARCH OBJECTIVES	RESEARCH METHODS	RESEARCH SCHOOL FORMATION AND FUNDING CONTEXT
▪ Creation of cost management model based on contextual analysis of cost management methods and tools ▪ Development of process-oriented cost management tool in construction companies ▪ Optimization of construction project costs using ICT and knowledge technologies	▪ Qualitative analysis of methods and techniques in cost management ▪ Multi-stage questionnaire survey on sample (2011: n=41, 2015: n=125,) of Slovak construction companies ▪ Inductive statistical data analysis, AHP technique for multi-criteria decision making processes	▪ 3 topic related PhD. thesis/graduates ▪ 3 research projects (VEGA 1/0840/11, VEGA 1/0562/14, VEGA 1/0828/17)

FINDINGS AND RESULTS:

Multi-criteria cost management model for construction enterprises



- Identification of problem areas
- Processes revisions
- Implementing controlling tools and techniques

Criterion and Sub-criteriendescriptions	Weights calculated by Entropy method	Weights calculated by AHP method
Criterion A - The collection and use of information about costs	$w_A = 0.6211$	$w_A = 0.2674$
Sub-criterion A.1 (Tracking actual costs)	0.5124	0.2364
Sub-criterion A.2 (Obtaining the cost information from accounting)	0.1520	0.2464
Sub-criterion A.3 (Obtaining the cost information from accounting - identifying the share of the cost on certain projects or activities)	0.0397	0.2087
Sub-criterion A.4 (Responsibility for obtaining information in the company)	0.0656	0.1193
Sub-criterion A.5 (Using of modules of enterprise information system for cost tracking and cost management)	0.2374	0.1892
Criterion B - Using the tools for managing	$w_B = 0.0892$	$w_B = 0.2651$
Sub-criterion B.1 (Using the data about cost)	0.3364	0.3130
Sub-criterion B.2 (Using the tools to manage costs)	0.0222	0.2401
Sub-criterion B.3 (Using the the new tools to manage costs)	0.3983	0.1634
Sub-criterion B.4 (Reasons of unit costs tracking)	0.2432	0.2835
Criterion C - Cost optimization	$w_C = 0.2331$	$w_C = 0.2322$
Sub-criterion C.1 (Monitoring the cost of construction)	0.5950	0.2614
Sub-criterion C.2 (Incidence of problems in identifying the cost of construction)	0.0658	0.2327
Sub-criterion C.3 (The frequency of problems with optimizing resource costs)	0.1660	0.2551
Sub-criterion C.4 (The frequency of problems with cost optimization of construction processes)	0.1732	0.2508
Criterion D - Business strategy (optimization)	$w_D = 0.0567$	$w_D = 0.2352$
Sub-criterion D.1 (The frequency of problems with optimizing the portfolio of contract in construction)	0.7083	0.4854
Sub-criterion D.2 (Identification of problems with a portfolio of customers in construction)	0.2917	0.5146

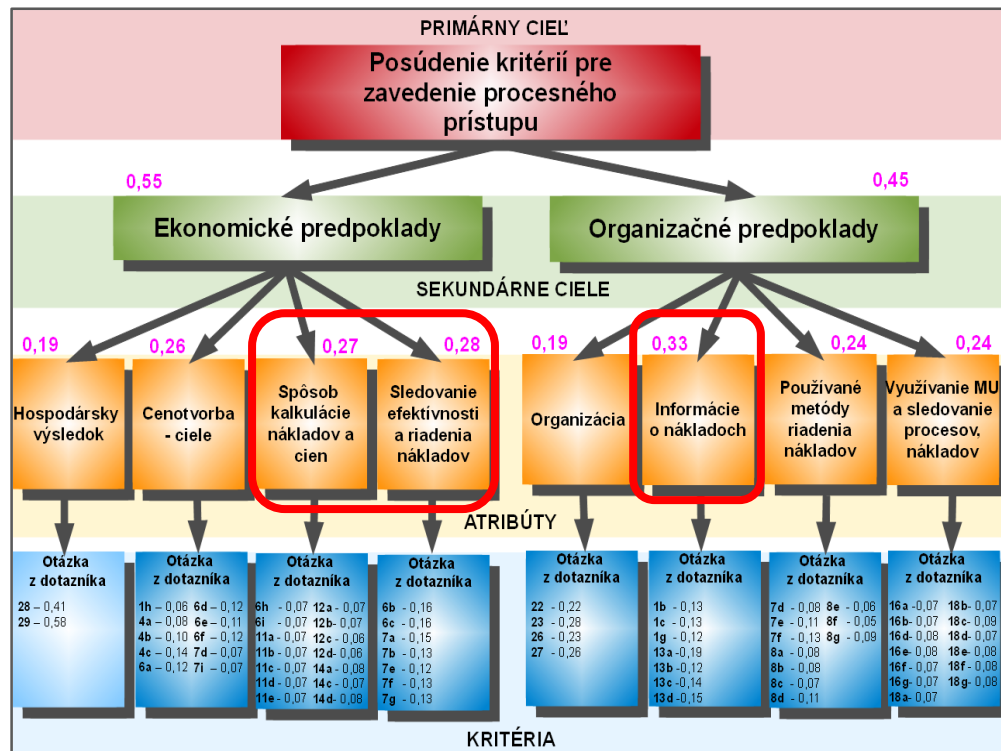
FINDINGS AND RESULTS

Assesment procedure for process-oriented approach in cost management

- Empirical and expert's identification of assumptions
- Quantification of relevance
- Calculation of readiness for process-oriented cost management

MODEL

- Goals
- Criterion
- Attributes (multiple hierarchy arrangement)



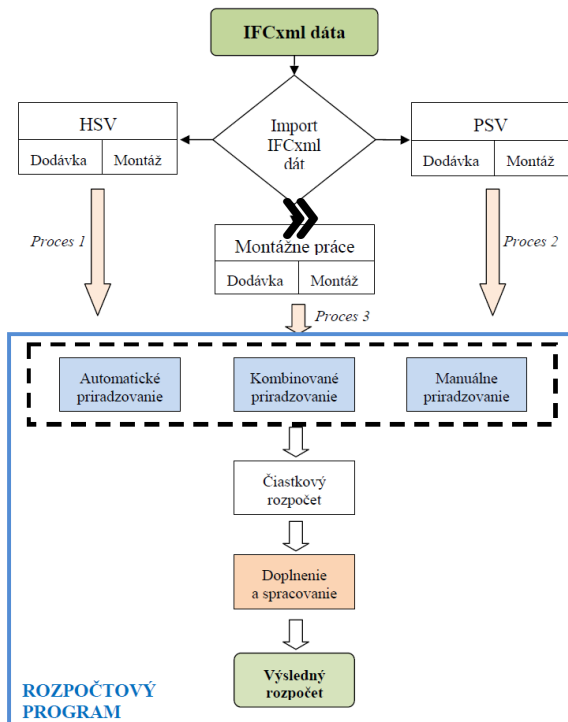
B) Automation of cost estimating in construction projects, 5D BIM

Research objectives	Research methods	Research school formation and funding context
▪ Development and verifying of automated procedure for cost estimating (applicable in Slovakia and Czech rep.) ▪ Laser scanning digital data aquisition for quantity takeoffs in reverse engineering (renovations, reconstructions, deconstructions)	▪ Analysis of input data and Inter-connecting formats for 3D CAD applications and software for cost estimating ▪ Adoption of cost estimating standards and Slovak price libraries for cost estimation ▪ Data-processing virtual model for cost estimation and its verification, analysing and completing point clouds ▪ Calculating the time/cost efficiency of autoamted cost estimation and digital data aquisition	▪ 2 topic related PhD. thesis/graduates ▪ 3 research projects (VEGA 1/0840/11, VEGA 1/0828/17, APVV-17-0549)

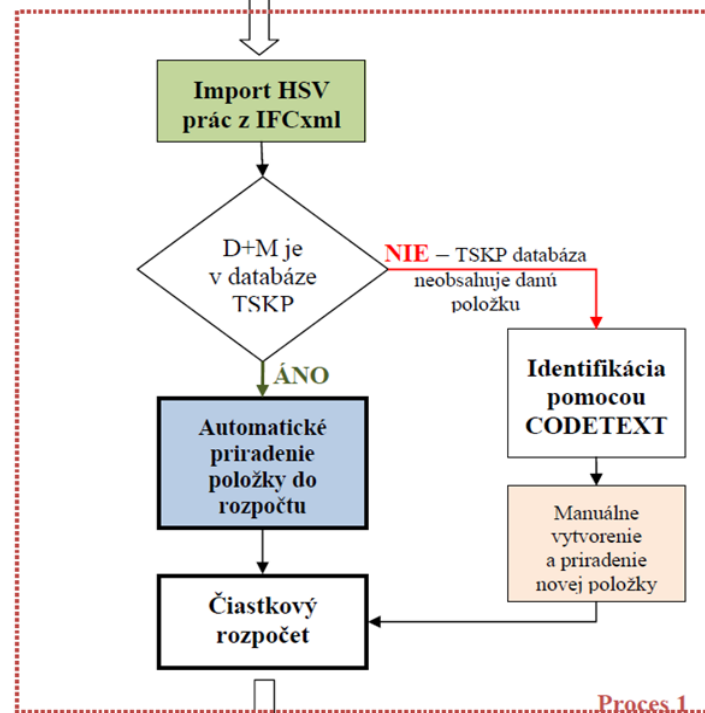
FINDINGS AND RESULTS

Automated cost estimation methodology with unique coding in IFC xml format

Importing and validating model data



Pairing with price list for main production items Identification code assignment

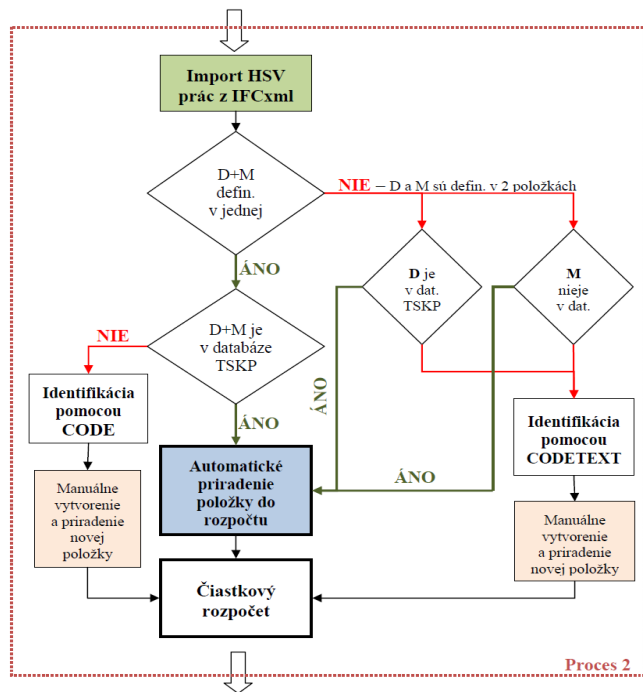


FINDINGS AND RESULTS

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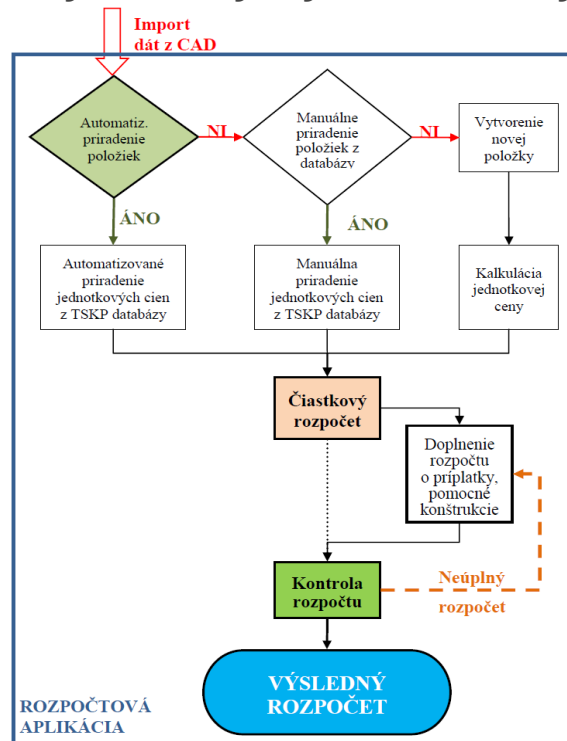
Pairing with price list items for associated production

Identification code assignment



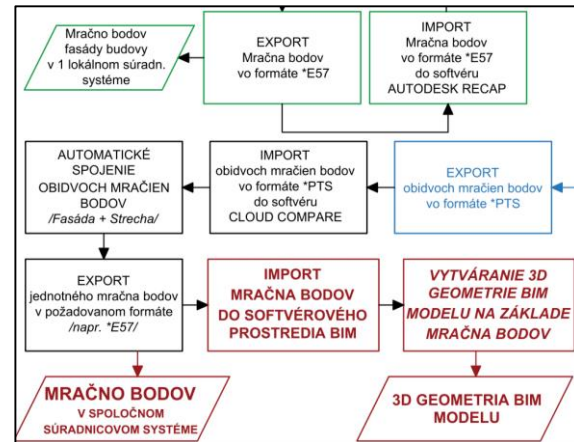
Checking the budget draft

Completing and finalizing budget in cost estimating SW



FINDINGS AND RESULTS

Methodology of point cloud-to-model solution for generating quantity take-offs



Object data acquiring
Laser scanner and drone



Point cloud SW processing
Point cloud validating



Point cloud transformation
Creating 3D model geometry



Quantity take-off generating

3. RESEARCH ACTIVITIES IN THE FIELD OF ICT AND DIGITAL TECHNOLOGIES IN THE CONSTRUCTION PROJECTS



C) Economic parameters in information modeling – sustainability within the life cycle of buildings

Research objectives	Research methods	Research school formation and funding context
• Creation of 5D (nD) construction elements for smart designing (contextual and digital) • Creation of multi-criteria methodology for design phase - optimization of sustainability level using ICT and knowledge technologies • Development of supporting tool for smart and sustainable designing	• <i>Identifying the structure of information for knowledge database, analysis of technology platforms</i> • <i>Knowledge techniques and digital tools limits</i> • <i>Analysis of parameters (scale and impact)</i> • <i>Process mapping and process designing</i> • <i>Software designing</i> • <i>Modeling optimisation algorithms in decision-making</i>	▪ 5 topic related PhD. thesis (2 graduates, 3 students) ▪ 2 research projects (VEGA 1/0828/17, APVV-17-0549) ▪ 2 educational projects (KEGA 059TUKE-4/2019, Erasmus+ 2019-1-SK01-KA203-060778)

FINDINGS AND RESULTS

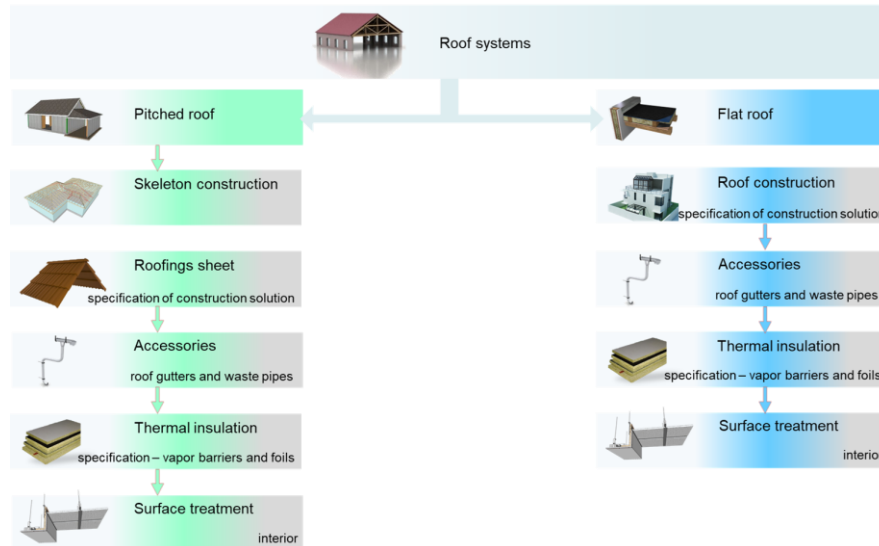
Flowchart based methodology for sustainable designing (multi-criteria approach, 5D smart elements)

Construction elements database

System with material/technology representants
(50+ smart elements in database)



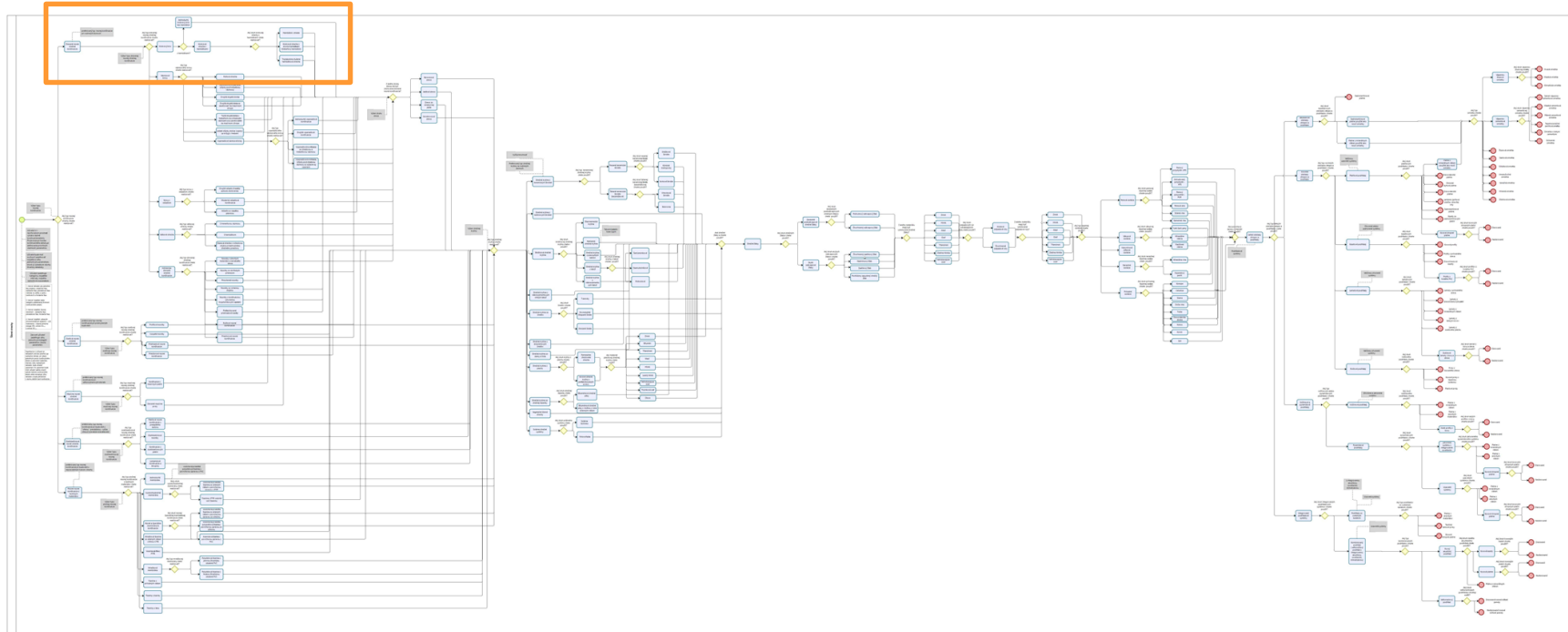
Multicriterial assessing and selecting appropriate solution
(pre-defined sustainability aspects for each element)



		1	2	3
€	Entry price	low input cost	medium input costs	high input costs
	Durability	long service life	medium life	short life
	Carbon footprint	low value of CO2 emissions	medium value	high value of CO2 emissions
	Recyclability	high recyclability rate	medium recyclability rate	low recyclability rate

FINDINGS AND RESULTS

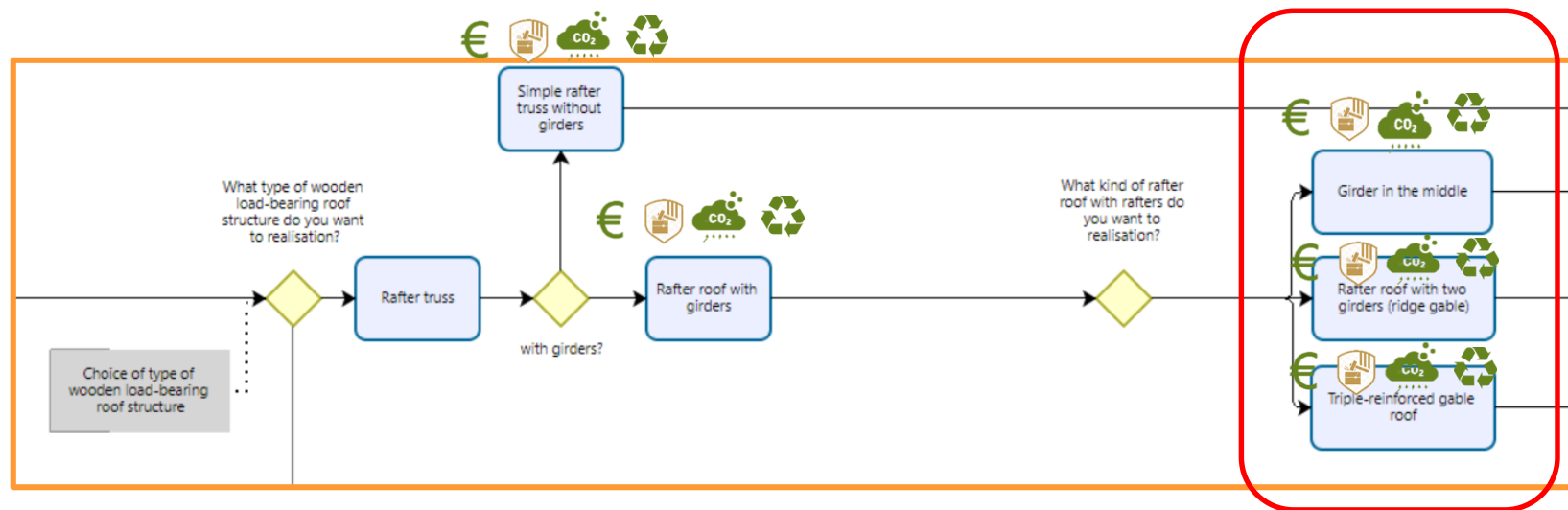
Flowchart based methodology for sustainable designing (multi-criteria approach, 5D smart elements)



Selecting construction element – Roof system sample

FINDINGS AND RESULTS

Flowchart based methodology for sustainable designing (multi-criteria approach, 5D smart elements)



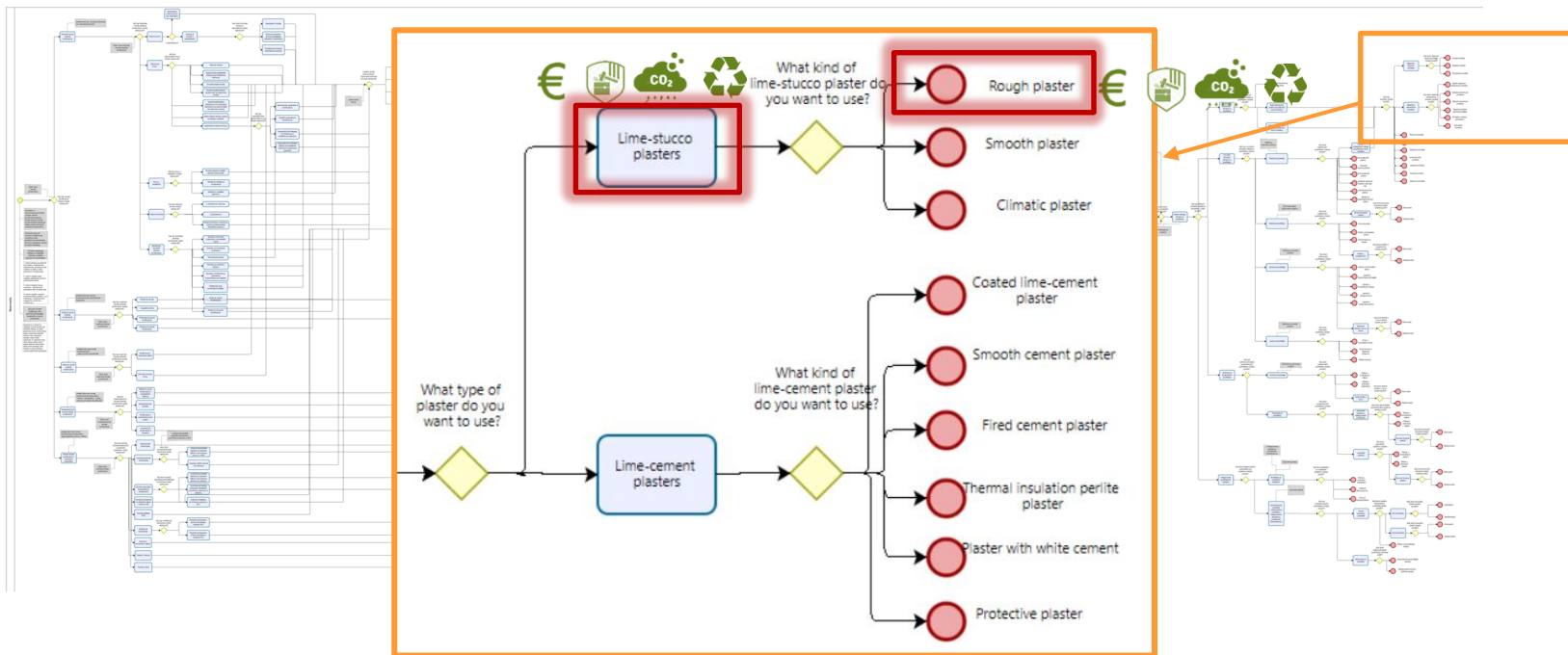
Roof system sample - construction element choices



Choosing the required level of parameter for construction element

FINDINGS AND RESULTS

Flowchart based methodology for sustainable designing (multi-criteria approach, 5D smart elements)



FINDINGS AND RESULTS

SW tool enabling modeling and economic evaluation of construction elements across their life cycle



FINDINGS AND RESULTS

SW tool enabling modeling and economic evaluation of construction elements across their life cycle



Choosing the structure of building



SUSTAINABILITY parameters assignment

APP filtering smart elements with required level of parameter



Total cost calculation – connected to cost estimate – based on quantity and unit price



Results in education activities

- **13 related study courses** (8 at TUKE, 5 at EUBA) slovak/english
- **3 new topic related study courses** – implementation at Faculty of civil engineering
- **73 thesis supervising**
Bc. – 6, Msc. (Ing.) – 16, PhD. – 6 at TUKE, Bc. – 8, Msc. (Ing.) – 35, PhD. – 2 at EUBA
- **5 awarded thesis:** 3 at national level, 2 at international level
- **2 education projects – leader:**
 - KEGA 059TUKE-4/2019 **M-learning tool for intelligent modeling of building site parameters in a mixed reality environment** (national, funding €30,600)
 - Erasmus+ - 2019-1-SK01-KA203-060778 **Construction Safety with Education and Trainign using Immersive Reality** (international, funding €400,000)
- **6 education projects – member:** 2 x KEGA, 2 x Erasmus, 1 x Leonardo da Vinci, 3 x SF Education programme
- **6 international mobilities** (Czech, Poland, Spain)
- **5 topic related publications** – university text books



Results in research activities

▪ **Topic related publications**

- 12 CC journals (Q2-10, Q4-2)
- 10 monographs
- 86 journal papers
- 84 conference papers

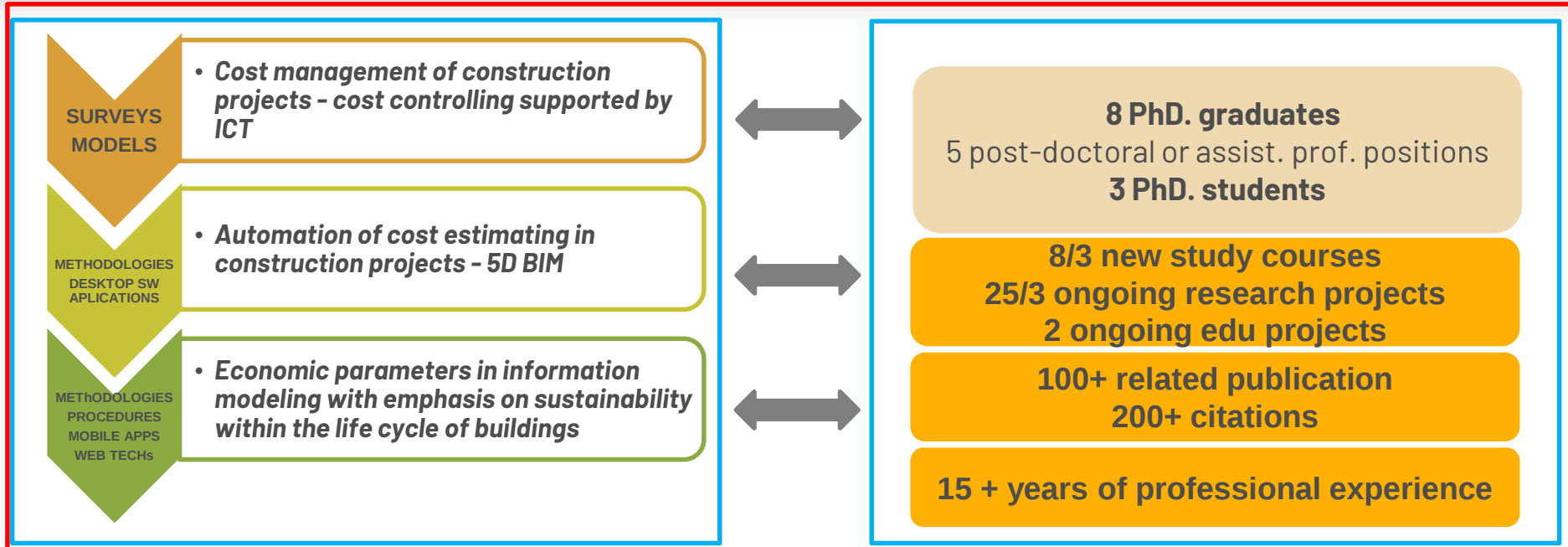
Reviews

- 49 Journals, 19 books, 63 conference papers
- 5 habilitation thesis, 20 PhD. thesis

Metrics

- WoS: 54 publications/92 citations/h-index 6
- Scopus: 78 publications/182 citations/h-index 7

4. EDUCATION AND RESEARCH ACTIVITIES – CONTRIBUTION TO STUDY FIELD CIVIL ENGINEERING



RESEARCH SCHOOL FORMATION

DIGITAL TECHNOLOGY AND BIM BASED COST MANAGEMENT AND MULTI-CRITERIA PROJECT ASSESSMENT FOR SUSTAINABLE (ECONOMIC, ENVIRONMENTAL, SOCIAL) PLANNING OF CONSTRUCTION PROJECTS



International impact and recognition

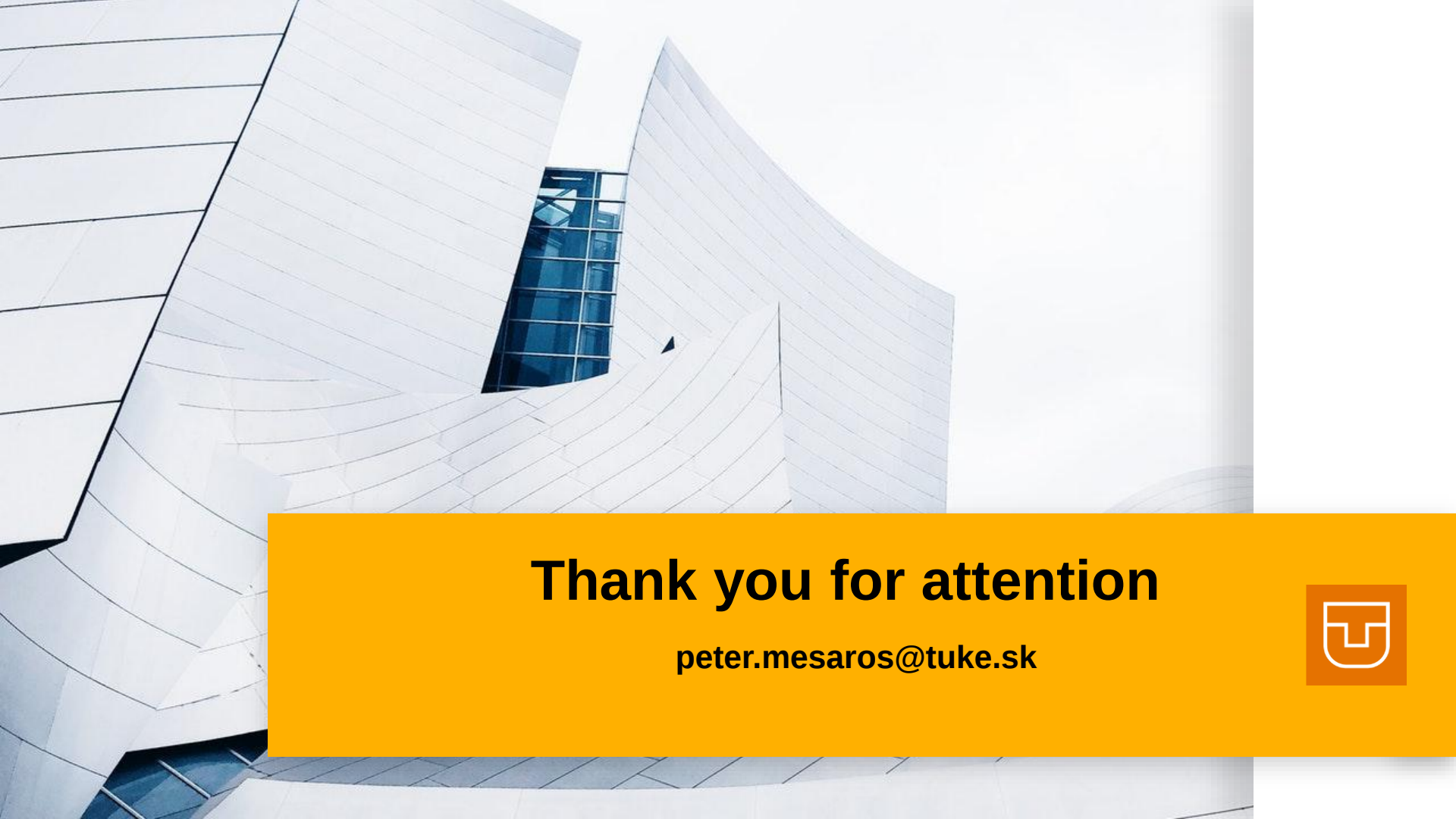
- **International project cooperation** – leading partner of Erasmus+ - 2019-1-SK01-KA203-060778 „Construction Safety with Education and Trainign using Immersive Reality (SK, PT, HR, GR)
- PhD. thesis reviewer (Czech Republic, Spain)
- Conference scientific comitee membership

Professional/industry activities

- Association of Slovak Construction Entrepreneurs (ZSPS) - Steering commitee member
- Working commission for public procurement and business environment
- **Working commission for innovations, digitization and climate changes adaptation**
- Expertise reports and application outputs – 25 (City of Košice, City of Prešov, KSK, Ministry od culture of SR, EUROVIA SK a.s., SKANSKA SK,a.s., COLAS Slovakia, BETPRES, s.r.o.)
- EUROSTAV TOP 100 Companies in cosntruction – multicriteria assesment,
- Cooperation in **construction software development and implementation**: CENKROS, since 2003



- **Continual topic shifting to Construction 4.0 challenges**
- **Data and information based construction management**
 - automated processes (SW apps, cloud solutions a co-working platforms, **AI- machine learning, neural networks, in cost estimation and sustainable designing**)
 - **modeling of economic efficiency of sustainable construction project,**
 - *Multi-dimension structures for BIM information flow in*
 - **Climate change adoption** – new condition for construction life cycle, waste optimization and carbon neutrality, social sustainability
- **Cross sectoral interdisciplinary cooperation**
 - Software and technology engineering (software engineering, artificial intelligence, virtualization techniques)
 - Mechanical engineering (automation procedures, smart construction devices, machinery, technology)
 - Environmental engineering (assessment procedures, forecast models)
 - Material engineering



Thank you for attention

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