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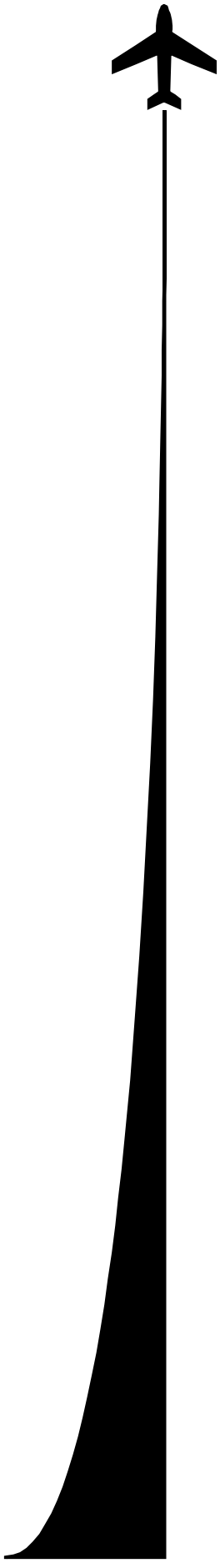

Plenary Session

AIRLINE STRATEGIC PLANNING IN TIMES OF UNCERTAINTY

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Keywords: Airline planning; strategic decisions; network design; fleet composition; optimization models; uncertainty

The airline industry is certainly amongst the most competitive and fast-changing in the world. Globally, air transport activity has been following a strong upward trend, but there have been periods when it has decreased, sometimes severely, as after the September 11 attacks and during the subprime crisis (2007-2010). At present, we are living one of these periods owing to the dramatic impact on aviation of the covid-19 pandemic. These types of disruptive events have somehow affected all airlines. In addition, individual airlines can be, and often are, subjected to substantial demand fluctuations in specific routes due to a variety of reasons. All these situations require responses from airlines that should desirably be grounded on a long-term outlook wherein changes in their network design and/or fleet size and composition need to be appraised. Identifying these responses is the main role of strategic planning.

The airline planning process comprises not only strategic decisions, but also tactical and operational ones. Optimization models have long been used to support tactical decisions (e.g., flight scheduling, fleet assignment, aircraft maintenance, crew pairing) and operational decisions (e.g., revenue management, crew rostering, flight planning, schedule recovery). Models of this type have also been developed for strategic airline planning, yet much more rarely. Indeed, comparatively, the literature on optimization-based airline network design and fleet planning is rather meager. The most common models apply to hub location problems. However, at least for the overwhelming majority of legacy careers, hub location is surely not an issue – the location of their hubs is defined since when they were founded and is highly unlikely to change in the next many years (if ever). In contrast, they regularly need to re-appraise the destinations where the airline should fly, and how often, as well as the aircraft they need to acquire (or lease) or sell or retire, particularly when new destinations are to be served or current destinations are to be discontinued.

In this presentation, recent and ongoing research on airline fleet planning and network design developed at the University of Coimbra (Portugal) is described. This research is being carried out in collaboration with colleagues from the University of Lancaster (UK), the University of Bergamo (Italy), and the Massachusetts Institute of Technology (USA). The presentation consists of two parts. In the first, the focus is placed on an optimization model for planning long-haul fleets under demand uncertainty and on its application to TAP Portugal's service to Brazil. The second part addresses a comprehensive network design/fleet planning optimization model and respective solution algorithm(s), whose performance is analyzed using Alitalia's European network as case study. An important feature of the latter model is that it handles supply-demand interactions in an integrated way instead of taking demand as fixed; i.e., it takes into account that a higher passenger demand leads to higher flight frequencies (and hub connectivity), and the converse is also true. This makes the model non-linear and non-convex (in addition to being mixed-integer), and therefore considerably complex, but its outcomes are much more accurate.

The uncertain times the world is currently living because of the covid-19 pandemic will undoubtedly require airline managers to implement frequent and substantial changes of their strategic plans. The models described in this presentation can certainly assist them at making such plans in a better-informed and more efficient manner.

THE INFLUENCE OF INFORMATION ON MOBILITY BEHAVIOR AND CHOICES

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Keywords: intelligent transport systems, route choice, social media, traveler behavior, behavior modeling, traffic simulation

As need for traveling becomes higher and more demanding, traffic volumes increase, which causes increase of congestion and the consequent impacts to the environment, nature and life quality. This phenomenon is more intense in urban areas, which concentrate most of the world's population. Sustainable transportation systems are acknowledged as the means to tackle this situation. How such systems may be developed and to what extend they can provide economical, environmental friendly and efficient mobility to the users is the main topic of recent research and application in governance and engineering. As transportation systems' users comprise the individual and grouped decision making centers which affect the systems' performance, their knowledge and understanding of the mobility choices they have, is of great importance. Information availability, content, timeliness and trustfulness influence travellers' decisions.

The paper concentrates on analysing information systems which provide knowledge and trigger travellers to select the time of their trip, their destination, the mode of travel, the route to take and their trip companions. It focuses on three information systems groups. One group concerns traveller information systems which disseminate traffic conditions, such as travel times and delays, incidents on the network, time tables and schedules' updates. They also provide advising on alternative modes and routes. Such systems belong to the Intelligent Transportation Systems and are operated by transportation providers. Another group helps travellers plan their trips by providing alternative and optimum route plans, based on specific information set by the users. These systems are designed and operated by transportation providers and other bodies. The third group relies on social media, as they provide the communication channel for information and opinion exchanges and are considered as a major potential influencer of activity planning. Their owners may be designated transport accounts or any user and user groups.

The analysis includes a compilation of literature findings on the degree of influence of information on travelers' behavior and choices and the correlation with additional parameters related to the individuals' characteristics, trips' specificities and transportation systems' attributes. Furthermore, it presents the implementation of discrete choice, fuzzy logic, artificial neural network and other modeling techniques which are used to explain the relationship between the above parameters and the decision variables. It also demonstrates the impact of information on the transportation system sustainability, based on results of impact assessment methodologies. Finally, it discusses the implications of the combination between information systems groups and models, setting at the same time the challenges for transforming information into a strong alias towards sustainability.

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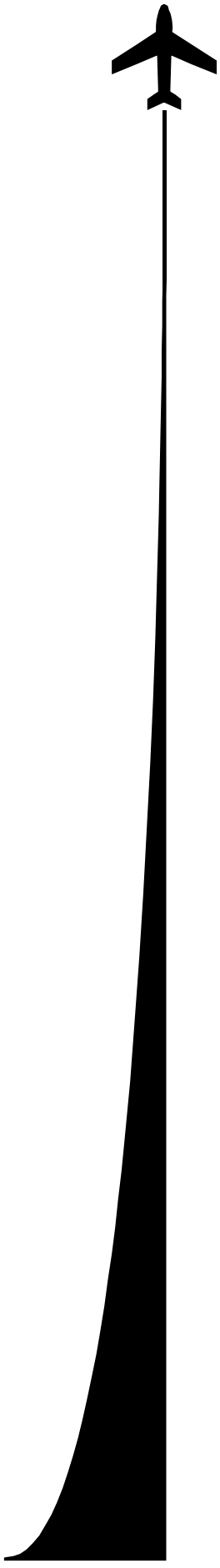

Data Science

SIMULATION EXPERIMENTS ON MARKOV-MODULATED LINEAR REGRESSION MODEL

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Keywords: Markov-modulated linear regression, simulation, Markov-additive process

Markov-modulated linear regression (MMLR) is a two-component model (Andronov and Spiridovska, 2012). The first component is Markovian. The second one is additive described by a linear regression. MMLR is a special case of Markov-additive processes that belong to a broad class of Markov-modulated processes (modulated by an external environment) (Pacheco *et al.*, 2009). Unlike other switching models, MMLR has several distinguishing features including a new analytical approach and known transition intensities between the states of Markov component. Since a trajectory of an environment is unknown, estimated conditional average sojourn times are used in the environmental state instead of actual sojourn times.

MMLR model proved its worth in practice. Namely, it has been tested on real-world transport data in the form of two cases studies (Spiridovska, 2018; Spiridovska and Yatskiv (Jackiva), 2018). These case studies demonstrated that it is crucial for practical applications to have more simulation-based empirical validations of model's estimator properties. That is why, this paper studies the influence of sample parameters and the effect of deviations from initial assumptions on the consistency of model estimates. Sample parameters under consideration include sample size and distribution of the initial data.

The paper presents a detailed description of artificial domains, empirical process and obtained numerical results. The conducted study uses simulated data, which provides one with ability to control complexity and expand the field of experiments. Based on the experimental results the paper concludes with the statement that both the sample size and choice of weight matrices have significant influence on the accuracy of estimates and the convergence speed. The model and experiments are implemented in Python 3.7 and the source-code is available in the Github repository.

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DEVELOPMENT OF A TECHNOLOGICAL SOLUTION FOR AUTOMATED REINTRODUCING OF MIXED LOT GOODS IN THE TRADING PROCESS

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Keywords: Artificial Intelligence, Logistics, Mixed Lot Goods, Text Processing, Image Recognition, Natural Language Processing, Neural Networks, Deep Learning, Big Data

Today, the amount of orders made via internet shops is increasing continuously. From books, over clothes, up to technology and media, each consumer group can be served. Major enterprises such as Amazon, Zalando SE, etc. are offering their customers the possibility to receive a perfect shopping experience. Whereas during a personal shopping experience, the customer can inspect their products directly in the store, this is not possible when ordering via online marketplaces. Products, which are not sufficient to the customers attitude, like and taste, are returned to the seller. Not all of the returned goods can be sold again, as some are damaged or the value for reselling is too low. These products are packed on pallets and sold blind as mixed lot goods. Reintroducing these goods is currently still done manually. This paper is focusing on the development of a technological solution to reintroduce these mixed lot goods into the economic traffic in an automated way. To fulfill this task, a technological model has been developed. This model is using text processing aspects as well as Artificial Intelligence based algorithms such as Deep Learning and Big Data aspects, combined with simple digital workflows to reintroduce and digitalize the goods part by part. Applying the planned algorithms, the concept model is using a scanner device (e. g. a smartphone camera). Pictures of the products of the mixed lot goods, will be analyzed with neural networks and compared with similar goods in the internet, by using automated robots.

USING MACHINE LEARNING FOR DOS ATTACKS DIAGNOSTICS

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Keywords: DoS, Machine Learning, IDS, KNN

Due to European Union Agency for Network and Information Security (ENISA) 2018 report on the fifth position of the list of security threats is Deny of Service (DoS) or Distributed DoS (DDoS) attack. In the list are 15 different types of attacks and in the last years the role of DoS is only increased. Researchers suggest that the number of DDoS activities is on the rise (16% for one year).

According to reports, most of the attacks focused on specifically peak interval of time to strike their targets with UDP, TCP (SYN) and ICMP floods being the top 3 so-called vectors of attack (the total number of different vectors in the report is 20). The duration of these malicious attempts were less than 90 minutes and the longest time interval of attack was more than 6 days. The last fact is important using ML (Machine Learning) (Al-garadi & Al-Ali, 2019) algorithms for attacks detection.

There are a number of data sets that are used for testing Intrusion Detection Systems (IDS) in what ML algorithms are used (Buczak & Guven, 2016). In our research, we are using the tests sets UNSW-NB15, KDD-Cup 99 and NSL-KDD, which include different numbers of records, different vectors types. We are analysing the correlation between features of vectors (47 in UNSW-NB15 and 102 in KDD-Cup 99) and we pay attention to those that are corresponding to the DoS attacks. We are using k-Nearest Neighbours (KNN) and Artificial Neural Networks (ANN) methods in classifying the events in IDS for learning and testing (Zhoul, 2015). One important problem that we try to overview in the research is the possibility to use some "standard" data sets for IDS Machine Learning in the process of DoS events attacks detection.

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SYSTEMATIC LITERATURE REVIEW OF QUESTION ANSWERING SYSTEMS

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Keywords: Question Answering, Question Analysis, Natural Language Processing, Information Retrieval, Systematic Literature Review

Increasing number of healthcare organizations are providing self-service for citizens with the help of online Question Answering (QA) systems on their websites. This kind of services are typically restricted domain systems and can be found specific to healthcare expertise and areas of maladies. Citizens post questions to be answered by professionals and experts. These Question Answering services can be roughly classified into two main categories based on how the questions have been processed and answered. The service may be run by professional experts, who first read the questions, which the visitors have asked online. They then write and publish the answers for the questioners thus helping other visitors looking for information to their similar questions. Another way to run such a QA service is to let visitors help each other. This user-generated or user-created content (UGC) is mainly run as a non-professional activity unless occasionally experts are taking part in the answering process as regular visitors. The quality of user-generated answers is based on confidence among the users, peer monitoring and rewarding mechanisms (Molino *et al.*, 2016). A systematic literature review according to Kitchenham *et al*. (Kitchenham, 2004) is performed to find current solutions and implementations especially for Finnish language processing and QA web services. While there are numerous studies on Question Answering techniques, only few of them deal in Finnish language. The literature review is organized to answer the main research question "How to formulate the search and information retrieval for data intensive Finnish language-based databases?" Study searched ACM, IEEE, Scopus, and Springer scientific databases and resulted in 460 articles. After screening and applying exclusion and inclusion criteria 14 articles are
selected for the further study.

Question Answering system has at least three sequentially executed main modules. The process starts with question analysis followed by information retrieval and finally, answer processing. This review gives some understanding of possible obstacles when designing a QA system for a specific foreign language other than English. Not all techniques developed for certain language can be utilized in Finnish because of the nature of the language. Finnish is an agglutinative language where words get new meaning with affixes emphasising particularly question analysis (Reddy and Madhavi, 2017). Reviewed systems developed for domestic languages often rely on existing NLP techniques despite of their generality (Wilkens and Villavicencio, 2010).

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SPATIOTEMPORAL FORECASTING OF URBAN TRAFFIC FLOW VOLATILITY

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Keywords: spatiotemporal models, predictive models, urban traffic control, multivariate time series

Short-term urban traffic forecasting is an integral part of intelligent traffic engineering systems. A wide variety of models and algorithms are developed for accurate and reliable traffic forecasts, including classical times series models like autoregressive integrated moving average models and generalized autoregressive conditional heteroskedasticity (GARCH), multivariate time series model like vector autoregressions, artificial neural networks, Bayesian networks, among many others. Recently the research attention is shifted to spatiotemporal model specifications, which utilise information about relationships between traffic flows at neighbour and distant road segments. In this paper we adopt a recently developed spatial specification of the GARCH model for short-term forecasting of urban traffic flows.

Many time series models assume about the stationarity of traffic flows – constant first-order (mean) and second-order (variance) traffic flow structures. This assumption is hardly satisfied for real traffic data, so researchers frequently ignore dynamics of traffic flow volatility or transform a time series to a stationary state. The univariate GARCH model allows explicitly modelling conditional volatility changes and was widely used for financial time series and in the traffic forecasting domain (Chen *et al.*, 2011; Zhang *et al.*, 2014). A spatial specification of the GARCH model (Otto *et al.*, 2018) utilise potential relationships between volatility values of traffic flows.

The primary goal of this study is an empirical application of the spatial GARCH model for real-world traffic data and testing different aspects of model specifications, in particular: different approaches to learning spatial contiguity matrixes; different components of the model (autoregressive and autoregressive moving average specifications of volatility); different functional forms. Obtained empirical results indicate a slight preference of the spatial model specification, and provide clues for spatial organisation of traffic flows.

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FAST CONNECTED COMPONENTS OBJECT SEGMENTATION ON FUSED LIDAR AND STEREO-CAMERA POINT CLOUDS WITH VISUAL-INERTIALGIMBAL FOR MOBILE APPLICATIONS UTILIZING GPU ACCELERATION

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Keywords: object segmentation, visual-inertial gimbal, sensor fusion, GPU-accelerated, mobile applications

Computer vision systems in mobile applications require low-latency responses and a high framerate due to the highly dynamic environment. Autonomous driving computer vision systems are often based on regular cameras, stereo cameras or on Lidar technology. Recently developed AI methods are often used for object detection in image data. These learning-based methods require a large amount of training data, the quality of its outputs highly depend on the quality of this training data and they rarely achieve high frame rates (Murray, 2017). Lidar has a high reputation for safety applications (Asvadi, 2018). Yet it suffers from a high price and a low number of points to reason from. Image-based computer vision can derive information from a much greater amount of data. Stereo-Cameras derive depth information from two images by the optical principle of parallax. This can be used to enrich the already safe lidar, to make a more reliable sensor system.

Sensors in mobile applications are subject to orientation changes, movement and vibrations. These negatively influence the data sampling process and therefore need to be compensated for. Lidar and stereo cameras have other sensor effects like flying pixels, which need to be filtered.

We propose a high-performance object segmentation system on Lidar point clouds fused with stereo camera point clouds. For motion and vibration compensation, we propose the use of a visual-inertial-sensor based virtual gimbal. Modern graphics processing units (GPU) are used for sensor filtering, point cloud fusion, voxelization and connected component segmentation to achieve the high framerate and low-latency necessary for use in a dynamic environment.

The high-performance object segmentation system is used for the collision avoidance system of an autonomous cargo bike developed in the research project RavE-Bike.

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NEUROEVOLUTIONARY APPROACH TO METAMODEL-BASED OPTIMIZATION IN PRODUCTION AND LOGISTICS

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Keywords: Metamodeling, optimization, simulation, production, logistics, inventory control

As it is pointed out by such prominent researchers as Duan and Liao (2013) and Tsai and Zheng (2013), practical problems in logistics and production are usually analytically intractable, due to their complexity, dimensionality and stochasticity. In this regard, approaches based on simulation are becoming common for solving complicated real-world problems. However, simulations, especially detailed, require sheer amount of computational resources. In the light of these facts, it frequently appears to be reasonable to use an alternative model, which is specifically built in order to approximate an original one with a sufficient degree of accuracy. Such an approach is widely known as metamodeling (Blanning, 1975).

Considering recent success of neuroevolutionary approaches in neural architecture search (Real *et al*., 2019) and hyperparameter optimization (Elsken *et al*., 2019), its application to metamodeling in logistics and production becomes promising. In this regard, this paper examines, whether it is feasible and efficient to combine artificial neural network with genetic algorithm for automated metamodeling of logistic and production systems. The paper describes, how genetic algorithm can orchestrate evolutionary morphism of neural architecture and hyperparameters with regard to search space, search strategy and performance estimation metrics. Additionally, the possibility of using the proposed approach to derive optimal control parameters is demonstrated.

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AN ARTIFICIAL INTELLIGENCE BASED SOURCING AUTOMATION CONCEPT FOR SMALLER AND MID-SIZED ENTERPRISES IN THE METAL INDUSTRY

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Keywords: Natural Language Processing, Natural Language Generation, Text Processing, Automation, Sourcing, Procurement, Artificial Intelligence

Smaller and mid-sized enterprises in the metal industry often face problems during their sourcing and procurement processes. These problems are caused by the policies of wholesalers, which optimize their business processes by passing on better, i.e. cheaper prices for bulk procurement or even just selling products only in large quantities. These policies mainly confer benefits to big companies and leading to the elimination of small customers who want to order only small amounts of a product. That is the reason why smaller and midsized metal enterprises must invest a lot of time to find the right suppliers and to order the right products. To save time and money, there are already a few known approaches like marketplaces and shops. However, these solutions do neither solve the problem of finding the right wholesaler nor do they automate the whole process from order to delivery. This paper focuses on an approach to simplify the sourcing and procurement processes by automating parts of it. To achieve this goal, an automated bot technology is suggested which allows for an easy search for dealers and potential suppliers. The implemented bots will be linked to a web crawler with a matching algorithm to detect relevant offers in the world wide web. All information gathered by the crawler will then be processed automatically to start a request for quotation (RFQ) process. The artificial intelligence starts the RFQ process by (1) analyzing existing offers found in the world wide web with Natural Language Processing (NLP) and (2) generating automated written requests to dealers. The algorithm will additionally help by finding other prospective buyers, i.e. other small or mid-sized companies which are interested in the same product. This enables a group of customers to perform bulk procurement together. This paper discusses the current possibilities as well as the practical implications of the suggested approach.

OVERVIEW OF SPATIAL DECISION SUPPORT SYSTEM AND MULTIPLE CRITERIA ANALYSIS IN DISTRICT HEATING NETWORK MAINTENANCE

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Keywords: Multiple criteria analysis, spatial decision supporting systems, District heating networks, Leakage localization methods

Community heating systems are services composed of district heat stations, pressure and volume control, water treatment, district heating (DH), distribution networks, and heat transfers to clients. Such a system must be in balance between central heating power and consumers; therefore, it is the responsibility of an additional heating center to manage the system effectively. Maintenance of heating network to avoid heat loss and heated water damage to the environment is an ongoing challenge in Nordic countries and Russia during severe winter weather conditions. Heating network pipelines contributes to the loss of significant volumes of hot water. Defective nodes are identified and solved in different ways of state monitoring. More effective leak detection techniques are needed in order to minimize risks on the rapidly growing heat supply networks. The most challenging is the identification of heat losses in the subterranean thermal pipelines. By Chan et al. (2018), 11 leak detection methods are identified to detect leakages in hidden pipes, and all of them have pros and cons. DH systems always have heat losses, unlike ordinary water supply systems. Search for an innovative solution in combination of geographic information systems (GIS) technology with heatmaps is the focus of this research. In Ferretti *et al*. (2016), spatial decision support system (SDSS) is identified as an important component of the decision support applications in the future. A robust decision support is essential to the successful combination of GIS and non-GIS methods. The development of SDSS using GIS has been encouraged by recent technology developments.

This article provides an overview of current technologies, maintenance challenges and proposed an intelligent system for DH systems maintenance. The main goal of this research is to enhance and automate the work of the Director of the Operations and Management Center (OC) to help reduce accidents by combining GIS and prioritization maps introduce by Nefros *et al*. (2018) for the "decision making" process. A case study is being carried out in the municipality of St. Petersburg, Russia.

The research methodology is based on using GIS and data modelling in combination with pixel analysis. To spatially identify problem areas, a raster of temperature values is created using values of the temperature of the soil surface above the network. The DH schema in GIS filters excess noise that is not related to the DH network. The shape of the outliners on the heatmap and the mathematical model parameters define the type of leakage. A list of maintenance work is given by the type of leakage and total heat loss.

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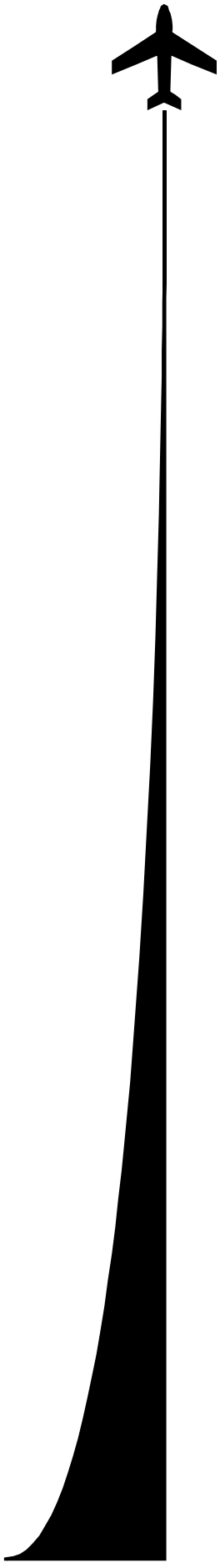

Aviation

VALUE CREATION IN AIR TRANSPORTATION: BEYOND PRICE, QUALITY AND SPEED

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Keywords: Aviation, startup, value proposition

Primary purpose of companies is to create value; in aviation traditional dominant values are price, quality, and speed (IATA Passenger Survey, 2019).

New values are increasingly being adopted by companies to increase their profitability and resilience. According to the Harvard Business Review study, success of companies is driven by ability to deliver on multiple Elements of Value (in smartphones, for example, Apple delivers 12 elements, Samsung 10 and LG 3); companies delivering strong performances on more elements than competitors will attract more customers and can price higher than rivals do. Red Bull (the company sponsors extreme sports connecting sports enthusiasts worldwide), Nordstrom (the company acquired Trunk Club giving sense of affiliation and belonging) (Almquist, 2016). Amazon is notable for delivering on eight Elements of Value: quality, hassles-free, reduces effort, saves time, reduces cost, variety, access, informs. Adding new values allows companies to differentiate and strengthen their market position.

The adoption of novel values is often driven by:

- *Internal initiatives*; e.g. budget airlines delivering personalization values by allowing passenger selecting only the needed services; user experience values via flexible online booking and changes, bundling value provided by other supplementary services such as parking or bus tickets.
- *External factors*; e.g. security (09/11/2001 terrorist attacks in USA), eco-friendliness (climate change), health (COVID-19), new technology (mobile).

In this research, authors investigate mechanisms for new values adoption driven by both internal and external influences. They aim at quantifying value adoption by conducting over

100 surveys; the results have been analyzed for linguistic features and patterns identification: semantic categorization, morphemic analysis, word's structural analysis, and part of speech (POS) tagging.

For internal value study, authors showed the possibility to improve value adoption via training via the following steps: (1) baseline values, (2) wide variety of values identification, (3) values adoption. Baseline was established via a pre-survey where participants were asked to list as many values as possible (in the context of air transportation). For value identification, authors designed an exercise where participants were tasked with identifying wide variety of values (100+) by looking at 1,000+ startups' landing pages (startups are frequently the first to identify novel values). Finally, to evaluate how well participants were able to adopt the values that they were exposed to (the previous step) as well as improve their creative thinking (values that they haven't been exposed to), authors conducted a post-survey. To identify and adopt values early on is important for business performance. The challenge is to increase their awareness and adoption among aviation management.

External value adoption study occurred by happenstance. Shortly before COVID-19, authors conducted a pre-survey for the internal values factors study; post-survey was conducted amid the COVID-19 pandemic. Comparing results from pre/post survey gave us a unique opportunity to see how the external factor (COVID-19) influenced the value adoption.

Surprisingly, the results show that recent dramatic change in circumstances (COVID-19) has little affected the participants' general idea on value proposition in air transportation; in particular health value was not explicitly mentioned and seems to have been simply accepted as a "new reality". The hypothesis is that it is due to overly positive view (such as happened after WWII - baby boomers; art, style, and culture dramatic liberalization). However, the sampling is biased to participants that closely related to transportation area as well as age (millennials); this might not generalize to wider population and e.g. the overly negative reaction might be possible as was the case after WWI (Lost Generation, Dadaism).

Ability to operationalize rapid identification and adoption of new values allows corporations not only to improve profitability; but even to become resilient to unexpected external factors that suddenly impose new values.

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DATA QUALITY INDICATORS OF ETL IN THE PROCESS OF IMPLEMENTATION OF INFORMATION SYSTEMS FOR AIRCRAFT MAINTENANCE AND OPERATION

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Keywords: extraction transformation loading, migration metrics, data quality characteristics, aircraft maintenance and operations

Nowadays, any modern business is based on data. To process this data, in order to support the business processes of enterprises, tens of thousands of information systems have been developed and are being developed. Each information system goes through a certain life cycle, some systems are modernized to meet current requirements, while others leave the market, giving way to new ideas and solutions. In the process of implementing new information systems, there is inevitably a need for the creation and effective management of the process of data migration from an outdated system to a new one, better known as ETL (extraction, transformation, loading).

When building any complex ETL process, difficulties inevitably arise associated with all stages of this process. (Vassiliadis, 2011; Kabiri and Chiadmi, 2013). In addition to technical issues on the organization of this process, one of the key analytical tasks is to assess the quality of all stages of the process. Despite the fact that the process of measuring quality is insufficiently studied and systematized (Sánchez-González et al., 2012), in the scientific literature there are a number of works that describe models for highlighting the characteristics of quality of ETL processes and methods for their assessment (Theodorou et al., 2016). In this article, based on the existing literature, we take the first step towards systematizing knowledge in this area of scientific activity.

The main goal of this study is to define the indicators of data quality in ETL processes in the area of aircraft maintenance information systems. As part of the study of this task, at each stage of the process under consideration, the characteristics of its qualitative assessment were formulated, those of them that directly affect each of the stages were identified, and the rationale for excluding those characteristics that can be left outside the scope of the current research. The classification obtained is based on the data presented in the scientific literature in various fields of science and industry and also on personal experience by the author of the article.

As a result of research, the main characteristic of the ETL process assessment in the area of aviation maintenance determined the characteristic of data quality. The paper presents a classification and methods for calculating various measurements (indicators) of this characteristic.

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REMAINING USEFUL LIFE FOR TIRES ON AIRCRAFT'S MAIN WHEELS: PREDICTION BASED ON QUICK ACCESS RECORDER DATA

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Keywords: inventory and maintenance; proactive maintenance; healf monitoring system

The development of new approach for the application of existing maintenance programmes in aviation is one of the key factors in improving economic efficiency of Maintenance Repair and Overhaul (MRO) organisation. The main direction for improvement is the use of modern technical monitoring systems for various parameters of the aircraft and its main components. The use of health monitoring systems provides a large number of parameters, but at the same time requires the development of new models for their application.

Current tire replacement rules for aircrafts take into account both limits for maximum flights quantity and minimum tread depth, with aircraft owner checking wears and cuts absence daily. Actually, when active operation season comes, the current situation leads to high loads on the wheel maintenance shop, and downtime risks due to the lack of replacement. Ongoing research project focuses on providing predictable workload without peaks for wheel shop, with downtime risks for airplanes to be minimized. Accurate removal date forecasting for each wheel could help in work optimization for wheel shop.

Modern passenger aircraft records a wide range of sensors information by default, this data being extensively used for diagnosis and monitoring of plane's different systems. To date there is no standard technique with reasonably accurate tire lifetime prediction based on aircrafts' sensors' data, despite various tire-wear control studies. This paper addresses models for daily forecast of remaining useful life for main wheel tires in flight cycles. Data for modelling includes values from aircraft's standard sensors, transaction of wheels installation/removal and flights schedule. The results of the study are to be used in everyday routine in wheel shop, therefore computational resources for forecasting are limited. With the above taking into account, the linear regression has been chosen for modelling. As a result, we obtained a quick method for evaluating the remaining wheel cycles, which does not require significant computational resources and can optimize the operation of the wheel shop. Comparative analysis between current approach and the suggested models is presented.

OBJECTIVE FUNCTION OF PREDICTIVE MODELS IN MAINTENANCE, REPAIR, AND OVERHAUL ORGANIZATIONS

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Keywords: aircraft predictive maintenance, target function, F1-score, financial savings

Predictive maintenance is data-driven fault diagnosis and prognosis technique designed to reduce unscheduled maintenance and to increase aircraft in-service operations time. The traditional approach of aircraft predictive maintenance assessment in aviation industry is based on technical scores, usually F1 (or also F-score or F-measure) which measures a forecast's accuracy (Panagiotis, 2017). It is calculated as a combination of the recall and precision, where the recall is the number of correctly forecasted positive results divided by the number of all samples that should have been identified as positive and the precision is the number of correctly forecasted positive results divided by the number of all positive results, including those not identified correctly. Nevertheless, the model with the highest technical score does not necessarily lead to the highest financial savings of predictive maintenance and even can result the additional costs for the business. At the time the highest financial saving in aircraft predictive maintenance could be achieved through the predictive model with a relatively small technical score.

The description of the saving function of the predictive maintenance is common for airlines. At the same time the saving function for maintenance, repair and overhaul organizations which performs maintenance for airline is different from the airline's saving function. Thus, highest airline's savings does not always lead to maximum maintenance, repair and overhaul organization's savings, and vice versa. The factors defining maintenance, repair and overhaul organization's saving function includes the cost of development, maintenance and usage of predictive tool; type of maintenance, it's TAT (turnaround time) and frequency of work; the costs associated with the planning and preparation of maintenance event; the lead-time of material delivery; the terms of work with suppliers and customers (airlines); the opportunity cost of unplanned downtime of maintenance, repair and overhaul organizations, etc. Usually verification of all such factors for each specific defect is quite a complex task, mainly because it requires a detailed accounting of the actual losses associated with unplanned maintenance.

This article researches the efficiency of using the financial savings in comparison with technical scores, describes the boundaries of the application of each approach and provides a systematic description of the methodology for calculating the financial savings for maintenance, repair and overhaul organizations.

The correct verification of the financial savings, rather than the complexity of the mathematical models used for predictive forecasting mostly determines the success of predictive maintenance project. A properly verified financial savings before start of predictive maintenance project will help maintenance, repair and overhaul organization to understand the potential benefits and losses of the project and it will allow to segment several thousand defects into several groups with a high, medium, low and negative value of return. In addition, it will support to choose projects that can be interesting to both the airline and the maintenance, repair and overhaul organization and will ensure the pooling of resources, reduce the project's risks and costs for each of the organizations, and ensure synergy of benefits in case of successful forecast.

The approach proposed in article will support maintenance, repair and overhaul organizations increase efficiency in predictive maintenance activity, will increase repayment of predictive maintenance and will provide a clear picture how to allocate and prioritize resources in such projects.

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PREDICTIVE MAINTENANCE MODEL OF REFINED AIRCRAFT TIRES REPLACEMENT

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Keywords: Aircraft Predictive Maintenance, MRO Stock Optimisation, Capacity Management, Regression analysis

The development of new predictive maintenance models in aviation relies on traditional maintenance programs that cost-effectively ensure flight safety. The specificity of numerous systems, assemblies and structural elements of modern aircraft requires the need to take into account their individual trajectory of behaviour during aircraft operational life cycle and to develop individually oriented predictive maintenance programmes for each group of units.

This paper describes a current practical approach and proposes model of predictive maintenance in tandem with an airline warehouse stock optimization system and Maintenance Repair and Overhaul (MRO) organisation capacity management with special focus on tires.

Analysis of parameters that can potentially affect aircraft nose wheel tires wear and selection of the most relevant factors to build a model for tire replacement forecasting using flight data recorders are described in paper.

The resulting model is used for creating an automated production load management system for MRO organisation facilities taking into account their maximum capacity.

The model determines the optimal stock or buffer needed for wheel replacement and continuous aircraft fleet operation. The model gives possibility to calculate the minimum necessary number of spare wheels in the warehouse to ensure the continuous operation of a given number of aircraft and a given MRO capacity. Analysis of the method's economic efficiency is presented, losses associated with early wheel removal and unused wheel capacity is evaluated.

INBOUND AND OUTBOUND AIR TRAFFIC OF RIGA INTERNATIONAL AIRPORT ANALYSIS OVER A WAYPOINT LAPSA

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Keywords: airspace design, air traffic analysis, Riga Flight Information Region

In order to organize aircraft instrument approaches and departures to or from an airport, Standard Instrument Departures (SIDs) and Standard Arrival Routes (STARs) are used. Eurocontrol European Air Traffic Management EATM glossary of terms defines SID as a standard Air Traffic Service (ATS) route, which is identified in an instrument departure procedure and by which an aircraft should fly from take-off phase to the en-route flight phase. But STAR is defined as a standard ATS route, which is identified in an instrument approach procedure and by which an aircraft should fly from the en-route phase of flight to an initial approach fix (IAF).

The aim of this work is to determine, whether the particular SIDs and STARs at Riga International Airport (EVRA) shall be changed and organized in a way, so that they do not go via one waypoint LAPSA. Flight plan data were used in order to obtain statistical data and illustrate air traffic intensity and consequently- possible conflicts over a radio navigation waypoint LAPSA for traffic inbound and outbound EVRA for four months: from May 2019 until August 2019.

Riga Flight Information Region (FIR) is divided into several air traffic control (ATC) sectors: West area control center (ACC), East ACC, Approach and Tower. There are two runway directions available at EVRA: RWY18 and RWY36 which are changed depending on wind direction. If RWY18 is in operation at EVRA, for westbound traffic departures LAPSA 5E SID is used, but for arriving westbound traffic LAPSA 6A STAR is used. If RWY 36 is in operation at EVRA, for westbound traffic departures LAPSA 5G SID is used, but for westbound arriving traffic LAPSA 4C STAR is used. This means that the beginning and end of the relevant SIDs and STARs is in one waypoint- LAPSA. In Riga FIR this waypoint is located on the border between West and Approach control sectors, consequently, if one aircraft has departed from EVRA and the other is approaching the same airport via waypoint LAPSA, then there is additional risk for ATC to have two aircraft with changing vertical profile (one- climbing, the other one- descending) over one waypoint. As a result, ATC workload rises, because, area controller and approach controller need either change flight paths of these aircraft to get the separated laterally by minimum 5 nautical miles or use altitude restrictions in order to get them separated vertically by minimum 1000 feet. Such airspace layout requires also additional coordination between two ATC sectors, which means- additional time to solve possible conflicts.

The system which is currently available for aeronautical data storage at an air navigation service provider (ANSP) concerned is capable of providing aircraft flight plan data. The results have been summarized in a table showing number of aircraft pairs which have crossed the waypoint LAPSA within 5, 5-15, 15-20 and 20-30 minutes interval.

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SCENARIO MODELING IN A CENTRALIZED AIRPORT GROUND TRAFFIC CONTROL SYSTEM

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Keywords: Scenario modeling, airport modeling, ground traffic control, ground traffic scenario simulation

In 2011 the "Vision 2050" reports that traffic control in the airfield zone are expected to be performed by automated systems in the nearest future (International Air Transport Association, 2011). As the result, air and ground traffic controllers are expected to monitor the functioning of such systems and primarily play a role of operators. Centralized objects control on the airfield territory starts with obtaining accurate data on object's location in real time. The control system adjusts the speed and direction of all moving objects taking into account not only the values of physical parameters of objects (location, geometric dimensions, speed and movement direction), but also final destination, function and priority level. Simulation modeling is known as the most efficient method of studying transport processes at airports (Alomar *et al.*, 2017). In order to study the process of mobile object control, this paper develops a model that includes the following components:

- a model of objects movement on the selected paths and free movement on the grounds;
- a model for determining the location coordinates, speed, and direction of mobile objects;
- a model of an automatic dispatcher that controls the movement of objects.

The paper discusses the current development state of the simulation model. The model applies the discretization of aerodrome space by presenting it as grid-based space. Discrete time "delta T" is used for modeling continuous movement of objects. The developed method to modeling discretized both space and time, which can significantly simplify the solution of problems associated with the analyzis of the relative positions of objects in 2D space.

Ground Traffic Scenario Simulation (GTSS) has been developed by the authors. The program is not intended for statistical modeling of aircraft and ground vehicles mass flows, but for specific, precisely described scenarios. The GTSS program is universal and can be applied to research transport processes at any airport in order to test the feasibility of centralized control algorithms.

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MODERNIZATION OF LANDING SYSTEM FACILITIES AT RIGA INTERNATIONAL AIRPORT

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Keywords: GBAS Landing System, Riga International Airport, GBAS antenna siting, Local Object Consideration Area, Reference Receiver Antenna, VHF Data Broadcaster

GLS or GBAS (Ground Based Augmentation System) Landing System is the most modern and precise landing system currently available in civil aviation. The most widely used landing system is still Instrument Landing System (ILS), which was developed in 1940s. The rising number of air traffic faces a necessity to improve current airport infrastructure to enable airports to handle more air traffic.

Currently more than 100 airports in Europe, USA, Asia and Australia are equipped to enable pilots to commence GLS approach. If analyzed by certain characteristics, these airports show wide variety of runway dimensions, airport capacities and other factors. For instance, Frankfurt airport EDDF in Germany has four active runways, the dimensions of which are 4000x45 meters, and in accordance with "Traffic Figures" annual airport statistics report in year 2018 it handled around 69,5 million passengers. The other example might be Bremen airport EDDW also in Germany. It has two active runways, the dimensions of which are 700x23 meters and 2040x45 meters, and in year 2018 it handled 2,5 million passengers. For comparison at Riga International Airport there is one active runway, the dimensions of which are 3200x45 meters and in year 2018 it handled 7,06 million passengers.

GLS is a Global Navigation Satellite System-dependent landing system. As most modern aircraft, such as Boeing 747-800, Boeing 787 and Boeing 737NG, as well as Airbus A320, A330 and A340 family aircraft and also A380, are equipped with GBAS, it is obvious, that modern navigation moves towards wider use of satellite systems. Introduction of GLS would open new possibilities of constructing approach tracks in a way to reduce noise pollution and fuel consumption, offer varying final descend angle from 3 degrees to 3.2 degrees, give opportunity to make curved approaches to avoid densely populated areas and increase airport traffic during low visibility operations, mainly by getting rid of requirements to keep clear sensitive area of the ILS system, thus reducing aircraft separation.

The GBAS Ground Facility Equipment Local Object Consideration Area (LOCA) is an area near the GBAS Ground Facility Reference Receiver Antennas (RRA's). It marks the safety area and LOCA for the GBAS VDB antenna. All antennas mentioned before shall be free from stationary objects, such as trees, equipment shelters, to make sure that GBAS accuracy, integrity, and continuity is within acceptable limits. There are two separate LOCA's used. One is used for the RRA's and the other one for the VDB antenna(s).

When considering GLS siting at Riga Airport, it is necessary to analyze possible positions of LOCA and VDB antennas of the system. In case 4 antennas are used, the required area is 302021m^2, which is quite demanding. This area might be reduced, if considering minimum antennas array separation of 100m. Assuming, that there are 4 LOCA antennas, which require rectangular shape area, it gives in total 168100m^2. This is the closest possible siting, after adding additional area we may define the total area needed of approximately 180000 m^2. We may assume, that this area is a circuit with a radius of 240m. It is nearly impossible to find such large area at Riga International airport. For this reason, it is impossible to locate antennas ensuring minimum LOCA intermediate area clear. Cosequently, outer LOCA selective masking procedure is unavoidable.

After analyzing advantages of GLS system over existing landing systems, a conclusion has been made, that GLS implementation sooner or later will become real with high probability. The system is the most perspective one and will lead to a reduction of landing system maintenance costs, management of air traffic flow increase and safety enhancement.

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PRECISING THE ACCURACY OF AVIATION SPARE PARTS FORECAST

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Keywords: aircraft planning, maintenance fast movers, intermittent demand, demand uncertainty, aftermarket, bootstrap, slow moving parts, sporadic

Spare parts forecast of consumable and expendable materials in aviation in-dustry is very challenging and is not very precise and accurate. As statistics shows, airline com- panies that have less than 100 aircraft in their fleet or maintenance organization that do less than 100 heavy maintenance checks during the year have more than 80% of spares they have on stock that refer to slow moving stock. And as material with little transaction history is involved then all the companies worldwide have difficulties to predict demand with high level of accuracy.

One of the reasons the forecast is not precise is that all the companies are trying to fore-cast spares based on the history of transactions and future insights are hardly used. This result either in elevated expenses or in under delivery of spares parts that affects strongly the turnaround time of aircraft on maintenance.

The idea of this work is to make an experiment and reveal if there is a correlation between aircraft quantity planned for maintenance and consumable spare consumption required for re-pairs. As well one of the goals is to define the right approach to make existing model more precise and define the algorithm to make classical methods more precise.

Finding solution to this problem is very relevant because all the aircraft repair organiza-tions never have stable demand for periodical maintenance works.

THE DEMONSTRATOR OF HELICOPTER STRUCTURAL HEALTH MONITORING TECHNIQUE

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Keywords: structural health monitoring, helicopter, vibrations, modal passport

The presentation is devoted to the demonstrator of the experimental structural health monitoring (SHM) system based on operating helicopter Ka-26. The operating demonstrator is the final stage of the research study aimed for verification of practical applicability of modal analysis techniques for monitoring of helicopter structures in-flight.

SHM is necessary for helicopters throughout its life cycle to satisfy the requirements for flight safety and operational efficiency. The SHM is needed by manufacturers in order to solve problems of structural development during the design stage of a new helicopter or modifying an existing one. The operators, especially using helicopters under severe conditions, require monitoring to predict possible failures of the helicopter structures.

As a theoretical basis for the experimental SHM system of the helicopter, the modal analysis methods are applied. The close relationship between the modal and mechanical properties of the structure leaves room for detecting any changes in the latter by evaluating the former. Any modification of the helicopter structure leads to a change of its modal parameters (modal frequencies, shapes and damping). The operational modal analysis (OMA) approach allows estimation of the modal parameters to be made using only the vibration response of the operating structure and does not require use of controlled excitation. Such specialty makes helicopter structures modal properties estimation possible in-flight. This paper briefly describes the basics of OMA methods application on the operating helicopter.

Besides the structural modifications, the modal properties of an operating helicopter depend on many external and internal factors. For instance, the outside air temperature affecting the structural rigidity is the typical external factor, while varying mass of fuel is an internal one. There is also a modal variation between helicopters of the same type. Therefore, in order to provide structural monitoring, it is necessary to isolate the changes of modal properties that are caused by influencing factors. The novel approach is proposed called “modal passport” that offers the solution for such isolation, combining common features of helicopters of the same type, and taking the individual properties of the specific helicopter into account. The following presentation introduces in the structure and principles of the modal passport of the helicopter.

There is a brief description of the operating demonstrator and of the key solutions implemented in its measurement system. The measurement system, including the network of sensors and the data acquisition units, as well as data transfer is briefly described therein. The sensor network covers fixed structures of the helicopter, the main rotor with blades and the power units (engines and the main gearbox). The benefits of piezo-films in measuring the helicopter structural parts deformation for modal estimation in relative scale are noted as well. The rotating data acquisition and transfer unit is mounted on the shaft of the main rotor, while the data acquisition unit for fixed network is located in the cabin. The paper presents the consequence of data development procedures, including the measured data collection, the OMA proceedings and modal parameter identification. Additionally, the results of the completed research stages are described. These include modal simulation, experimental estimation of modal properties, modal passport formation, and structural failures simulation.

Application of modal passport approach on the operating SHM demonstrator allowed:

- Experimental validation of the technical solutions of vibration measurements of the helicopter structures, including rotating and stationary ones in operating mode;
- Modal properties estimation using OMA both of fixed and rotating helicopter structures,
- Verification of the modal passport abilities for characterization definition of structural properties of fixed and rotating helicopter structures,
- Detection of seeded structural faults simulating typical failures on fixed and rotating parts.

Further stages of research based on the SHM demonstrator are formulated as well.

DEFINING THE BEST MODEL TO FORECAST AVIATION SPARE PARTS WITH LITTLE TRANSACTION HISTORY

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Keywords: fast movers, intermittent demand, demand uncertainty, bootstrap

These days all the companies worldwide in aviation industry and not only are doing well with material consumption predictions on fast and middle moving spare parts. That is to say good results are mostly achieved with materials that have a history of transactions higher than 100 for 1 part number on a limited period of observation. But when it comes to a small number of observations then almost all the models that are wide spread within aviation industry and that are basically installed in their ERP systems are not able to provide with a good result and predict with huge deviation or error.

As the statistics of an aviation maintenance company LLC S7 Engineering shows almost half of line items the company has on stock are not referring to the middle movers and fast movers but to the slow-moving parts. In terms of money assessment slow moving parts equal to 40% of the inventory value.

From financial point of view this is considered to be frozen cash in stock. On the other hand, not having this, spares on stock will lead to an aircraft on the ground situation or poor turnaround time with aircraft heavy maintenance that will result in further money loss as well.

The possibility to reduce cash expenses in stock keeping the same service level or even improving it could be beneficial for an airline or for the maintenance organization and may cheapen the net cost of purchasing, warehousing, and spares processing.

The idea of this work was to reveal the models that are doing fine with slow moving parts. This paper advises what data should be used and what minimum data landscape is required. On the example of Bootstrap and Croston methods, that are considered to be the best for intermittent demand, the simulation on the real data of aviation maintenance company was run and the accuracy results was examined. The output of the simulation shows how efficient the chosen models are, what is the accuracy and what forecasting period is better for each model.

CASE STUDY FOR RIGA INTERNATIONAL AIRPORT MODERNIZATION: ILS LOCALIZER SIGNAL ACCURACY DEPENDING ON GROUND OBSTACLES LOCATED NEARBY

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Keywords: Instrument Landing System, Localizer signal accuracy, Difference in Depth of Modulation, Riga International Airport

An instrument landing system (ILS) is a navigation system, which guides an aircraft during approach and landing phases of flight. It uses a combination of radio signals to enable a safe landing even in challenging conditions, such as low visibility. Although the system increases overall runway capacity, it is a subject to certain errors. Localizer (LLZ) and glideslope (GS) signals reflect, for instance, from hard objects, surfaces, vehicles, even from other aircraft flying below 5,000 feet above ground level (AGL). Consequently, it might disturb the LLZ or GS signal for aircraft approaching the runway and might affect accuracy of aircraft position in respect to predetermined approach path.

To handle passenger growth, it is necessary to improve and expand an infrastructure of Riga Airport. There are several new projects scheduled, but this paper will consider three projects- Rail Baltica, new air traffic control (ATC) Tower and Riga Airport Terminal 6.

To analyze the influence of nearby obstacles mentioned before, a special simulation software ATOLL (Advanced Training on LocaLizer) was used. Initial simulation with the new ATC tower, Rail Baltica and Terminal 6 shows that influence on ILS LLZ signal accuracy is acceptable, because difference of depth of modulation (DDM) values do not fall beyond the CAT I, CAT II or CAT III requirements. Maximum DDM deviation is -2.6μA at 3880 meters from LLZ/LOC antenna ray, where maximum allowable DDM is -5.8μA. It shall be noted that currently at International Riga airport there is CAT II ILS.

During construction work some cranes are going to be used, which also might affect ILS LLZ signal accuracy. Simulations show that if the crane is located parallel to the Terminal 6 building, DDM does not exceed allowable limits for CAT I, CAT II and CAT III ILS. Maximum DDM is -2.7μA at 3880 meters from LLZ antenna ray, where maximum deviation allowed is 5.8μA.

If the crane is rotated by +45 degrees (anti-clockwise), then for CAT I and CAT II ILS it is acceptable, but for CAT III further activities shall be taken in order to eliminate DDM fluctuations or to re-rotate the crane. For CAT III maximum DDM is -12.2μA at 1780 meters from LLZ antenna ray, where maximum allowable DDM is -9.1μA.

At 25 degrees angle of the crane DDM is -16.9μA at distance 2100 meters, where maximum allowable DDM deviation is -8μA. 20 degrees turn of the crane gives DDM -14.3μA at distance of 2220 meters, where maximum allowable DDM for CAT III is -7.8μA. 15 degrees turn of the crane shows even less deviation. At 10 degrees turn of the crane ILS LLZ signal DDM deviation exceed the limit of 6.8μA by 0.1 giving value 6.7μA at 2550 meters.

At Riga International Airport INDRA 20 elements NM20 Dual antenna ray is used. Previous simulation results were obtained using exactly this antenna ray. But for wider analysis also weaker antenna ray had been used- Thales 12 elements Single antenna ray. It does not satisfy even CAT I LLZ signal accuracy, thus, it shall not be used at Riga International airport. For CAT I maximum allowable DDM is -5.9μA, but using this antenna ray maximum DDM was registered -20.1μA at 3880 meters from LLZ antenna ray.

New obstacles of Riga International Airport will not affect ILS LLZ signal accuracy, also taking into considerations that CAT II ILS is currently available. In order to eliminate possible ILS LLZ signal fluctuations because of the construction crane position in respect to runway centerline, it is advisable to do construction work at night time or at least not in peak hours of airport traffic.

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THE INFLUENCE OF COGNITIVE-STYLE CHARACTERISTICS ON THE SUCCESS OF TRAINING OF FUTURE AIR TRAFFIC CONTROL SPECIALISTS

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Keywords: cognitive styles, cognitive-style characteristics, field dependence – field independence, impulsivity-reflexivity, rigidity-flexibility of cognitive control, air traffic control specialists, simulator training

There is a need to focus on effective diagnostics of ATC's errors related to the assessment and resolution of potential conflict situations (PCs) with the aircraft. This task becomes especially important in the light of the concept of free flight, which is planned to be implemented by many countries in the next 10-15 years. The largest number of procedures performed by an air traffic controller are related to the information and analytical function, which is a reference and precedes the decision-making procedure by the air traffic controller. The most dangerous range of errors is expected when performing this function. This is due to the fact that the air traffic controller, as a rule, has a very limited reserve of time for detailed analysis of information. Thus, the errors of air traffic controllers in assessing the air and meteorological conditions require special control.

In our opinion, an important aspect in the professional training of future ATC specialists and professional selection is the cognitive and style characteristics: field dependence – field independence, impulsivity-reflexivity and rigidity-flexibility of cognitive control. These characteristics allow us to pay attention to the following aspects: the speed and accuracy of decision-making by specialists; the ability to make effectively alternative decisions under conditions of time constraints; the ability to analyze a large amount of information; flexibility of thinking. These indicators characterize the parameters of cognitive styles – field independence, reflexivity and flexibility of cognitive control.

Relevant to engineering psychology are issues related to determining the impact of cognitive style on professional training and professional activity of a specialist. Due to the fact that an important aspect in professional training of ATC future specialists in simulator training is among the topical and unexplored issues we can distinguish the influence of individual cognitive style characteristics on the solution of complex professional tasks simulator training that require quick and timely adoption of alternative solutions, flexibility, mental activity and ability to analyze large amounts of information, systematic analysis, high level of automation of cognitive functions.

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WEARABLE TECHOLOGY ADAPTATION TO AVIATION CABIN CREW'S FATIGUE ASSESSMENTS

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Keywords: Sleep Efficiency, Cabin Crew Fatigue, Wearable Devices, Aviation Fatigue Risk

Aviation industry is one of the safest transport systems available for global travel and transportation. With the increase in commercial air travel, airlines require extra cabin crews. Aviation industry's cabin crew members are faced with working overtime, working in shifts, long working hours as well as to cope with differences of time-zones during long distance flights (Dorneich *et al.*, 2011). The shift system causes fatigue for cabin crews. One of the most important factors in the reduction of mental and physical performance ability of the cabin crew is related to individuals sleep and wakefulness (Caldwell, 2005). Operational data is normally collected to estimate the safety risks associated with fitness and performance. The sleep and wakefulness assessment data collection methods and metrics vary among airlines (Gander *et al.,* 2014). It is difficult to collect data in shift work due to the low flexibility in terms of experimental control and measurement strategies. Daily sleep data collection uses subjective questionnaire surveys and the use of available assistive technology such as wearables (de Zambotti *et al.*, 2016) are not heard of.

This research investigates the reliability between subjective and objective measurements employed during sleep and fatigue data collection and measurements. It further examines whether those measurements can be improved by the use of wearable devices to measure sleep and a wakefulness to support a cabin crew member's fit to fly assessments.

The research methodology consist of the exploration of related works, evaluation of 3 commercial airlines and their fatigue risk assessment methods and tools to identify the gap in the objective sleep and wakefulness measurement approaches in practice, and the evaluation an assessment of wearable technology adaptation to sleep and wakefulness measurements of aviation fatigue risk assessment models.

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RELIABILITY MODEL OF INTEGRATED MODULAR AVIONICS

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Keywords: Reliability, integrated modular avionics, failure model

Digitalization is one of the distinguishing features of the transformation of modern complex control systems. Air traffic control systems fall into their category. These systems are classified as mission-critical systems, as their operational reliability directly affects flight safety. Modern avionics systems are built on a modular basis. Many traditional architectural solutions, traditionally built on the basis of hardware solutions, in modern avionics systems are implemented on the basis of software applications. The combination of technical and software components has led to the emergence of a new class of systems – integrated modular avionics (IMA).

Modern IMA platforms provide several types of joint interaction between infrastructure and software components, the main of which include sharing resources between multiple applications, scheduling resources at the hardware and software levels, exchanging data between applications and diagnosing the functionality of both hardware and software.

The combination of hardware-oriented and software-based solutions within the same functional tasks of the system requires new approaches to evaluate their reliability.

The article proposes an approach to the analysis of the dependability for IMA platforms in relation to the functionality of the on-board data link system. The article uses the Failure Mode and Effects Analysis method to identify failures of components, systems or processes that may lead to failure to fulfil their assigned function in the IMA.

Using the Fault Tree Analysis method, a failure tree is constructed in the paper for the indicated main interaction between infrastructure and software components which may contribute to failure of IMA on-board data link system. The constructed fault tree was used to create a model based on Petri nets for modelling the influence of various factors on the availability of the IMA hardware-software complex. The article describes the method of constructing a reliability model based on Petri nets. Using the obtained model, the main dependability indicators of the system under study are determined.

RELIABILITY MODEL OF AIR TRAFFIC CONTROL WITH IMA ONBOARD DATA LINK SYSTEM

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Keywords: Reliability, air traffic control, failure model

Reliability and continuity of interactions between ground and airborne systems during data exchange in process of the flight is the critical factor of aviation safety.

Modern avionics systems are built on the modular basis (Windsor *et al.*, 2011). Instead of traditional hardware architectural solutions the modern avionics systems are implemented on the basis of software applications. The combination of technical and software components has led to the emergence of a new class of systems - integrated modular avionics (IMA).

The state-of-the-art in the development of modern air traffic control (ATC) technologies with IMA is concentrated mainly on the architecture of the hardware and software components of the on-board-ground information exchange (Jacob *et al.*, 2016). At the same time, the reliability of these combined systems is not yet sufficiently investigated.

Despite the fact that the ground side of the air traffic control system has multiple hardware redundancies, this does not exclude disruptions to the ground side of the interaction channel, which is caused, for example, by malfunctions in application software. In the general case, the ATC hardware and software can have failures of the first and second types – "failure of functionality that was not detected by the monitoring system" and "absence of functional failure, but false identification of the failure by the monitoring system".

The ATC architecture reliability model based on Markov chain is developed in the (Wang *et al.*, 2012). The article proposes an approach to the analysis of the dependability for ATC with two types of functionality failures for system with combination of hardware-oriented and software-based solutions. In the paper the Failure Mode and Effects Analysis method is used to identify failures of components, systems or processes that may lead to failure to fulfil their assigned function in the ATC.

In the paper the Fault Tree Analysis method is used for building of failure tree for the indicated main interaction between infrastructure and software components which may contribute to failure of ATC part of data link system. In the paper the constructed fault tree is used for creation of model based on Petri nets for modelling the influence of various factors on the availability of the ATC hardware-software complex. The article describes the method of constructing a dependability model based on Petri nets. Using the obtained model, the main reliability indicators of the system under study are determined.

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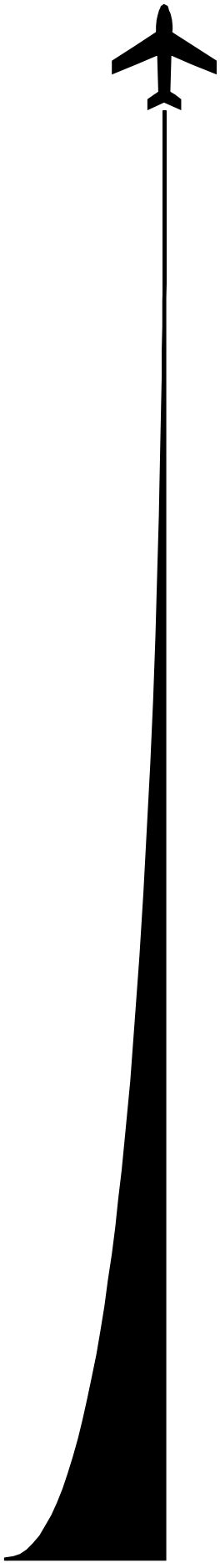

Smart Logistics

TRANSFER OF KNOWLEDGE AND ALGORITHMS FROM INTERDISCIPLINARY FIELDS OF RESEARCH TO THE MEASUREMENT OF CARGO WITHOUT PROCESS INTERRUPTION

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Keywords: knowledge transfer, cargo measurement, motion analysis, object detection, real time processing, sensor synchronization, exposure time

Interdisciplinary research subjects can be used to gain expertise that can be adapted to other applications with similar topics. As a research institute for applied science in the field of factory operation and automation, including material flow technology, we made use of these synergies. Material flow technology deals with the transport of a variety goods. Core tasks are the identification, analysis and tracking of flows, cargo and people. When implementing these objectives using 3D imaging technologies, a variety of challenges has to be addressed. Of particular relevance is the synchronous acquisition and processing of multidimensional sensor data with high frame rates and low exposure times. We have utilized the high demands of image-based motion analysis of athletes from cross-country skiing and rowing, as well as object recognition to enable an autonomous cargo bike and transferred the obtained findings to a logistic freight measurement application. Previous findings from the MultisensorLog project served as a basis for further development and improvement of the measuring system (Riestock *et al*, 2019). This eliminated the need for analyses of suitable sensors, allowing the focus to be placed on tuning the existing system. The high-performance algorithms from the motion analysis of athletes and object recognition in autonomous driving could be transferred easily due to the same sensor technology, although these two projects are based on mobile, autonomous sensor carriers (Groneberg Brauckmann and Richter, 2020). The findings include the tuning of sensors and the enhancement of software performance. This paper discusses the individual projects in more detail, focusing on commonalities in terms of tasks, requirements, technologies and associated problems. Subsequently, the algorithms used are introduced, which are used throughout the several projects to satisfy the demands specified.

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INTEGRATED ARCHITECTURAL APPROACH TO ENSURING STABILITY OF PROCESSES OF THE DIGITAL SUPPLY CHAIN

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Keywords: digital transformation, integrated architectural approach, life cycle management, process sustainability, digital supply chains, transport and logistics system

The methodology of digital transformation of transport and logistics systems (TLS) and supply chains is aimed at organizing and managing digital transformation processes at various stages of the life cycle and digital technologies, as applied to complex organizational and technical systems (COTSs). In addition, in the context of the transition to Industry 4.0 technologies, it is necessary to revise the supply chain management (SCM) processes, the success of which also depends on the transformation of all physical assets and their integration into the digital ecosystem together with partners involved in the creation chain cost (Kravchenko, 2019).

In this case, the classical supply chains will turn into digital "supply chains" of the matrix type, in which each link at every moment of time affects the entire network as a whole and changes it, i.e. the era of hybrid supply chain management is coming (Laaper and Yauch, 2018).

For the initial analysis of the problem, a crisis tendency is considered to decrease the efficiency or breakdown of traditional supply chains and transportation processes, which are mainly focused on digital technologies. Existing traditional approaches to supply chain management no longer satisfy the needs of science and practice. To solve such a problem, a system-wide approach is needed that ensures, on the one hand, effective interaction of processes throughout the life cycle, and on the other hand, the stable functioning of all facilities and the supply chain as a whole.

The use of reference models of architecture of systems such as GERAM (ISO 15704, 2019) allows more efficient management of digital supply chains (DSC) throughout the life cycle due to standardization and a unified architecture of modules, functions and processes, ensuring high complexity and stability (Bubnova and Nekrasov, 2017), (ISO 28002, 2011).

The authors introduce the term "organizational and technical sustainability" (OTS), which implies the possibility of adapting the central processing center based on the interaction of autonomous links – competence centers (CC) using the principle of self-organization. Critical control points (CCPs) for life cycle processes are introduced into the management process. Competent centers provide autonomy and form the basic architecture of the DSC. In addition to the term "homeostasis", the study uses the approach of ensuring stability based on the "homeokinetic plateau" (Grishakov and Loginov, 2014), (Sokolov and Mirotin, 2011), (Gig, 1981), (Sundeev, 2004), (Radionova and Abdullina, 2017).

The plateau is considered as a region of a relatively unstable state of the system, in which the system tends to self-organize and is controlled on the basis of CCP the stability area of the DSC. The characteristics of acceptable risk for such points are considered as CCP. They are determined on the basis of a combination of reliability (probability) and profitability (value) of the functioning of processes.

A comprehensive-architectural approach to the management of the DSC provides a flexible combination of the mechanism of hierarchical and network interaction throughout the entire life cycle. A compromise between business goals and digitalization of processes is ensured with the introduction into the scientific and practical circulation of elements such as the homeokinetic plateau, CCP, which characterize the stable mode of functioning of the CC based on the principles of self-organization. The development of recommendations in this direction makes it possible to successfully transform the DSC in the face of a cardinal change in the economic and business environment.

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PROPOSAL FOR DRUG MONITORING IN THE SUPPLY CHAIN

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Keywords: Drugs, supply chain, monitoring, verification, trasnport, barcode, RFID

The article deals with the design of the possibility of monitoring drugs in the supply chain. Thus, the possibility of monitoring the movement of drugs from production to final consumption by patients. The introductory part of the article is devoted to legislation that regulates the monitoring of drugs within the European Union. The whole issue is based on the FMD 2011/61 directive, ie the Falsified Medicine directive, issued by the European Council and the European Parliament. The aim of this regulation is to increase patient safety. The whole system is to be secured through the European System for the Validation of Medicines and the other national systems for the verification of medicines of the Member States of the European Union. Thus, in general, the establishment of such a system that prevents the entry of falsified drugs into the logistics-supply chain. The main part of the article deals with the identification of individual stakeholders as well as the identification of different scenarios in the transport of drugs between the various points of the transport process. Furthermore, the article also deals with the description of individual GS1 identification keys required for the above system. In addition to the description of the keys, the article also contains specific examples of the use of GS1 identification keys in terms of their structure. The article also describes the design and method of drug monitoring at individual points of the transport process. A distinction is made between the processes used for verification and the processes used for the exchange of logistical information between the parties involved. The conclusion of the thesis is devoted to the design and description of the specifications of probable data structures according to the information requirements for individual subjects of the transport process. The specification of data structures is supplemented by possible exchanges of information between stakeholders.

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COMPARISON OF SPREADSHEETS AND COMPUTING LANGUAGES IN SIMULATION OF STOCHASTIC INVENTORY MODELS

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Keywords: newsvendor model, Decision Support Systems, simulation, inventory control

Two widely used tools for simulation in supply chain management are spreadsheets and computing languages (Albright and Winston, 2003; Lawrence and Pasternack, 2002). Few studies provided a direct comparison of each tool's performance in supply chain modeling. Excel, on one side, and Matlab, on the other side, are compared in terms of performance in conducting a simulation of the Newsvendor model, the foundation of stochastic models in supply chain management (Hill, 2011). The Excel model of the Newsvendor was the fastest in separate simulations with a limited range of parameters in sequence. Furthermore, the spreadsheet model demonstrated the superior displays of outputs and ease of use compared to computing languages. However, the Matlab model outperformed the Excel model in a series of simulations for purposes of sensitivity analysis with a wide range of input parameters. Open- source versions of the software were tested that were capable of producing the same outputs but at a significantly lower speed. The results show a comparative advantage of each method for academic and business users. Implications for managerial decision making and educational applications are discussed.

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AUTOMATIC CONDITION MONITORING SYSTEM FOR PARCEL SORTING CONVEYOR SYSTEMS THROUGH INFRASTRUCTURE-FREE SENSOR TECHNOLOGY IN A COMPACT MOBILE DATA LOGGING UNIT SUITABLE FOR A VARIETY OF PACKAGES

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Keywords: mobile observer, infrastructure-free analysis, anomaly localization, parcel sorting systems, predictive maintenance

The reliability of parcel sorting systems is essential in intralogistics in order to sort hundreds of thousands of parcels according to their intended purpose during peak periods. Constant monitoring of the system allows an inspection of its condition at any time and can provide forecasts of maintenance requirements. Targeted maintenance work can be carried out and total breakdowns avoided. This not only saves costs with regard to the maintenance personnel to be deployed, as their deployment can be better planned, but also the immense costs due to a total breakdown, damage to important components or even the freight to be transported. Currently, such inspections are carried out by trained personnel manually looking for faults. A continous monitoring is very time-consuming and the subjective observations make anomaly detection error-prone. Even slight deviations from normal conditions can automatically be recognized using modern sensor and information processing technology. To avoid the need of an expensive statically installed sensor infrastructure we explored the use of mobile sensor platforms in other areas like mobile wind power plant inspection with sensor-equipped drones (research projects InspektoKopter and RotoKopter) or movement analysis in sports (Groneberg, 2020).

We propose an objective measuring system with multiple sensors which allows to automatically record, compare and inform about normal/anomalous conditions from the perspective of a mobile observer moving in a parcel sorting system. Recent progresses in the availability and mobility of depth cameras enable the mobile observer to spatially recognize its environment. (Riestock, 2019) Conveyor technology assemblies can be characterized by sensor fingerprints consisting of typical sensor readings and can thus be recognized in the collected data of a measurement run. With the help of a-priori knowledge it is possible to derive the real path in space of the proposed mobile observer monitoring system. Anomalous sensor readings, like unexpected vibrations, can thus be assigned to the specific conveyor belts of the parcel sorting system. The mobile observer moves the same routes as the parcels would do and provides a unique and complete insight into the sorting system without requiring instrusive and complex sensor infrastructure installed throughout the whole system.

To validate this approach, a prototype was designed, which is based on a 10-DOF motion capturing sensor, including air pressure sensor, additionally equipped with microphone and regular color and modern depth cameras facing different directions. First tests have shown that these data give an objective insight into the quality of the system, which ensures reliability and saves costs. The aim of this research is to develop a system that guarantees continuous automatic monitoring while remaining user-friendly and versatile. The understanding of the operator can be increased considerably and targeted maintainance work can be planned accordingly. We describe the underlying concept as well as insights into the opportunities opened up by the data evaluation.

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SELECTION OF AN INVENTORY MANAGEMENT STRATEGY IN A LOW-DEMAND ENVIRONMENT

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Keywords: supply chains, inventory management, low demand, reliability of forecasting estimates

It is known, that one of the most important tasks of logistics is minimization of costs in supply chains, in particular, those related to inventory management, seeing as inefficient inventory management is characterized with two negative outcomes: emergence of shortage or surplus.

Analysis of the problem showed (Akcay *et al*., 2011; Axsäter, 2013; Balugani *et al*., 2019; Buchan and Koenigsberg, 1963; Chopra and Meindl, 2013; Dolgui and Pashkevich, 2008; Hadley and Whitin, 1963; Jackson *et al*., 2018; Seaman, 2018; Taha, 2011; Ventsel and Ovcharov, 1983), that, despite the significant results achieved, a number of issues is still open, in particular, development of inventory management strategies under low demand.

In order to solve the aforementioned tasks, it is necessary to develop a new model that will allow to increase the accuracy and reliability of forecasting estimates of stock consumption parameters for short time series of low demand.

As a working hypothesis, in order to develop the model, it is appropriate to use alternatives selection methods under uncertainty and risk. The basic terms of the method – state of nature S_j and alternatives selection for decision making A_i – are determined based on two time series characteristics: statistical in the form of discrete distribution function $F(x)$ (Poisson, binomial, hypergeometric) and analytical, including combined forecasting estimate for stock consumption $y = f(x)$ based on trend models.

Calculations for different time series for trade, service and shipping companies were conducted in order to test the suggested approach.

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SOLVING THE LAST MILE PROBLEM BY CREATING DSS TO MANAGE BIKE-SHARING INFRASTRUCTURE DEVELOPMENT

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Keywords: bike-sharing, last mile, road transport infrastructure, decision support system

Urbanization, accompanied by an increase in the number of urban agglomerations and megacities, necessitates the solution of new problems in the citizen's mobility field. At the same time, the task of increasing the transport system's environmental friendliness should be solved without compromising mobility, which stimulates the development of public and non-motorized transport. While for small cities non-motorized transport can be considered as an independent transport mode, in large cities individual transport (bicycles, scooters, electric bikes, segways) are increasingly used to solve the problem of the last mile. Here, development proceeds in two directions: in the first case, when the use of a personal vehicle is implied, conditions are created for its transportation in public transport (lightweight and folding constructions appear), in the second case, a bike-sharing network are developing (Makarova *et al*., 2007a).

Although vehicle sharing systems have proven themselves well in tourist cities and regions, such systems will be effective in resolving the problem of the last mile at the optimal state of both the sharing infrastructure itself and its management system (Makarova et al., 2007b). The development of the sharing system is associated with the study of demand for its services, the presence of a developed bike paths structure, the target groups characteristics, as well as trips types. An important issue that should also be assessed when choosing an infrastructure project is its safety in terms of traffic management.

Our proposed system is aimed at evaluating cycling infrastructure development projects, including the development or adaptation of a management system. In the system presented in the article, it is accepted that cyclist safety can be assessed using a risk coefficient. The danger degree is affected by the presence of intersections, the density and speed of the traffic flow, the bike path type, as well as its width (Makarova *et al*., 2007c).

When drawing up urban traffic routes, it is necessary to choose the safest route, taking into account the characteristics of the road user. The route categorization can be carried out taking into various factors presence, which complicating the traffic conditions. The combined route, as a rule, includes areas where the movement is carried out by public transport, and the movement between the start (end) point and the stop of public transport is carried out on foot or by bicycle. These route sections are evaluated using our developed methodology for assessing the multi-criteria routes safety. Factors that determine the route safety, can be either objective (for example, location, the presence of unregulated intersections, etc.), or subjective due to the characteristics and physical condition of the road user (age, state of health, etc.). The adequacy of the assessment will depend on the correctness of the selected factors and their combined inclusion. For example, the same route may be safer in daylight than in the dark, or in summer than in winter, etc.

We propose to predict the effectiveness of projects, choosing from several options the one that will initially be most acceptable in each case under consideration. The management decision support system used for these purposes will use simulation models as the intellectual core.

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ASSESSMENT OF THE LOGISTICS SOLUTIONS IN THE AUTOMOTIVE USING OPERATIONS RESEARCH

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Keywords: efficiency, transport mode, simulation, logistics, MCA

The different aspects of logistics solutions affect the choice of transport mode during exporting cars. The aim of the paper is, based on an analysis of different aspects as a determinant of the choice of means of transport in the transfer of cars, to compare the individual modes of transport involved in the provision of logistic processes in automotive industry in the Slovak Republic. The main objective is to create a mathematical-statistical model. Model enables to simulate the required output effect (transport mode) on the basis of the change in the significance of the decision criteria, as well as to point out important factors and determinants influencing/selecting the means of transport and the mode of transport in this process with respect to the social-economic and environmental requirements in the context of sustainable development.

The choice of the transport mode during the transportation of the final products – cars in Slovakia is a complex process and depends on several factors. The price, delivery time and infrastructure are the criteria that most significantly affect the selection process. The optimal ratio of criteria with the highest weight of significance also represents the most suitable variant - the transport mode.

The simulation consists of a sequence of steps that follow each other and depend on the decision method used. Application of the MCA in determining the significance of selected options – the most suitable transport mode create the basis for simulating the required conditions. The basis of the simulation is the determination of the matrix that compares the individual criterion and the subsequent calculation of the normalized vector "v_i", that represented the weight of significance of the criterion. The decision analysis for each criterion is applied to the calculation of the weighted sum separately in relation to the compared options – transport modes. The calculation of the weighted sum determines the order of importance of the transport modes based on the weights of the criteria.

The result of the decision analysis is a "baseline model" that forms the basis for simulating the required conditions. The simulation process consists in increasing or decreasing the significance of the selected criteria in relation to the transport mode. Changes in the significance

of criteria are defined as percentages. This change adjusts the value of the normalized vector "vi". This is the basis for calculating the weighted sum and propose the most appropriate transport mode.

The model of choosing the optimal transport mode allows simple simulation of the required conditions by increasing or decreasing the significance of individual criteria.

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DIGITAL TRANSFORMATION IN SMALL AND MEDIUM-SIZED PORTS: CROSS-BORDER CAPACITY BUILDING AS KEY DRIVER FOR INNOVATION

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Keywords: small ports, digitalisation, Blockchain, online trainings, SMEs, Baltic Sea

In times of a recent breakout of a new virus COVID-19, the topics of change in physical and social interactions and trading structures, importance of intertwining physical and virtual worlds as well as an eager search for new digital business models are on priority lists of many actors. Its effects and exacerbation of the economy is felt around the globe, despite any difference in region, size of economy or production structure of economies. In particular, in face of COVID-19, a large blow is apparent in the services sector.

One of the key challenges related to the threat posed by the global coronavirus pandemic is to preserve many jobs and protect staff working in order to continue port operations and keep ports open for ship calls. This is crucial for the EU and European ports, since 75% of the EU external trade and 30% of intra-EU transport goods are moved by waterborne transport. As a response to the global lockdown and vulnerability of global supply chains, several international organisations and maritime ports networks shortlist measures necessary to keep severe affects of the lockdown away or reduce them to any possible minimum. One of key measures is to limit physical interactions. In this particular context, the use and higher deployment of digital technologies, such as digital documentation, tracing information systems, digital group-working platforms, Blockchain and data-enabling systems become a core element maintaining the uninterrupted flows of goods and services at ports.

Technological platforms are expanding into different aspects of our daily life. One of the most critical challenges that the transportation and logistics industry is facing is how to move people and cargo safely and efficiently. Access to real-time data is crucial for companies to determine how to improve operational efficiency and performance. With tailor made Internet of Things (IoT) or Industry 4.0 solutions, transportation and logistics enterprises connect devices to accelerate productivity. As a result, connected vehicles and traffic management centres make transportation more secure, improve safety and traffic flow, and reduce costs for greater scale.

In pursuit of these goals, the research paper in hand addresses this situation for small and medium-sized ports in the Baltic Sea as critical actors of the ecosystem. Given the topicality of this research and taking the research gap into account, the authors display a conceptual capacity building framework for port employees. This framework is based on the empirical insights:

primary and secondary data collected during the project "Connect2SmallPorts", part-financedby the Interreg South Baltic Programme 2014-2020 from the European Regional Development Fund (ERDF). The conceptual framework is a practical training programme dedicated to fill in missing skills or expand limited human resources' competences and ports' capacity when adapting or advancing digitalisation in ports' ecosystems. In particular, specific organisational areas of capacity building are addressed and individual solutions suggested, such as for management, administration, logistics and marketing. In face of the coronavirus and stronger need to switch to digital services, the research highlights the conceptual training framework as an online and distance training tool showing opportunities to upgrade ports and their infrastructure in terms of safety and security with the Blockchain technology; to advance transportation, environmental and economic performance with the improved digitalisation. For this purpose, the researchers use action research and deploys concepts and approaches from the management field, such as absorptive capacity construct, organisational learning, transformation, resourced-based view and dynamic capabilities concept included in the ecosystem discourse and linked with open innovation and service design. The present research provides both theoretical and practical contributions, where the affected stakeholders can test and utilise the developed tool as well as transfer it to other regions.

SERVICE DESIGN FOR SMART SUPPLY CHAINS

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Keywords: Service Design, Smart Supply Chains, Smart Contracts, Blockchain, Business Processes

Supply chain management passes through fundamental changes driven by new smart technologies. Smart contracting and blockchain technology represent innovative form of automation bearing the potential to establish new forms of cross-organisational collaboration and their underlying business processes. First cases in trans-national supply chains highlight that these technologies are able to support the integration of entrepreneurs and SMEs by reducing high entry barriers and weakening the dominating position of big players. However, the success of these approaches and new systems depend on the acceptance of the users of such systems as well as with the ability to cope with the requirements in the trans-cultural environment.

A promising and proven approach to facilitate the business success of innovative products and services emerge more often as result of cross-sectoral combination of technologies, design and business models comprising concepts like Open Innovation and Design Management. Unfortunately, the logistics sector is lagging behind in the application and implementation of design management concepts, which is surprising since smart supply chain management requires service solutions integrating networked technical systems and self-organised decentral structures on application level.

Recent research revealed that especially the logistics processes based on technical innovations like blockchain technology and smart contracting can benefit and be improved by service design solutions due to its international and often multi-modal nature. All stakeholders in trans-national logistics and supply chain processes follow their own business models as well as their cultural and organisational background so that the underlying technical solutions have to be covered on application level by smart service design interfaces in order to avoid frictions, inefficiencies and mistakes due to different mind-sets.

The paper investigates and discusses the research question of what service design can contribute to the integration, modelling and reconfiguration of trans-national supply chains and logistics processes. The origin is the Open Systems Interconnection (OSI) model for IT systems that link the technical level with the application layer and that will be exerted to an application in maritime supply chain management. The underlying technical solution is blockchain and smart contract based whereas the international stakeholders are interacting via the user interface for which service design blueprint is developed and empirically validated. The empiric results lean on expert interviews and a case study approach that was part of the EU projects “Connect2SmallPorts” as well as “Creative Ports”.

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MACHINE VISION USING FOR DETECTING DEFECTS IN THE FLOW OF GOODS

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Keywords: machine vision, visual inspection, identification, egg defects

When moving fragile goods by any type of transport, there is a possibility of damage or contamination. In the case of small and bulk cargo, sorting and rejecting damaged goods can be quite difficult. Chicken eggs are one example of such products.

In the field of the chicken egg quality and number inspection there are many solutions that allow using optical or mechanical sensors to control the quality and quantity of eggs passing through them and sort them. However, existing solutions are quite cumbersome and expensive, which greatly limits their application. In most cases, one or two of the inspection machines stand on the conveyor, sorting the total flow of the chicken eggs (Cho H.K. *et al*., 2000; Jin C. L. *et al*., 2015). With the regular appearance in the general flow of eggs with defects, contaminated or broken, there are a need the localization of a faulty section of the conveyor or the detection of a problem's laying hen, but existing inspection solutions do not provide this. Therefore, it is important to carry out the chicken egg quality and number inspection on in all sections of the conveyor of the poultry farm.

The purpose of this study is to propose and test in practice a method that uses machine vision (Aghkhani M.H. *et al*., 2007; Priyadumkol J. *et al*., 2007) to analyze the condition of chicken eggs passing through the conveyor, at any arbitrary point in the conveyor of the poultry farm.

The hardware of the system consists of high-resolution IP cameras. The cameras, using a local computer network, are connected to the computer on which the software is installed. The software performed step by step the detection of defects in eggs and the identification of defects (Li Y. *et al*., 2007).

At first the image of the moving tape is frame-by-frame processed by the algorithm for recognition and selection of egg contours. At second step in the operation of the software is the recognition of non-defective and defective eggs. To do this, color histograms of the image inside the egg contour are calculated. By the presence of certain colors in the histogram, as well as by the number of pixels colored in it, the main color of the egg can be uniquely determined, color analysis also allows to determine the presence of contaminants, blood, feathers or damage. However, to accurately identify the type of defect, it is also necessary to identify the problem areas and analyze them. So the next step is to search for defective areas with a convolution- based filter is applied to the image. After the convolution-based filtering, the boundaries of problem areas are clearly visible in the image, that to build color histograms of problem areas. At the final step the color histograms of problem areas are used to recognise the type of problem area.

Tests of the proposed visual recognition system for egg defects were at Balticovo. The data obtained from the visual control system during the day were compared with the general data obtained from the MOBA sorting machine.

The main results of tests are following:

- the total error in the calculation of the number of eggs is small and amounts to 0.02%;
- recognition errors of various egg defects do not exceed 7,5% ;

- the errors are mainly due to the fact that the cameras examine the eggs on only one side, covering only 60% of their surface area;
- proposed machine vision system may be used in any sections of the conveyor of the poultry farm and Its use will allow to accurately track problems with individual production sites and quickly solve them.

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PRELIMINARY ANALYSIS OF CHANGES IN LOGISTICS PROCESSES TO ASSESS THE IMPACT OF A PANDEMIC

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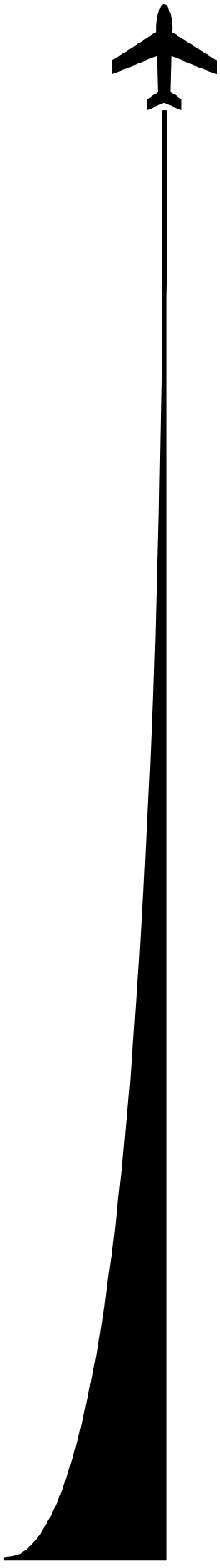
Keywords: Logistics, processes, market, economics, impact, pandemic, Covid-19

The spring of 2020 will enter World History as the start of a global Covid-19 pandemic that has had a far-reaching impact on logistics activities. The impact of the pandemic has been and is being felt in both global logistics supply chains and local markets, which are directly related to the Last Mile issue. In the public sphere, the term was particularly often referred to as "*Intermittent logistics supply chains*" - which was often misunderstood as stopping transport and logistics processes within the supply chain itself. To this end, it should be noted that global logistics processes were not directly affected as strongly as most logistics companies operated, but other members of the logistics supply chain, manufacturing and trade, came to a standstill. It is assumed that production has stopped due to the increased demand for the products concerned - usually personal protective equipment - and the exposure of workers to Covid-19 virus and disease. The suspension of trade was affected by universal quarantine, as well as the possible infection of workers with the virus. In any case, it must be acknowledged that the logistics processes have changed quite significantly in several respects. First, they became more tense, accelerated, and affected by circumstances that were caused by the epidemiological situation. Secondly, increased demand has necessitated the use of non-conventional modes of transport, such as the very frequent replacement of maritime and rail transport by air. However, air transport was severely affected, especially in the first weeks of the pandemic. Thirdly, the aspect of safety and security has become especially important in logistics processes - the need to use face masks when communicating with colleagues or customers, to use disinfectant fluid, to react appropriately in case of illness of employees and others.

Analyzing the publications of scientific publications of this period linking Covid-19 with logistics processes, it should be noted that there are not so many of them yet. Most of the sources are related to the recommendations provided by international and local transport and logistics organizations on how to deal with a pandemic situation and what measures to use. Therefore, in preparation for this publication, a study was conducted in the autumn of 2020, an expert survey to identify key changes in the logistics supply chain related to the pandemic. Experts from Lithuania, Latvia, Finland, Germany, Poland and other countries participated in the study and presented their assessments. The results of the study are very broad and can be interpreted in a variety of ways. In part, they confirmed the assumption that disruptions in logistics processes are directly dependent on fluctuations in demand for goods, quarantine measures, and business shutdowns. On the other hand, it has been observed that some processes have returned or are returning to relatively normal operating conditions, while others, such as passenger transport, may have long-term changes.



Smart Technology

TERNARY LOGIC IN DECISION MAKING

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Keywords: Intelligent system, decision making, ternary logic, open World assumption, closed World assumption

Decision making is a contradictory process: on one hand, it should base on strict rules and regulations; on other hand, decision is to be taken even the necessary information is missing, incomplete or controversial. An indicative example is flight operation where The Federal Aviation Regulations in unclear cases delegate authorities to the pilot-in-command. Obviously, if we mention about unmanned vehicles, we need a robust decision taking system that able to operate in these conditions.

Classical intelligent systems use production (based on rules) knowledge model and binary logic that does not distinguish a negative result and missing of solution. While acting in Closed World Assumption (CWA) where missing of data is equivalent to missing of the fact one can solve the data missing problem by assuming negation as failure. An alternate approach to build intelligent systems is Open World Assumption (OWA) where everything is possible unless the explicit negation is found. The main disadvantage of OWA is possible endless search of needed data in an undefined context. Consequently, OWA can yield very long search and it is not applicable in real time decision taking systems. The third possible approach is fuzzy logics where resulting decision is probabilistic. The weak side of fuzzy logics is necessity to assign probabilities and define methods to calculate a certainty of the result.

This paper develops an approach of information retrieval in production knowledge base using ternary logics (Bessmertny, 2014) to decision taking systems. In ternary logic, beyond known states *true* and *false* the third state *unknown* is included. This third state spans all uncertain results and just allows to distinguish negation of a decision and a decision that is not proven yet. Though, the fact the decision is not proved carries little information so it is reasonable to provide together with *unknown* result the list of facts those truth or falsity should be established to prove or deny the decision. Then, the search space can be expanded to find missing data.

Below is a fragment of production rules describing the conditions to take a decision to abort an approach of the aircraft because of meteorological condition. These rules are based on Federal Aviation Regulations (2009) and definitions of Hydrometeorological Center of Russia (meteoinfo.ru, 2020).

aborted approach ← severe meteorological phenomena severe meteorological phenomena ← very strong wind severe meteorological phenomena ← very heavy rain severe meteorological phenomena ← large hail
very strong wind ← average speed ≥ 20 m/s very strong wind ← gust speed ≥ 25 m/s
very heavy rain ← amount of precipitation ≥ 30 mm/h large hail ← hailstone diameter ≥ 20 mm

One can see that the decision of landing is to be taken after the examination of meteorological conditions, particularly, by missing a strong wind, a heavy rain and a large hail. In binary logic, missing data related to a wind speed, a precipitation amount or a hailstone size leads to the negation of severe meteorological phenomena and to the false decision to permit the landing. If the search engine returns not just *unknown* but the list of missing conditions like this:

aborted approach : unknown because of amount of precipitation is missing,

then one can expand the search to the meteorological service asking for the missing data and take a true decision.

This example demonstrates productiveness or proposed approach to building of decision taking systems based on ternary logic. This approach allows to search in expanding domain and avoid endless search in open World assumption.

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EFFICIENCY ANALYSIS OF STANLEY'S CONTROLLER APPLIED TO THE AUTONOMOUS GROUND VEHICLE MOVEMENT CONTROL UNDER EFFECT OF VARIOUS PERTURBATIONS

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Keywords: efficiency of control, controller, Stanley‘s control law, autonomous ground vehicle, constant radius turn, perturbation

The entire transport system rapidly moves towards the realization of the high level autonomous ground vehicles: SAE International constantly updates the standard that defines the six levels of driving autonomy (SAE J3016, 2014; SAE J3016, 2016; SAE J3016, 2019), different manufacturers are testing their autonomous vehicles in special facilities, various countries try to develop legal frameworks for the usage and testing of the autonomous ground vehicles in the actual traffic, etc. It is assumed that the autonomous ground vehicles are going to be the key factor that will cause positive changes in the transport system: from the more efficient road freights transportation and decreased emissions to the zero fatalities in road transport. Although there already are attempts to integrate the autonomous ground vehicles into the transport system, the legal framework is being developed, the deployment of technological innovations is growing, and all of the assumptions regarding the future of the autonomous ground vehicles are positive, the safety and convenience of the autonomous driving remain major concerns.

From the technology and development point of view, autonomous ground vehicles are a multidisciplinary research object which includes such research fields as vehicle dynamics, control engineering and computer sciences. Regarding the development process, the relation between the autonomous ground vehicles and all of these research fields can be summarized as the development of the control system for the autonomous ground vehicle. According to (Amer *et al*., 2017) there are three basic stages and modules in the control system of an autonomous ground vehicle: Sensing and Perception, Planning and Control. Each of these modules are equally important, but the control module is the main one that is responsible for the stable, accurate and safe movement of the autonomous ground vehicle under various and changing movement conditions. Thus, the analysis of various controllers is a relevant task, which allows for closer examination of the autonomous movement by determining and objectively evaluating the impact of various factors on the results of the control process.

The Stanley’s controller is one of the most promising and effective controllers, however, its performance is dependent on the movement conditions. Based on the performed simulations, this study presents an analysis of the Stanley’s controller efficiency, while in a constant radius turn moving autonomous ground vehicle was affected by various types of perturbations: steering angle, movement coordinates and movement velocity. The results of such analysis can be applied while seeking to modify the Staley’s controller in order to apply it to the autonomous ground vehicle control under various and changing movement conditions.

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STEEL AND HYBRID BUS SAFETY FRAME: THE ANALYSIS OF DEFORMATION

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Keywords: Bus, composite, impact, mass, safety frame

Buses are one of the most popular types of vehicles that allow people to travel both in the city and on the highway. Innovative materials (such as glass or carbon fiber) and their bonding technologies can be used in the construction to reduce the weight of the bus, which is directly related to the running costs, environmental protection and safety. Carbon or fiberglass composites have long been used in the passenger vehicle manufacturing industry to reduce vehicle weight. However, the safety structure of the bus is still made of steel. On average, the safety structure makes up about 20-25 percent of the bus's weight. The traditional steel construction of the bus safety frame could be replaced by a hybrid construction. A hybrid structure is a structure that is composed of at least two completely different materials.

The use of these innovative materials also faces another problem – structural strength. Attention must be paid to the strength of the structure, as the replacement of steel by glass or carbon fiber can lead to certain unacceptable deformations of the bus safety frame, which may not ensure the safety of the driver or passengers in the event of an accident (Jeyakumar and Devaradjane, 2012). Of all bus-related accidents, i.e. frontal collision, side collision and rollover. Such an accident can claim the lives of several passengers in one accident. Compared to car overturning, bus overturning is a much rarer phenomenon, but due to the higher number of passengers carried, bus overturning is much more dangerous (Kang *et al*., 2012; Zhou and Lei, 2005).

For this reason, safety testing is a very important aspect of vehicle design and manufacturing. In order to save money on costly component testing, digital methods and modeling programs used for dynamic vehicle body analysis are used at the design stage (Na *et al.*, 2015). The results obtained may make it possible to identify structural weaknesses which may be unduly deformed under high loads (Gombor, 2005).

In this work, computer modeling of bus frames is performed. In the construction of the bus safety frame, the steel is replaced by fiberglass. The obtained results are analyzed. The effect of the use of fiberglass in the structure on mass reducing, deformation and stresses when modeling frontal and lateral impacts is assessed.

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EXTENDING FATIGUE LIFE OF ALUMINUM ALLOYS DUE TO PREVIOUS IMPACT-OSCILLATORY LOADING AND USE OF NANOTECHNOLOGIES

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Keywords: aircraft structures, damage tolerance, design against fatigue, realistic testing

In this research, we obtained the original experimental data on the peculiarities of the mechanical behavior of aluminum alloys D16CzATW and 2024-T351 with a thickness of 3 mm at variable loads, which were subjected to impact-oscillatory loading of different intensity during tension, with nanosolutions of different metals applied to the surface of the alloys investigated. The following basic nanosolutions were used: titanium carbide (W-C), carbon (C), copper (Cu) and manganese (Mg) nanosolutions. In addition, Al + Cu nanosolution at a concentration of 50:50%, and Al + Cu + Mg nanosolution at a concentration of 33:33:33% were used.

The research was conducted in two stages. At the first stage, macrohardness of the surface layers was evaluated for nanosolutions of different metals applied to specimens from the D16CzATW alloy at a working load of 4.56 N. The intensity of introducing impulse energy during tension was εimp ~ 3.85%. The data obtained were compared to the specimen processed at the same intensity of introducing impulse energy without metal nanosolutions applied (εimp ~ 3.85%), and to the specimen with the same degree of static deformation (εstat = 3.85%). To ensure the correctness of findings, the results obtained for the working part and the head of the specimen were compared for each specimen. It was found that without metal nanosolutions applied, macrohardness of the specimen working part decreases by 12.8% compared to the gripping parts at a given mode of introducing impulse energy. This is due to dissipative structures of lower density that appear on the surface layers of the alloy. Conversely, it is possible to adjust and increase microhardness of the specimen working part by up to 13% after the introduction of impulse energy, depending on the metal nanosolution applied.

At the second stage, specimens of aluminum alloys were tested at variable loads after DNP on a high-frequency testing machine RUMUL Testronic. In this case, the intensity of introducing impulse energy into alloys was determined by jumps of dynamic deformation during the realization of impact-oscillatory loading εimp within the range εimp = 2… 9%. Loading conditions were soft; cycle asymmetry coefficient R = 0.1; maximum dynamic loads F were 13.2 kN; 12 kN; 11.1 kN; 10.2 kN, respectively; test frequency was 110 Hz. All tests were performed at room temperature.

The analysis of the data obtained for alloys D16CzATW and 2024-T351 showed that the additional use of nanosolutions of tungsten carbide, carbon, copper and manganese in the process of impulse introduction of energy into alloys improved the durability of alloys significantly under almost all variable loading conditions used. It should also be noted that when the modes of impulse introduction of energy were close to optimal, the additional use of metal nanosolutions led to even greater positive effect compared to the initial state. The greatest effect for alloys D16CzATW and 2024-T351 (up to 33%) was attained due to the impulse introduction of nanosolutions of tungsten carbide and carbon. However, the use of nanosolutions of copper and manganese also provides for significant (up to 12.5%) positive changes leading to the extension of fatigue life of the D16CzATW alloy.

ENERGY POLICY AND ECONOMY BASED ON SMART GRID ROUTING PROTOCOLS AND ENERGY TRADING

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Keywords: Energy policy, energy economy, smart grid, HEMS, energy generation

Energy policy and economy defines Routed Smart Grid operation protocols and introduces energy trading to the country energy sector. Energy trading is based on the idea of distributed energy generation and distributed energy storage in the Smart Grid. This makes a significant energy sector move from a country utility to a new type of market which makes energy a powerful economic engine of the country and significantly contributes to renewable energy sources penetration.

This research project is implemented with a system dynamics modeling approach, which simulates the energy trading within the Routed Smart Grid. The model operates based on the defined energy trading policy. The goal is to observe the system operation and to configure the policy aspects for a stable country energy model and supportive environment for renewable energy sources introduction.

Many researchers are working towards developing efficient and reliable distributed energy generation concepts for RES and new architectures for the energy distribution systems. There are ongoing researches on home energy management systems (HEMS) which improve the energy utilization and try to reduce electricity cost by shifting and curtailing demand in response to electricity tariffs and consumer comfort during peak hours (Jin *et al.*, 2017; Nordman *et al.*, 2017; Shakeri *et al*., 2018)

The model includes factors of availability, costs and efficiency of customer-level and retail-level devices for energy generation and storage. These are solar panels, small and medium size wind generators, small biomass power plants, diesel electro generators, and batteries. As a result, based on the proposed energy policy the model shows a stationary and predictable behaviour with a certain percentage of customers involved into country energy generation from (private) renewable energy sources, and other certain percentage involved into energy supply and demand stabilization.

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A STUDY OF THE STABILITY CHARACTERISTICS OF THE INTELLIGENT ROBOTIC VEHICLE MOVEMENT

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Keywords: robotic vehicle, movement; controllability, alignment, deviation from the course, 3-D modeling, physical modeling

Unmanned vehicles have been developing at a rapid pace around the world (Al Khawaldah *et al*., 2014; Santosh *et al*., 2008). However, despite the significant sophistication of these technologies, there arises a broad list of problems related to the IRV (intelligent robotic vehicle) movement. One of the most important problems is to ensure the stability characteristics of the IRV movement (Stotsky *et al*., 2007; Thuilot *et al*., 2002; Fang *et al*., 2006). To this end, we developed a methodology for calculating the angular parameters, the radius of the trajectory curvature, and the coordinates of the IRV position during its movement. We created a 3-D model of the IRV, which allowed us to provide the most complete insight into its movement, placement of new sensors, monitoring, and calibration (Wang and Liu, 2008; Wallgrun, 2010). We developed a program for processing and logical analysis of the data received from the encoder. We installed the TRD-S500VD encoder and developed IRV control algorithms based on the encoder data. We improved the algorithms of the IRV operation for an automatic stop in case of the control signal loss and the operation to improve the IRV ability to move autonomously in space. We described the developed intelligent robotic vehicle. We developed a 3-D model of the IRV and carried out physical modelling of its movement. Experimental studies have shown that the minimum deviation of the trajectory is observed at the IRV movement speed of 7 km/h. The obtained data will be further applied for calibration through the use of the coefficient K of the real IRV movement trajectories.

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EVALUATION OF THE EFFECTIVENESS OF ENERGY STORAGE SYSTEMS (ESS) IN PROBLEM OF REDUCING THE ENERGY CONSUMPTION COSTS IN LONG-TERM PLANNING

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Keywords: Energy storage system, ESS efficiency, battery life, optimal charge-discharge planning

The aim of this study is to analyze existing energy storage systems (ESS) based on powerful electric batteries from the point of view of algorithms for intelligent control of its charging and discharging processes on optimal schedulling on a long time period.

We discuss possible ways in reduction of the cost of electricity consumed by the enterprise due to the redistribution of energy depending on changes in tariffs and the load over time. It is based on usage of the Energy Storage System (ESS) and the optimal battery charge / discharge schedule (ESS control algorithm).

Evaluation of the savings in energy consumption is carried out depending on the power, power ESS, as well as the length of the planning period. This study considers significant planning intervals when it is necessary to take into account the decrease in the probability of correct price forecasting (Krivchenkov *et al*., 2019).

In addition, when scheduling for long periods (more than several weeks), one should also take into account the aging of the batteries, since the battery life is usually guaranteed by the manufacturer only if the conditions for maintaining its charge are in the range from 25% to 75% of the maximum value. If these conditions are not met, the rate of loss of electric capacity of the battery increases. Based on the numerical simulation of battery charge-discharge control by linear programming (Krivchenkov *et al*., 2020), the actual efficiency of using ESS was estimated in the range of less than 10-15% for different planning periods from 1 to 4 weeks.

The main purpose of research is to develop an algorithm for smart control in the conditions of variations of electricity hourly prices, in energy consumption and the aging process of batteries when expanding the charge-discharge range to values from 0% to 100%. Formalization of the problem of optimal control of battery operating modes and the formulation of its conditional constraints help to assess the potential economic efficiency of ESS.

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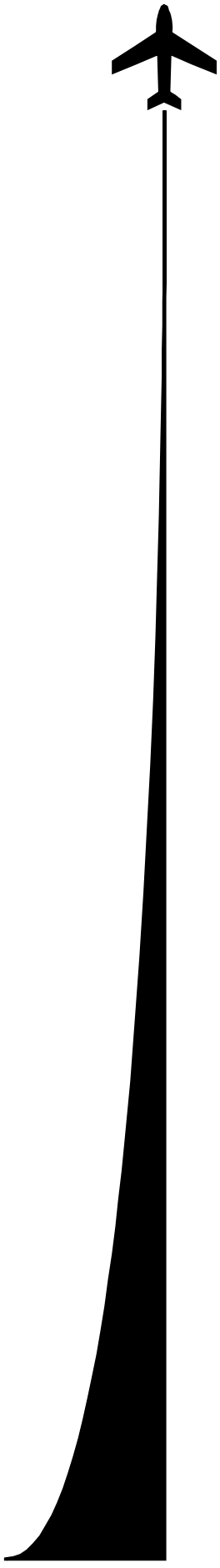

Smart Transport and Mobility

SUSTAINABLE TRIP PLANNER CONCEPT DEVELOPMENT

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Keywords: trip planner, public transport, passenger's behaviour, individual preferences, Big Data

Mobility is essential for society and economy and Arthur D. Little in his 2014 study (Arthur D. Little & UITP, 2014) highlighted that responding to increasing demand for urban mobility and users' needs for seamless, multimodal urban mobility requires cities to adapt their public transport offering from "delivering transport" to "delivering solution". Such transformation can be achieved throw public transport quality improvement and users experience via service offering extension. Mobility as a Service (MaaS) seeks to transform the way in which travellers to choose how he/she travels from origin to destination and the core elements of MaaS are ticketing and journey planning.

Trip (journey) planner's solutions main goal is to provide travellers with the multi-modal trip plan, time estimation routes choices options and some advisory suggestions. Trip planner solutions operate mainly with publicly open data sources, such as public transportation schedules and routes. But considering the changes and challenges that will bring post-pandemic transportation requirements, it is very important to keep society healthy and running throw seamless, safe, reliable and sustainable mobility.

The crisis has shown the importance of acceleration the digitalization of real-time travel information, ticketing and payment, etc. and the task to plan safe, resilience and the sustainable trip from the first mile to last one is the task for MaaS platform. Trip planning should include not only standard attribute of the trip – mode and duration, but also a lot of characteristics such as transport current occupancy, frequency of delay and other defined individual preferences.

The main research question is "what other real-time (or predicted) information is needed for the trip planner's system to be resilient and easily adaptive to the changing requirements". But the scope of the question is wider than only challenges of the post-COVID-19 world and we want to analyse the requirements to a holistic set of information for trip planners from the provided services quality view, like comfort, availability for different passenger groups, ecology and as well as investigate possible approaches to address new requirements for social distancing, transport load, life quality and crystallise other vital requirements.

If we look on everyday journey planning, then the majority of trip planners have limitations of integrated transportation information, it is mainly private car routes, public transportation routes, schedule and walking distances, less trip planners have the ability to plan expenses, forecast expected latency, influence on ecology, the convenience of provided route options. Worth to mention that there is no integrated ticketing system in Riga yet, that would provide the purchase of a single ticket that allows passengers to travel using different modes of transport provided by one or more operators.

The best practice analysed in the paper was an advanced platform for MaaS HAFAS (HaCon Ingenieurgesellschaft mbH, 2020) allows intermodal trip planning and integrated ticketing in several countries and major cities, and setting new standards in terms of comfort, feature richness and accuracy. HAFAS system has features door-to-door routing including all

modes of transportation (buses, trains, trams, ferries, planes, car, bicycle as well as pedestrian routing), real-time information and individual push notifications.

The particular interest and secondary goal were to provide analysis of trip planners available for Riga city and validation of their compliance against current updated requirements, clear vision of what passengers will consider as useful features and suggestions for complementary services, besides basic information about the journey, map and schedule.

It is critical now to accelerate the new approach to sustainable trip planning based on a variety of Big Data and give the possibility to passengers to make smart and safe decisions and plan routes to minimize their risk of exposure.

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SIMULATION TECHNOLOGIES OF THE MOORING OPERATION TO THE BERTHING PORT

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Keywords: Simulation, port, tug, mooring operation

The entry/leave of vessels to the port berths, as well as the vessel docking is associated with increased risk, as several vessels participate in operations at the same time. For some ports, the task is complicated by the presence of narrow approach channels or a narrow port water area. The towing operations safety is directly related to the correct choice of the required number and tugs towing forces for mooring operations.

To solve this problem, a simulation technology for mooring / unmooring various types of vessels to the berths of the port, as well as entering vessels in a dry dock, is proposed. The technology was created on the basis of the simulation modelling theory (Law, 2015), practical recommendations on the use of tugs in the port (reference) and the technique developed by the authors to determine the required number and tugs towing forces for doing mooring operations (Hensen, 2003). In developing the technology for modelling mooring operations, the authors used the results of their own research (Bondarenko *et al.*, 2018), as well as works (Paulauskas and Paulauskas, 2013).

The basis of the mooring simulation technique is based on complete systems of non-linear equations for the controllability of transport ships and tugs designed to determine the characteristics of their strong manoeuvres in the presence of wind and waves in the drift angles of ± 180 degrees. These systems are supplemented by equations of dynamics of diesels and steering machines that take into account the features of their operation, as well as the complete nonlinear dependencies of two types of propulsion and steering systems, the corresponding rudder propeller and screws in the nozzles with rudders behind the screws in the nozzles. The equations of controllability are supplemented by the relationships between the tugs of the tugs and the bulk carrier, which solve the problems of their force interaction both in the modes of operation of the tugs "on the bitters" and in their operation modes "for injection".

Solutions of the generalized system of equations of the "bulker-tugs" complex that determine the characteristics of their joint motion are obtained by numerical methods of integrating the equations of motion.

To display the results, a program for the trajectory representation of the solution on a chart of the earth's surface has been developed, which makes it possible to determine the position of the bulk carrier and tugs at each moment of their movement in the water area, both in metric measurement and in geographic coordinates.

The developed methodology for modeling mooring operations to port berths allows solving complex problems associated with determining the optimal location of port berths and choosing the necessary number and characteristics of tugs for mooring operations to these berths.

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MOBILITY AND ROAD SAFETY IMPROVEMENT BY OPTIMIZING SMART CITY INFRASTRUCTURE PARAMETERS: A CASE STUDY

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Keywords: adjustable intersection, driving time, road safety, simulation, smart city, traffic light

The United Nations estimates that by 2050, 67% of the world's population will live in cities. Accelerating urbanization leads to an increase in the number of commercial and personal vehicles. At the same time, the road infrastructure does not keep pace with the increase in the vehicle fleet, which causes the appearance of problematic situations in the field of road organization and safety.

All of the above problems require fundamental changes in the field of energy, mobility and the arrangement of urban systems, which are reflected in the Smart City concept. Intelligent traffic planning, the development and promotion of public transport, and improving communication between road users in citywide infrastructure are the main components of Smart City mobility.

To solve these problems, an information management system is proposed. Since decision-making should be based on real data on the urban transport system, for analysis and strategic decision-making, information was aggregated in a data warehouse containing data from several databases (flow rate, traffic accident statistics, location and characteristics of infrastructure objects). The purpose of building a repository is the integration, updating and coordination of operational data from heterogeneous sources to form a single consistent view of the control object as a whole. For the correct reproduction of real situations, operational information is used, which can come from various sources: from video cameras (Fedorov *et al.,* 2019), equipment for operational monitoring of the traffic situation (GPS / Glonass devices). To assess the dynamics of the road network parameters according to different measurements (number of vehicles, road section, season, average speed, traffic lights, etc.), a multidimensional intelligent data model (online analytical processing cube) is used, which makes it possible to predict possible changes situation on the city roads in subsequent periods. Decisions are made on the basis of multivariate data analysis and computer experiments on simulated micro-models of the road network problem areas. Modeling options for possible solutions with varying system parameters allows to choose the best of them and form the knowledge base of the best solutions with fixed parameters of the traffic flow and the environment.

The practical significance of the system lies in the ability to calculate the effects of the implementation of the proposed solutions at the stage of development of projects for the modernization and reconstruction of the parameters of the road network. The system can also be used for operational management decisions in the event of extreme situations in the transport system of the city (lockdown, public events).

As an example, the installation of a traffic light at a selected intersection is considered. Two series of experiments were carried out, during which the number of the traffic light phases and their duration were varied. The optimal parameters of the traffic light can reduce the number of conflicts and traffic congestion, increasing road safety, and also reduce the volume of exhaust

gases by shortening the idle time of vehicles engines (Makarova *et al.*, 2020). In addition, the found phase durations can be used when introducing elements of an intelligent traffic planning system, including adaptive traffic lights (Makarova *et al.*, 2018). Their use is an affordable solution that does not require large-scale reconstruction of the engineering structures of the transport infrastructure associated with high material costs.

Thus, the system allows to develop recommendations for the rational management of the transport system of urbanized territories both at the strategic level (when determining constant traffic light settings) and during operational management (changing the duration of phases depending on various parameters), integrating simulation models of problem areas into the proposed information managerial system of the city transport system.

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IMPROVING THE CITY'S TRANSPORT SYSTEM SAFETY BY REGULATING TRAFFIC AND PEDESTRIAN FLOWS

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Keywords: traffic flows, pedestrian flow, simulation models, vehicles environmental impact, road safety

The transport and road complex plays an important role in human activity and is an integral part of the successful functioning of an urbanized territory. The increase in motorization, caused by the need for mobility, is the cause of negative phenomena in the transport systems of cities around the world, such as obstruction of traffic and emissions of harmful substances. This has a negative impact on human health, has economic and social consequences, damages the environment and causes the risk of catastrophic global climate change. However, road accidents, injuries and loss of life are the main concern among the negative consequences of the intensive growth of the car fleet. Inefficient organization of interaction between pedestrian and transport flows is often one of the reasons for traffic difficulties on city roads. Infrastructure solutions often do not improve the situation, and they are expensive. At the same time, checking the adequacy of the proposed solutions on simulation models is a good way to choose the most appropriate case for a particular situation.

For this purpose, the statistics of road accidents are analyzed, the places of their concentration are selected, and the causes are found out. Then, if the causes are irrational managerial and organizational decisions, possible solutions to the problems are checked and the most rational one is selected for the specific case. The aim of the study is to optimize the busy sections of the city's road network by regulating traffic and pedestrian flows using simulated micromodeling. For this purpose, the methods and models used in the field of traffic management were analyzed, including methods for reducing and preventing congestion on the city's road network in General and on its individual sections in particular (Al-Dabbagh, 2019; Turcu, 2012; Makarova, 2020).

Data on the intensity of traffic and pedestrian flows were obtained by conducting field surveys. The basis for building the simulation model, its validation and verification, was the data of field surveys, data of monitoring and analysis of traffic accidents of the traffic safety service. The proposed solutions to improve the situation in problem areas were studied during experiments on a simulation model. The following research methods were used: video surveillance for visual short-term determination of the intensity of traffic and pedestrian flows, methods of mathematical and simulation modeling of traffic, theory of experiment planning, computer experiment. The results of the conducted research and experiments, as well as the assessment of the effectiveness of the chosen solutions, indicate that the use of micromodels to evaluate solutions to improve the situation on the city's roads can ensure effective management of the city's transport system and reduce the negative consequences of motorization in both social, economic and environmental terms.

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HYBRID MODEL OF CONTROLLING TRAFFIC FLOWS WITHIN REGIONAL INTELLIGENT TRANSPORTATION SYSTEM

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Keywords: Hybrid model, intelligent transportation system, stochastic freeway capacity, ramp-metering

The paper considers the problem of building a hybrid model of regional intelligent transportation system (ITS) controlling traffic flows within high-speed transportation corridors for unmanned and manned vehicles, which could be adopted to different regions taking into account their economic situation and geographical location. In the case of manned vehicles, the system transmits instructions to drivers via interactive displays and mobile information. For unmanned vehicles which are connected to the system, the module for transmitting control actions to on-board computers is provided. The study presents a scheme of regional ITS consisting of high-speed transportation corridors and the algorithm of access to corridors. This problem is based on optimization problem consisting of searching the minimum waiting time and time of movement for all participants within the current section of the system (using ramp- metering system as a control). The stochastic nature of freeway section capacity is considered. Based on the available data on traffic flow parameters and taking into account Mathematical Remodelling concept it was proposed to use a neural network to predict freeway section capacity. To define the most important factors affecting capacity it was proposed the approach to Sensitivity Analysis based on applying Analysis of Finite Fluctuations. Obtained results of the proposed analysis were used to form productive rules to control variable parameters of the system.

Consider a section of a transportation corridor with a ramp-metering system. Depending on various factors, this system may be active or not. To determine the optimal parameters of the ramp-metering system, it was proposed a formulation and numerical solution of the optimization problem providing a global minimum of time needed to overcome the entire section of the corridor, taking into account all delays at on-ramps. Depending on the location of traffic merging point all sections could be divided into two types (Sysoev, 2017): (I) there is the only off-ramp and (II) there is on-ramp. Both types of sections consider the time required to pass the main road calculating based on real-time data. Traffic delays caused by traffic characteristics occur on approaches equipped by ramp-metering system and refer only to sections of type II. Based on known models of travelling time (Geistefeldt, 2014), average speed and time losses (FGSV, 2014), delays on approaches with traffic lights controlling (TRB, 2010) the problem could be formed as

$$\min_{x \in R^n} \sum_{j=1}^{m} (t_j(x) + d_j(x)) \tag{1}$$

with the boundaries:

$$\begin{cases} x^{\min} \le x \le x^{\max}, \\ g(x) \le 0, \\ h(x) = 0, \end{cases} \quad (2)$$

where $t_j(x)$ is the total time required to pass the section j (veh.·h), $d_j(x)$ is the delay on the approach to the section (on-ramp) j (veh.·h), x is the solution (vector of optimal parameters) (sec), $x^{\min}$, $x^{\max}$ are boundaries on optima solution (sec), $h(x)$, $g(x)$ are boundaries defining local features of the section.

Neural network describing section capacity consist of one hidden layer with 8 neurons. The study (Sysoev, 2019) provides an approach to Sensitivity Analysis of this model showing the most significant factors affecting the capacity: the number of traffic lanes (a parameter of the transport system that can be changed by using reverse traffic lanes and/or hard shoulders), the percentage of heavy vehicles (there may be a restriction on the passage of such vehicles along sections at certain times of the day). According to the results of the analysis, the structure of the expert system was determined, which will allow forming recommendations for connected vehicles. The concept of building a base of production rules for developing control actions on a section of a transport corridor is proposed (Khabibullina, 2020). This neurofuzzy algorithm for production rules formation will allow building intelligent systems based on observed big data and with minimal expert participation (only at the stage of evaluating the quality of the knowledge base).

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SUSTAINABILITY CHALLENGES OF MOBILITY IN AREAS OF NATURAL, HISTORICAL AND MAN-MADE BEAUTY

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Keywords: Environmental concerns; Tourism; Nature formulations; Man-made attractions; Systematic literature review

The continuously increasing proportion of people living in urban areas, the concerns for safety, pollution and congestion in cities and the newly technological advances have attracted the interest of researchers and policy makers for urban transport. The need for movement unavoidably generates both positive and negative impacts. Passenger and freight transport have been acknowledged as a significant disturbance to the liveability and quality of urban and suburban spaces, especially near to areas of man-made, historical and natural beauty value that must be preserved and be accessible, attractive and enjoyable to citizens and tourists (Dablanc *et al*., 2011).

The strong, interesting and complex relationship between transport and tourism is unquestionable (Hopkins, 2020), however the questions arising are how sustainable this relationship is and whether there is a need for transition from sustainable mobility to sustainable tourism, at least in areas of outstanding natural beauty. For example, the seasonality of tourism demand leads to rising demand for transport and mobility services during the high season, which affects excessively the traffic in specific touristic regions (Signorile *et al*., 2018).

Towards this direction, this paper discusses the main evidence emerging from a systematic literature review on the challenges, opportunities and barriers for areas of outstanding man-made, historical and natural beauty towards sustainability. The objectives of the paper are the following:

- Definition of the relevant policy context, i.e. legislation and determination of the role of different categories of involved stakeholders.
- Identification of the most serious local problems due to seasonal mobility needs of high demand.
- Recognition of best practices of sustainable mobility management in areas of outstanding tourism interest and classification of lessons learnt.

Based on the above, the main outcome of this paper is to provide a set of policy and practical recommendations and highlight the necessity for further specific analyses.

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FINDING THE WAY AT KATOWICE RAILWAY STATION: AN EYE TRACKING EXPERIMENT

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Keywords: eye tracker, pedestrian, passenger, transportation hub,·railway station, wayfinding

The aim of the presented work consists in providing a comparison of the results obtained from two wayfinding experiments with portable eye tracker. The main focus, among others, will be attributed to an assessment of an easiness of navigation and finding the station.

First, preliminary study was performed at Kraków Główny railway station (Pashkevich *et al*., 2020a) that aimed at comprehensive assessment of wayfinding performance of 25 young persons from three nations. Test participants were given the uniform task to find their way to the station, there locate ticket counters, departure schedule and proceed to a platform. The study has shown the following: each participant in average travelled 503 m and spent 484 s in order to accomplish the task. Only 96 of 193 visible signs or displays were noticed by the participants. Additionally, five confusion points were identified, where most of the persons had to slow down, stop or turn around to find a sign pointing in the desired direction. Overall, 23 out of 25 participants became confused during their wayfinding and 4 of them – all foreigners – became completely lost and needed to be guided to the final destination. Subsequent in-depth investigations were carried out in order to determine an effect of directional signs on wayfinding performance (Pashkevich *et al*., 2019) and to analyze situations in confusion points (Pashkevich *et al*., 2020b). The former study revealed that in spite of plethora of directional signs, navigation of test participants was not facilitated, but turned out to be even more overwhelming and complex. Inside the station hall, several signs were indicating to different routes to reach the same place (ticket counters). Also, location of signs was frequently quite unfortunate, thereby making wayfinding more difficult and stressful. In a second work, presented was a detailed analysis of two confusion points inside the station hall in terms of the change in speed and time being confused. According to a performed evaluation, confusion time varied between 2.0 and 35.4 s at the entrance to the station hall and between 4.0 and 39.7 s inside the station hall, with average speed decrease by approximately 25%.

Taking into consideration all the obtained results, it was decided to perform a similar experiment at Katowice railway station, which layout is assumed as less complicated. Sixteen recruited test participants were representatives of the youth and included individuals unfamiliar (test group) and familiar (control group) with the station design. In comparison to a situation at Kraków Główny, at Katowice railway station a test participant walked 373 m and it took 266 s in average to accomplish the same task. Even more contrasting is a number of confusions. Whereas at Kraków Główny a participant was confused in average 2 times, the same indicator recorded at

Katowice railway station is more than three times lower – 0.6. As in prior study, number of observed directional signs and displays amounts to 50% of all the visible ones (62 out of 124).

Results presented in the article give an indication that simple, straightforward layout of a station, with conveniently located facilities and wayfinding elements, is essential to ensure a smoothness of a wayfinding process.

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DIGITALIZATION AND NEW OPPORTUNITIES OF URBAN MOBILITY

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Keywords: mobility as a service, digitalization, mobile services, mobility on demand

The digital age opens up new opportunities in the field of transportation. The directions of urban mobility transformation can be described as new forms of vehicle control, new forms of routing, changes of business models in private vehicle ownership and use, mobile technology expanding opportunities of customers. In particular, a new transport system paradigm for the Smart City is being implemented, which provides dynamic trips on demand, so-called public transport vehicles. The rapid development of the automobile network and autonomous driving technologies makes it possible to increase significantly the transportation safety and efficiency. An alternative means of convenient and elaborated transportation to improve customer service – mobility on demand (MOD) – is rapidly growing and spreading around the world. For these purposes, various services are being created, including, on the one hand, tools to order and to plan a trip, and, on the other hand, transport companies, which carry passengers under the control of online services. Intelligent technologies being developed to provide customers with services are called mobility as a service (MaaS). They are individualized taking into account the needs and preferences of users, and allow to book a service, which is provided using available modes of transport. With the development of mobile and location-based technologies, new forms of smart city transport such as Uber & Lyft are becoming increasingly popular. At the same time, new business models, such as a service sharing model, can be combined with new mobility schemes. Car2Go, DriveNow, BlaBlaCar, Uber, Lyft, which use vehicle sharing schemes combined with a dynamic separation of trips, could be named as good practice examples.

Autonomous vehicles (AV) create new opportunities for both traffic planners and politicians. Thereby, in the case of shared autonomous vehicles (SAV), routing, vehicle allocation, and dynamic pricing strategies can be aimed to maximize the overall system well-being, rather than to increase operators' profit. Control forms can also be targeted to different groups of clients. For example, Ride-Hail services were created to implement "driver-driver" communication through smartphone applications. And the largest companies like Uber and Lyft offer rideshare services for people, who plan a trip in the same direction and at the same time.

We see the development of MaaS systems as a way to flexible transportation system, which includes intelligent bookable services on a certain route at a certain time offering options in terms of both travel time and fare. The article presents the concept of an intelligent passenger transportation service called "Social Mobility on Demand" (SMOD), which provides personalized services tailored to the special needs of passengers. SMOD is a demand response system, which offers a list of real-time travel options for each passenger request. The system allows passengers to choose an acceptable option using a set of options. It also allows operators to distribute optimally vehicles for the realization of various types of trips: taxi, joint taxi and minibus. Such rational travel planning will reduce the traffic load on the road network as well as the negative impact on the environment.

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EVALUATION OF THE TRANSPORT IMPACT ON ENVIRONMENTAL POLLUTION DUE TO THE USE OF CARGO BIKES

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Keywords: cargo bikes, environment pollution, transport demand, transport simulations

The constant increase in transport demand inevitably causes environmental deterioration and has a negative impact on the environment, especially this problem is relevant for city inhabitants. Therefore, the qualitative estimation of road transport-related emissions is a crucial task for the development of environmental protection strategies.

The use of environmentally friendly alternative means of transport is a constantly developing direction to improve the quality of life in urban areas. Restrictions on the use of transport with internal combustion engines are introduced in most European cities. These activities face strong resistance from the business environment: officials often find it quite difficult to justify the desirability of restrictions, because they do not have a tool to assess the effectiveness of similar activities. This also applies to the use of cargo bikes in the delivery of freight in urban areas.

A review of contemporary scientific literature (Wrighton and Reiter, 2016, Melo and Baptista, 2017, Binetti *et al*., 2019) shows that at present the problem of assessing the efficiency of the use of cargo bikes is not resolved: there is no methodology for estimating the impact of cargo bikes on the environment. For this reason, research and development projects recently started and funded by European Commission (Citylogistics, CitiChangerCargoBike) have a serious problem justifying the environmental performance of the solutions being developed – project effects are estimated based on tools that do not take into account the specificities of cycling technological process.

Among the variety of techniques and approaches (e.g., Arnold *et al*., 2018, Naumov *et al*., 2020), many studies use a combination of traffic simulation models, that analyse and predict traffic parameters, with emission estimation models, which allow for calculations of the harmful impact (defined quantitively for the main air pollutants) caused by transport operations in the considered city area.

This paper proposes a methodology for assessing the reduction of environmental pollution caused by the use of cargo bicycles. Particularly, the technological processes for the delivery of goods by bicycles and the relationship between the parameters of demand for goods transportation, characteristics of the delivery process, and environmental parameters (air and water pollution and noise pollution) are discussed. A case study of the Old Town district in Kraków, Poland, is presented to illustrate the developed methodology.

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GUARANTEED QOS MODEL FOR VIRTUAL DATA CHANNELS IN COMPLEX NETWORK INFRASTRUCTURE

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Keywords: Quality of Service, guaranteed QoS, stochastic modeling, data channels, network infrastructure

The paper considers the task of modeling guaranteed *Quality of Services* (*QoS*) in complex network infrastructure maintained by the railway industry. Preliminary technical aspects of the network infrastructure comprise the following parameters: 1) type of virtual data channel (permanent (*PVC*), and switched (*SVC*) virtual connections); 2) committed information rate (*CIR*), guaranteed data transfer; 3) burst information rate (*BIR*), non-guaranteed data transfer; 4) maximal peak information rate (*PIR*), sum of guaranteed and non-guaranteed data transfer. We note that *PIR* has stochastic nature [Park, 2005] as *QoS* metric, except the ideal maximum value depending on used technical facilities. Therefore *PIR* can be connected with a non-negative random value f_N describing every value of data transfer rate at the very moment.

Paper proposes the following novel *QoS* model to ensure *PIR* in every time moment $n = N$. Let $f_N = f_N(\omega)$, where ω is a channel state, can be interpreted as a situation concerned with virtual channel functioning capacity. The set of states Ω is finite and $\omega \in \Omega$.

QoS model has been formalized as a proposition:

for every moment n, $n = 0,1,..., N$ ***, every state*** $\omega \in \Omega$, ***overall network throughput must be kept, according to the following equality:***

$$PIR_N(\omega) = f_N(\omega). \quad (1)$$

Physically, equation (1) means if technical devices in the network have maximum throughput $M = const$ for their virtual channels and for all time moments the $f_N \le M$ condition is met, then (1) is a **guaranteed QoS model**.

Next, a control strategy to hold (1) has been proposed. That strategy is based on the stochastic martingale process and reassigning proportions *PVC* and *SVC* in overall network loadings.

The paper comprises a numerical example for calculation of the stochastic martingale process using four-step generalized Haar filtering (Ma *et al.*, 2019; Pakki *et al.*, 2019) with martingale deformations.

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AUTOMATION OF TRAFFIC FLOW CONTROL IN INTELLIGENT TRANSPORTATION SYSTEMS

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Keywords: intelligent transpotration systems, control, optimization, graph theory

The regional socio-economic development directly depends on the state of their transportation systems. Strategies to modernize transportation systems are developed at various levels: regional, the level of country and even interstate associations (Center for strategic research, 2018). Usually these strategies in addition to infrastructure changes such as the construction of roads, transportation hubs and the development of new transport modes, the significant attention is paid to the principles of organization and control. Taking into account the modern development of digital and smart technologies, control is implemented in intelligent transportation systems (ITS) (Dimitrakopoulos, 2020). The main problems for ITS at the level of traffic control are tracking the current state, predicting the dynamics of this state changes, implementing optimal control actions based on specified criteria.

The problem of tracking the current state is divided into subtasks for collecting, processing, and storing traffic data. The paper describes methods to record the current traffic state, a data warehouse model, information flows with state data and control effects and methods for pre-processing data for their further placement into specialized repositories. The storage information model is considered as a decomposition into three information models depending on the degree of structuring of the accumulated and processed data, as well as their volumes: a relational model, a NoSQL model for processing information in the form of documents, and a NoSQL model for processing time series (Khabibullina, 2020).

The information obtained and organized in this way can be used to determine the optimal control actions and predict dynamics.

At the stage of optimizing traffic control, it is necessary to determine the types and acceptable values of control actions and to select (after their definition) the optimal control actions with predefined traffic flow criteria. There are different types of criteria (Galkin, 2020): speed of movement, safety, environmental impact, etc. A set of criteria can be combined into a single integral criterion. For the selected criteria, there are developed control algorithms allowing to specify a set of control actions values delivering the optimal values of these criteria.

To describe the transportation system scheme graphs being a universal tool were used. Edges of the graph describe roads, and vertices of the graph correspond to transportation nodes such as road intersections. One of the most popular graphostructural objects modeling transportation flows is transportation networks (Iri, 1996). They are used to determine the equilibrium distribution (Shvetsov, 2009) or maximum flows (Omarova, 2014), (Skorokhodov, 2015). The application of algorithms to solve problems on transportation networks when controlling traffic flows in real time is difficult, because these problems assume known flows values from sources to drains and the sum of all flows in the network is equal to the sum of flows

from the source. The solution of such problems can be used in the case of accumulation of big data on transportation system functioning and its initial configuration.

The paper proposes the algorithm to control traffic flows in intelligent transportation systems. The problem is reduced to optimization on the graph (Sicuro, 2017). The maximum capacities for vertexes and edges are set. The control can be carried out by changing the traffic capacity, for example, switching reverse roads, adjusting the operation of traffic lights. The speed of movement is used as a criterion for the efficiency of the transportation system. The criterion is defined as the maximum value of graph elements (edges and vertices) for which the rate of incoming traffic flows is higher than the capacity. The rate of the current flow is collected automatically. The algorithm is based on sequential recurrent calculations allowing to redistribute capacities from underloaded sections to overloaded ones. The direct implementation of traffic light and reverse mode settings for specified capacities is performed using specialized algorithms (Sysoev, 2012).

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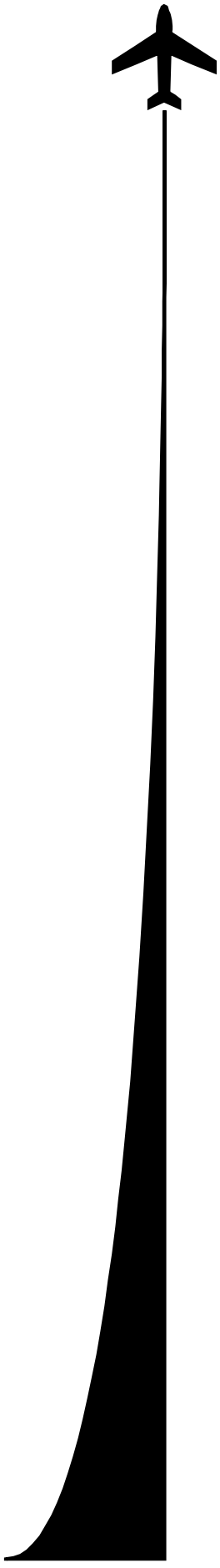

Economics and Business

THE ASSESSMENT OF WASTE HEAT RECOVERING SYSTEMS INSTALLATION ON SHIPS

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Keywords: Energy Efficiency, Emission Control, Maritime Investments, Real-Options

After a successful implementation of the sulphur regulations in the BSR and North Sea, the global sulphur cap was enforced from the beginning of 2020 suggesting that the activity towards less shipping emissions has become a global effort. Coupled with the sulphur law that forces shipping companies to opt for suitable compliance strategies requiring expensive investments in abatement technologies or compliant fuel management, is the CO2 emissions law. To ensure the compliant of the CO2 regulation, the IMO set standards for the Energy Efficiency Design Index (EEDI) for ships that also led to a higher propelling costs and additional abatement investments for shipowners making energy efficiency and fuel-saving a high priority in shipping operations.

This study focuses on the financial analysis of investment on waste heat recovery that has its origin in the heavy industry especially in power plants, steel mills and other high-energy fabrics. As with other industries, the waste heat recovery systems (WHRS) can also be used to reduce emissions and fuel consumption of ship engines but is still relatively new in the industry and until now, the economic assessment of the installations are still not adequately covered in the scientific literature. This might be because most maritime investments analyses use the classical capital budgeting methods, which are not flexible enough to allow the incorporation of future changes in fuel prices and other long-term costs.

The evaluation of the investment of the WHRS installations on ships carried in this work used the traditional capital budgeting analysis followed by the real-option approach. The results were further validated using data from three ships with different operational profiles gathered from EU projects "EnviSuM" and "CSHIPP" between 2016 and 2020. The capital budgeting analysis reveals that the investment in maritime WHR technology is economically favourable only under certain frame conditions. On the other hand, the real-option analysis shows a practical and pragmatic assessment of the WHRS investment even when implemented under high uncertainty and volatility condition in material resource markets.

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MODERN MANAGERS IN GIG ECONOMIES: COMPETENCES, PERSONALITY AND THEIR EFFECT ON MANAGER EDUCATION IN THE DIGITAL ERA

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Keywords: Manager Education, Managers' Personality, Digital Competences

Social and economic aspects of life of society have been impacted by digital technologies; a process, which has significantly accelerated with the new millennium. Making effective business decisions in the contemporary world of evolving digital solutions without considering digital information and sources is hardly productive. This has triggered a deep socio-economic transformation across various aspects of life of society, including a diverse range of business sectors and the emergence of the gig economy and gig workforce, which has been defined by Wood *et al*. (2019) as people who offer their services through mobile applications or consistently with the definition of the US Department of Labour who are people working as independent contractors offering their services to companies and customers through mobile applications or through other means. This results in the need of more rigid management systems. Furthermore, the EU vision of competitiveness of EU economies is associated with the transformation of markets and the acquisition of digital skills by the EU workforce. However, there is a lack of management professionals with digital skills capable of fluent use of digital technologies and their promotion in their teams. Business and management programs at universities are structural units that can offer the development of such skills. The key goal of this research paper is to identify managerial digital skills that are currently in demand and to determine if entrepreneurial skills and knowledge of personality can assist in the development of digital skills in order to provide more effective educational approaches to support the management needs in the era of digital transformation. In order to attain the goal, literature review and the survey of senior managers of Latvian enterprises were conducted. Latvia was chosen because Latvia has low indicators of integrating digital technologies into the economy. The outcome of the research is the proposal of conceptual aspects of enhancing students' digital, entrepreneurial and psychological skills in order to provide more effective educational approaches to support the management needs in the era of digital transformation and the digital quotient having been added to one of the key coefficients of people's abilities.

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DIGITALIZATION OF MANAGING FLEXIBILITY IN PRODUCTION LOGISTIC ASSIGNMENTS

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Keywords: flexibility management, Quantum-Decision-Theory, cybernetic management, digitalization, production logistic assignment

Due to fast development of information technologies, shortened product life-cycles, increasing speed of changing market demands and their processes, digitalization of company processes, the decision makers deal with strategic (and operational) uncertainties more intensively and use failure prevention and safety approaches as well as chaotic trial and error philosophy in their daily tasks. These hyper-complex decision situations request advanced approaches to handle the bounded instability and dichotomy of the parallel-processing of cognitive rational analysis of situations and the intuitive evaluation of dynamical element of development direction.

The author will provide the results of a study focusing on management of flexibility as a solution to measure and manage all aspect of an organisational system so that needed adoptions could be done fast and with minimal efforts.

The purpose of this study was twofold. The first target was analysing the implementation of the complex management variable flexibility to advanced modelling approaches based on Quantum-Decision-Theory solutions, on screenplay-based modelling set-up and on complementary multi methods handling in cybernetic management modelling. The second aim was as consequences of the implementation to identify the impact on changing toolbox and mind-set, especially with considering digitised modelling of decision making in production logistic assignments.

REINFORCING INNOVATION AND COMPETITIVENESS OF SMES BY NEW MARITIME CLUSTERING INITIATIVES IN THE SOUTH BALTIC SEA REGION

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Keywords: SMEs, maritime clusters, innovation, competitiveness, Blue Growth, benchmarking

The current and future economic development further on leads to an increase of globalisation and emerging societies. Especially the maritime sector is affected by this trend eminently through facing new challenges in competitiveness and growth strategies. Maritime SMEs of the Baltic Sea Region are conquering with competitors on national, European and global level. To increase their competitiveness and market share, building cluster is one main strategy of the recent years to use the obtained synergies and strengthen the own position on the market. Other European regions are already supporting maritime SMEs through the implementation of clusters in order to accomplish a strong position in the maritime sector.

In the frame of the EU project InterMare South Baltic – Internationalisation of South Baltic maritime economy, part-financed by the European Regional Development Fund (ERDF) within the INTERREG South Baltic Programme 2014 – 2020, the present paper analyses clustering possibilities for and competitiveness of SMEs in the Southern Baltic Sea Region compared to well established regional, national and international maritime clusters across Europe. Increasing competition in the field of Blue Growth and strong economic performance of well-known maritime clusters like Valencia, in Northern Europe and France make it difficult for smaller regions, as the Southern Baltic Sea Region, to facilitate internationalisation of SMEs in the maritime sectors. Thus, the present paper addresses next to the missing sound theoretical concepts also practical approaches applicable to maritime SMEs. As a result, the paper builds on concepts of benchmarking, clusters and corporate strategy.

The research follows qualitative approach (case study). Necessary data were gathered via interviews conducted with representative experts of maritime clusters from Spain, Sweden, Germany, Poland and Lithuania. The data pool was enhanced by analysis of the chosen maritime clusters from Europe and observations made during the project implementation from July 2017.

The paper delivers an analysis and evaluation of the Southern Baltic Sea Region regarding maritime cluster development. From the conceptual point of view, the research proposes qualitative indicator matrix, which can be used for benchmarking of emerging maritime clusters like in the Southern Baltic Sea Region and its comparison with counterparts of different size. In addition, current research proposes a novel concept by reconceptualising Porter's diamond framework to measure cluster competitiveness. Practically, the developed concepts can be used as strategic recommendations for SMEs to improve competitiveness and to generate best practices as well as serve as supporting tool for policy makers when setting up regional innovation and development initiatives.

ECONOMIC FACTORS OF LABOUR MIGRATION ANALYSIS

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Keywords: labour migration, economic factors, social factors, correlation analysis

Population of Latvia is declining every year due to rate of natural decrease and negative rate of net migration indicators (CSP, Population number, 2020). The number of emigrants is higher than number of immigrants in Latvia. Besides that, most of emigrants are economically active citizens. It is a topical issue since it affects stability and growth of the country.

The aim is to identify the related economic and social factors that affect emigration in Latvia based on analysis of migration data, and to develop proposals to improve the situation.

Latvia is also influenced by global affects around the world. Author made a research using scientific literature and statistical data in order to find the most important aspects of global migration and most popular reasons to emigrate from Latvia. This research helped divide many factors of migration according to categories and migrant goals, to further analyse relationships between specific economic factors and migration.

The research analyses determining factors of labour migration and there is used statistical analysis methods, including correlation method, which determines the relationship and closeness of various data as well as significance of the data that is analysed. The analyses identify push and pull factors of migrants. The Latvian workforce is mainly influenced by economic and social factors.

Research findings indicate that unemployment rate in Latvia and the number of emigrants has a positive, strong correlation. Apart from that the minimal wage and number of immigrants shows a positive, moderately close correlation. As well as the poverty and emigration shows a positive, moderately close relationship. Aside from that public order and security has negative, moderately close correlation.

Proposals consist of the need to reduce the number of Latvian emigrants by solving unemployment issues, problems related with minimum wages and necessity to reduce poverty.

Although the unemployment rate in Latvia is rather low compared with countries like Greece, Spain, France etc., it is mostly above the EU average in a period of 2004 until 2018 (Eurostat, Unemployment, 2020). The proposal for the Cabinet of Ministers is to focus on attracting investments in the regions that could develop entrepreneurship and create new jobs.

The analysis showed minimal wage is a significant factor that affects emigration. Although the minimal wage is increased every year, the cost of living also increases every year. Part of Latvians who receive minimal wage cannot feel an increase in their wealth. In the European Union, Latvia had the second lowest minimal wage in PPP (Eurostat, Monthly minimum wages, 2020). If a person has an opportunity to receive more income with same job leads he will choose to get more income. Increase in the minimal wage should be significant so people could feel these changes in their households. Wage increase can also change habits of spending, increasing the demand for goods and services, which will further increase economic growth. People who are at risk of poverty do not have enough income to meet even their basic needs. Government and municipality support to them is particularly important.

Huge investments are needed in order to improve net migration rate of Latvia, however, successful government support and investment in entrepreneurship can improve higher employment and wages, and most importantly, the sustainability of the country.

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DO THE RESEARCHERS HAVE ANY ECONOMIC OR FINANCIAL SUBSTANTIATION FOR SMART CITY: LITERATURE REVIEW

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Keywords: literature review, Smart City, cost efficiency, cost-benefit analysis

The research is composed to find the answer for the research question: *Do the researchers demonstrate economic or financial substantiation for implementation of smart solutions for different dimensions of smart city?* The goal of the research is to determine the publications presenting the economic or financial substantiations for smart solutions for smart city and to determine the type of the provided substantiation. It is very important, since Smart City is becoming our life step by step, though the components of it are introduced without any economic study, estimation and substantiation. This research is done to discover the areas where such substantiations exist, and to estimate the possibility of applying the methods, described in these studies, for smart solutions in smart city.

The study uses the similar methodology as in (Wee and Banister, 2016) The inclusion criteria are as follows: academic articles included in Scopus database; available online in full text; articles in English only; articles relevant to the research goal and research question. Exclusion criteria: the publications not corresponding to the inclusion criteria.

The key words and operators for query are as follows: "smart" OR "smart city" AND "cost" OR "cost approach".

As a result, the primary selection comprised 927 publications, including 148 publications in Open Access sources and 779 publications in other sources. The time span for the search was 1993-2020. The analysis by year of publication showed the constant and significant growth of publications number; this fact demonstrates the increased understanding of the necessity to apply the economic or financial substantiation to technical solutions within smart city; at the stage of implementation of smart city concept in practice it becomes absolutely urgent; it also evidences indirectly that the cities are becoming smarter and smarter each year, and more and more solutions must have economic basis. If to consider the publications by the journals, denoting the areas of study, Computer Sciences and Engineering take 33% and 21% relatively. The inclusion of the researches from Business area (2% of all publications) demonstrates that the interest to smart city appears among scholars concerned with business, finance and economics as well.

Then, after analysis of abstracts of the articles allowed selecting 159 articles for detailed reading. The most important reasons for excluding 768 publications from the analysis as follows: determination of cost efficiency due to the price of one device; considering price-decrease for clients, not costs; many studies are devoted to time, transparency, environmental or social costs; costs are just one part of multiple-component function.

After analytical reading of the selected papers only 22 articles were admitted as fully corresponding to the requirements towards economic or financial analysis. These articles used the financial tools (discounting, estimation of cash flows in time, NPV, IRR) (Bataev *et al*., 2020; Ferreira *et al*., 2017), or presented real cost analysis or cost-benefit analysis (Turečková and Nevima, 2020; Laha *et al*., 2020; Li *et al*., 2018; Ramli *et al*., 2018; Rodrigues Filho *et al*., 2018; Sarma and Ganguly, 2018; Huang *et al*., 2017; Al-Saadi and Al-Jabri, 2017; Beccali *et al*., 2017; Boeri *et al*., 2016; Gavalas *et al*., 2016), economies of scale (Pournaras *et al*., 2020), externalities (Dominković *et al*., 2018), traditional well-formulated cost functions (Chen *et al*., 2017), optimisation tasks (Tsegaye *et al*., 2020; Dongol *et al*., 2019), consideration of the depreciation

and idle devices [3], economic comparison of various scenarios (Ahvenniemi and Häkkinen, 2020; Bačeković and Østergaard, 2018) pricing model (El Yamami *et al*., 2018). One paper comprises the well-formulated guidance for cost management of smart devices (Alamaniotis, 2014).

The value added of this research is specifying the fact that very few papers devoted to smart solutions within smart city comprise the comprehensive economic or financial analysis, and it is time for multi-disciplinary researches in the field, including the economists.

The study allows the scholars to use the reviewed publications as providing the economic and financial basis for smart city; it also demonstrated the lack of such publications and discovers the area where specialists in economy can apply their competences.

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THE FORMATION LEVEL EVALUATION OF THE NEW TECHNOLOGICAL PARADIGM IN RUSSIA

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Keywords: Technological paradigm, innovations, formation criteria

Currently, intellectual, scientific and technical potential are considered as main resources for economic development, and the increase in gross product is generally carried out due to new knowledge (Rifkin, 2011). Consequently, scientific and technological progress is resulted in the formation of a new technological paradigm (Perez, 2009).

The modern economy is characterized by multistructurality. However, some features of the sixth technological paradigm are observed in several countries. The core of the new paradigm is interaction of info-, nano-, bio- and cognitive technologies and following production technologies: flexible systems, unmanned production, non-waste environmentally friendly production, non-traditional energy resources, new generations of smart materials (Nightingale *et al.,* 2008; Cozzens and Wetmore, 2011).

The transition to a new technological paradigm is performed by scientific and technological development, as well as improvement of infrastructure and resource management systems. The main goal is to determine the transformation course of the current technological paradigm based on new knowledge. It is also important to choose a technological shift strategy in the current paradigm, which will ensure the transition to a new progressive paradigm. This article will determine the formation criteria of the sixth technological paradigm and evaluate the formation and state of readiness for a new paradigm in Russia.

Share of the R&D financing budget; share of high-tech exports; number of innovative enterprises may be considered as key new paradigm formation criteria.

Such qualitative criteria as the introduction of IT and robotics in production, the formation of a human capital and knowledge management system in the enterprises can be evaluated.

Currently, in developed countries the share of enterprises of the fifth and sixth technological paradigm is constantly increasing. In Russian economy, the fourth is the dominant paradigm; there are also basic signs of the fifth. In several regions the third technological paradigm is prevailing (Batov, 2018).

As the result, the transition to the fifth and sixth technological paradigm in Russia is complicated by bureaucratic barriers, the lack of flexibility and the ability to adapt to rapidly changing market conditions, the wide gap between science and industry, the delay in innovation implementation into production, the lack of the necessary personnel and knowledge management systems at enterprises.

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MICRO AND SMALL BUSINESSES ACCESS TO FINANCE AND FINANCIAL LITERACY OF THEIR OWNERS: EVIDENCE FROM LATVIA, ESTONIA AND GEORGIA

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Keywords: access to finance, financial literacy, Georgia, Latvia, Estonia

Although the world post COVID-19 could look very different, probably micro, small and medium-sized enterprises (MSMEs) remain the most part of operating enterprises. To maximize MSMEs significant contribution to national economies, it is important to identify the causes of their financial exclusion. Lack of financial literacy of MSMEs managers, who are – in the most cases – the owners – is usually mentioned among the reasons.

The main objective of the article is to verify whether the targeted group – micro and small businesses - access to finance and financial literacy (FL) of their owners are closely linked. As a supportive objective, analysis of the relationship between FL of MSMEs owners, adult literacy and the level of general education in a country is also included.

The research methods applied in the paper are both quantitative and qualitative. The research is exploratory in its nature, based on intensive literature review and desk research as well as analysis of the countries' statistics and the case study. Desk research includes analysis of academic literature, national researches' reports, reports and working papers of international organizations.

The case of Georgia is studied in comparison with experience of two Baltic states, Latvia and Estonia, which are chosen as an example of EU good practice. Latvia and Estonia are in the group of countries, which results in availability of different financing sources are above the EU average.

Comparing national financial literacy surveys and learning from the best practices is always an important tool, which helps policy makers and other stakeholders to understand why one country achieves more than another and which approach is the most effective.

The main findings of the research are as follows:

- Lack of access to any type of external financing caused by both supply- and demand-side issues.
- Analysis of financial literacy scores and financial inclusion in two Baltic states, Latvia and Estonia, evidences a constantly positive association between these two indicators.
- The most vulnerable group of SMEs is micro and small businesses. Owners of such enterprises still mostly suffer from a lack of financial literacy and, therefore, mostly face limited access to external financing.
- Positive cause-effect relationships are observed between the level of general education of the population, personal literacy, financial literacy of MSMEs owners, on one hand, and MSME access to finance, on another.
- In the observed countries (Latvia and Georgia), the level of general education of the population is quite high, but the owners of micro and small businesses do not have sufficient specialized business education and skills.
- Based on essential background in terms of high general level of education, Georgia has a good chance to improve financial literacy of MSMEs owners in a short time.

Finally, it should be said that it is time for the governments to focus on the subgroup of SMEs – micro and small businesses - and to develop special programs to improve financial literacy oftheir owners. MSMEs as the most vulnerable subgroup, urgently need special targeting support in terms of free of charge training programs, mentorship, consulting and advisory services, online courses, educational TV-programs, webpages, etc., provided by the government agencies, financial institutions, universities, other stakeholders.

THE DEVELOPMENT OF THE BALTIC SEA REGION AS A CENTRE OF GLOBAL LOGISTICS: THE SITUATION REPORT AND FUTURE PROSPECTS

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Keywords: interterminal costs, terminal key performance indicators

The frustration of states' authorities has received scant attention in the Baltics where the new railway line is designed with a view of great opportunities of Baltic seaports in both East-West and Nord-South logistics (Henttu, 2015), hampered by relatively small inland distances, multiple cross-bordering and multitude alternative terminals. The cooperation concept that could help to solve the fragmentation problem, was challenged by the inconsistency of both transport policy interests and decision-making criteria among the stakeholders when stating strategic planning goals and those key performance indicators (KPIs) for the infrastructure of the new-developed terminals and the lack of interest in adaptation from the existing terminals.

Hu (2019) has shown that rail transport shows high dependence on interterminal transportation (ITT – in this article, the abbreviation ITT will be used to refer to all terminal operations in the multimodal transportation chain both in hinterland- and in sea- ports) efficiency. The main disadvantage in achieving the efficiency is failures in a terminal layout, as a proper design asks for challenging cooperation among stakeholders: the policymakers must develop terminal infrastructure further operated by a terminal operator for freight forwarders needs (Hu, 2019; Guo, 2017).

This prospective study was designed to investigate specific ITT KPIs of the Baltic region using existing knowledge and considering core competitiveness of the terminals group.

The overall structure of the paper takes the form of four sections. The first section analyses the seven multi-criteria groups considered for transport policy identified by Duran (2017); the overview of multiple criteria in terminal selection from freight forwarder point of view delivered by de Icaza (2018); and the key factors of terminal performance measurement identified by Rezaei (2018). A holistic approach is utilised, integrating the stakeholders' point of view to establish a common model for creating ITT KPIs. The second section is concerned with the methodology used in the third section, where core competitiveness ITT factors of the Baltic terminals group delivered by Liupeng (2017) are investigated based on a critical path method. The fourth section presents the findings of the research.

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FACTORS IMPORTANT FOR BANKS IN ATTRACTING AND RETAINING CUSTOMERS

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Keywords: Consumer behaviour, bank selection factors, customer relationship management, customer satisfaction

Nowadays the vast majority of the banks are fighting for attracting new customers, strengthening existing customers' loyalty offering more new products and services. Bank customers are moving from one bank to another and as a result the total number of customers is increasing at some banks and decreasing at the others. Many studies are devoted to the investigation and identification of factors that are influencing customers' behaviour. The aim of the given research is to recognize and determine factors important for customers when selecting a bank.

The research was conducted in the Latvian banking sector, primary data were gathered by quantitative and qualitative research methods. We have carried out a detailed questionnaire of 587 private persons, and a focus group discussion. As a result 44 factors impacting customers' behaviour were recognized and analysed. The most substantial criteria in selecting a bank were discovered in accordance with customers' evaluations, as well as the least essential factors. The whole set of these factors have to be taken into account in the process of developing the strategic plan for marketing activities. During the research we have found the five most essential factors for customers when selecting a bank. These factors are the following: service quality; flexible and handy distance banking services (online banking, telephone banking, mobile banking); a bank's reputation; financial stability of a bank, and finally, a bank's service costs. Statistically significant differences were observed in the customers' behaviour depending on their ages, educational backgrounds, and places of residence. The results of the research were also compared with identical studies in other countries.

The results of the research could be valuable for top management of the banks and other practitioners giving several recommendations for comprehending customers' behaviour and planning marketing activities more effectively.

JEL code: G21, G41, M10, O10

COMPARATIVE ANALYSIS OF TERMINOLOGY AND ALTERNATIVE FINANCING TYPES ON THE EXAMPLE OF ESTONIA

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Keywords: Alternative financing, alternative financing providers of Estonia, FIU license, FSA license

Alternative financing has gained great popularity since new market players appeared to offer new types of financing in Estonia as well as in other countries of the world. The extent of the alternative financing penetration across the population in Estonia was second highest in European countries after the United Kingdom, in 2016. In recent years, the Estonian market of alternative financing has grown and transformed, taking different complicated forms. The research therefore reveals major types of financing process of the licensed alternative financing providers of Estonia, highlighting its crucial elements, namely, possessors of funds, legal status of fundraising originators and addressees of financing. The research goal was to reveal actual alternative financing types in Estonia. Generally accepted methods of economic research were applied, including a combination of monographic descriptive, qualitative, method of analysis and synthesis. The research was conducted in the form of review with primary data being gathered via multiple on-line resources, such as supervising institutions of Estonia, professional organizations and data bases of licenses issued by Estonian Finance Intelligence Unit (FIU) and Finance Supervisory Authority (FSA). The research findings demonstrate brief review of terminology of alternative financing, licensing aspects of alternative financing providers of Estonia, and major types of financing models actual in Estonia. The presence of banks' funds in certain alternative financing models was revealed as well.

CHANGES IN THE BUSINESS SECTOR UNDER THE INFLUENCE OF THE PANDEMIC: CASE OF LATVIA

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Keywords: Latvia, pandemic, business, digital transformation

The pandemic caused a forced restructuring in the operating mode of many companies - there was a transition to a remote work format, part of the documentation had to be converted to digital format, and communication with employees was carried out using video communication systems. In addition, the coronavirus pandemic has led to changes in people's habits - a sharp transition has been made to online shopping and many will continue to make purchases on the Internet even after going through the active phase of the pandemic, which already caused and will continue to cause the active development of delivery technologies. The whole situation, which forced people and businesses to stay home, clearly shows that a business that is not represented on the Internet has huge risks in its work. Continuous development and improvement of business processes on the Internet is necessary to ensure stable growth in the number of customers and their service even in the absence of advertising. State and private enterprises during the quarantine have tested new technologies, new work schemes, and these innovations will undoubtedly develop in the future.

The purpose of this study is to find out the priority tasks for Latvian entrepreneurs after quarantine has been lifted.

The authors analyzed the official reports of the European Central Bank and the Bank of Latvia on the impact of the pandemic on business.

To achieve the goal of the study, a survey was conducted among Latvian entrepreneurs employed in industries such as trade, tourism and construction. The interview involved 52 senior managers. A survey among the owners of Latvian companies showed that digital transformation is the main business priority. Overall, 68% of managers said that the digital transformation of the business is their main concern at the moment. Enterprises will get rid of excess resources, reduce the area and will actively switch to outsourcing.

THE IMPACT OF CUSTOMER BEHAVIOUR ON BANKING SERVICE MANAGEMENT: EVIDENCE FROM LATVIA

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Keywords: Keywords: Banking customer, customer behaviour, banking service, customer satisfaction

In this paper we study banking customers' habits and behaviour in order to determine amendments needed in banking service management for improving service quality and raising customer satisfaction.

The objective of the study is to look into customers' activities and behaviour in the Latvian bank market, identify the main factors which influence customer behaviour, and draw up proposals for banks to improve customer service. As primary data collection methods we used a self-developed survey, focus groups and semi-structured interviews with professionals in the banking sector. To obtain secondary data, the authors investigated bank websites, gathered statistical data and reviewed the literature. Quantitative primary data, gathered from customer surveys, were analysed using IBM SPSS. As a result, several groups of factors affecting customer behaviour were discovered: the security and reputation of a bank; the geographical position of a bank; operation and quality of the customer service helpdesk in a bank; marketing materials about bank products and advertisement in public space; and finally, the traditional and national values and customs of Latvian banks' customers.

THE DEVELOPMENT OF A RELIABLE AND VALID SCALE TO MEASURE CUSTOMER PERCEIVED VALUE IN THE CRAFT SECTOR

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Keywords: consumer, values, craft, entrepreneurship, measurement, scale

Today's world is witnessing economic transformation and consumers becoming more cautious about their purchasing behaviour and the choices they make. This new tendency represents a shift in the consumption of goods and services and consequently, the growing importance of intangible, soft value of goods and services displaying aesthetics, design, feelings and experiences (KEA, 2009).

The Craft sector is currently experiencing a renaissance and developing (Jakob and Thomas, 2017) mainly due to the availability of new craft supporting mechanisms, such as the internet and social media platforms for distribution and idea generation and software support for production (Jacob, 2012). Craftsmanship is regarded as an important accelerator of economic development in Latvia and crafts enterprises play an important role in innovative product development while preserving Latvian cultural heritage (Cabinet of Ministers, 2008).

To date, research in the craft sector has been scarce and there is a lack of a comprehensive approach for assessment and measurement of the outcomes of entrepreneurial endeavours in the craft sector. Thus, there is a need to develop a measurement scale, which would allow exploration of these outcomes in more detail through understanding customer perception of value gained from craft products and services. Most of the literature regarding different dimensions and types of value relate to mainstream studies with only a few studies addressing the specifics of the craft sector. This study combines research available in the area of Creative Industries, of which the Craft sector is a part, with the mainstream theoretical findings in the area of value-based approaches to entrepreneurship and consumer behaviour.

The aim of this research is to develop and test a comprehensive measurement instrument, that can be used to assess customers' perception of the value of craft products and services.

Development of the scale is based on the integration of the Theory of Customer Values (TCV) and values identified by craft entrepreneurs (results of previous research carried out by the authors).

The five types of values according to the Theory of Consumer Value (functional, social, emotional, epistemic and conditional (Sheth *et al*., 1991a, 1991b)) serve as a core framework guiding the process of constructing a more detailed scale including a set of sub-dimensions for each main value of the framework. Sub-dimensions are offered based on twelve values indicated by craft entrepreneurs. Integration of these values with the values identified through a process of the literature review resulted in fourteen values: functional (price and quality), social, heritage, cultural, regeneration, economic/ethnocentric, emotional/hedonic, aesthetic, artistic, epistemic, innovative/creative and educational, conditional/symbolic and eco/green value.

This quantitative research which was based on the Theory of Customer Values proposes a 44-item questionnaire to measure customer perceived value in 5 value dimensions and 14 sub-dimensions. The reliability and validity of the scale is assessed in a post-purchase survey of 300

craft consumers. Data analysis is done using exploratory factor analyses and SPSS software. The results prove the reliability and validity of the scale and identify 10 dimensions of customer perceived value to be used in the Craft sector.

The originality of this study is in its multi-disciplinary nature combining different theoretical and practical contributions from various fields of research and practice. This research has potential applications in practice. The developed questionnaire would be beneficial for craft entrepreneurs considering a new range of craft goods or services as well as for the development of a strategy for the promotion of the attributes and characteristics they feature. The survey could be used in the craft sector as well as in other subsectors of the Creative Industries to explore customer values and modify the business models to better meet new consumer demands.

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EMERGING MACRO-REGIONAL COLLABORATION FOR CLEANER TRANSPORTATION AND ENERGY. THE CASE OF INTEGRATING LNG VALUE CHAIN IN THE BALTIC SEA REGION

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Keywords: LNG, value chains, clean shipping, alternative fuels, strategy, clusters, Baltic Sea Region

LNG can become an innovative cross-cutting solution for stronger and more balanced regional integration and development, supporting quantification and qualification of regional innovation outputs and smart specialisation in energy, mobility, water transport and industrial modernisations sectors in the Baltic Sea Region (BSR). As a result, 'Go LNG' ERDF part-financed INTERREG V project (2016–2019) aims at stronger regional development and innovation by reducing technological, legal, institutional, knowledge and business gaps and by providing operational and strategic approach towards exploitation of LNG and value creation resulting from diversified LNG businesses. Connecting into one chain different transport and mobility modes, energy and power generation sectors, different technological solutions, customers and end-users, LNG value chains' integration and sustainability might be accelerated.

This paper builds upon the project's vision and goals to create conceptual and strategic hallmark on integrated LNG value chain. Majority of literature and practical contributions address LNG topic rather from the economic point of view, e.g. trade, price policy, transportation costs (Wood, 2012; Schinas & Butler, 2016), environmental compliance (Ma *et al*., 2012; Okamura *et al*., 2007), energy or transport technology perspective (Deng *et al*., 2004; Yoo, 2017). An integrated view of LNG for regional integration, development and innovation combining transport, mobility, energy supply as well as business value chains and clusters with focus on regional perspective is claimed to be marginalised. Just a few studies record approaches on LNG use as opportunity, value proposition leading towards emerging value chains that integrate different transport modes and business sectors, and where LNG is recognised as value proposition for all stakeholders involved. This bears a clear need to react.

The present paper envisages advanced conceptual and practical approaches on integrated LNG value chain in the BSR. It builds upon the proceeding paper on grassroots concept on emergence on integrated LNG value chain in the BSR, the research done in 2016-2017, and dwells into deeper levels of proceeding integration on LNG value chains across the region. The research path combines diverse conceptual insights pertaining to supply chains, clusters, regional integration and ecosystems as well as integrates two-fold perspective (market-based vs. resource-based view) and related theoretical concepts. Building upon these concepts, value creation and shared value creation perspective from LNG related activities in the region is discussed and a consolidated theoretical framework proposed.

The research employs qualitative research approach, in particular, regional profiles, case studies, company LNG portfolios, study visits, experts' interviews, workshops implemented in 2018-2019. Following theoretical discourse grounded on the concepts as mentioned above, the research displays and exemplifies regional LNG ecosystem, where the light is shed on the functional LNG value chain integration across the BSR and the value map of the integrated LNG value chain encapsulated.

This research delivers both theoretical and practical contributions. From the scholarly point of view, it arrives at new combinations of existing concepts and builds solid analytical basis for

LNG value chain analysis and its evaluation in the region. The developed framework can be applied and transferred outside the regional scope as well. Practitioners will benefit from the undertaken research in terms of using insights and recommendations in the future as well as dealing with alternative innovative solutions. In particular, strong governance is needed in the context of LNG to provide businesses with good framework conditions – enabling doing business, innovating, exploiting and growing. The governance needs to ensure compliance with regulatory, legislative and environmental requirements. To enable this, there is a need, however, for strong competence & skills portfolio, operational capacity (infrastructure and technology) and social capital (collaboration, internationalisation, clustering).

THE MODEL OF QUASI-RESONANT MANAGEMENT OF MANUFACTURING PROCESS WITH USAGE OF ENTROPY AND ASYMMETRY APPROACHES

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Keywords: digital production process, dissymmetry, entropy, soft real time mode, probabilistic assessment

The article explores manufacturing process management in conditions of digital transformation.

The aim of the research is to create the model of management of digital manufacturing process (DMP) on the basis of combination of dissimmetry and entropy approaches. Usage of the model allows determining the area of preventive management decisions in soft real time to improve the stability of production processes and reduce non-production costs.

Application of dissimmetry approach is based on designation of the static part in the structure of the DMP that defines conditions for its stability, and the dynamic part that ensures its development. The static part is determined by the components of technical, software and information support, including a number of intellectual property objects, which are the basis of the technology of digital production. The dynamic part is represented directly by specialists who ensure application and creation of digital technologies and implementation of production tasks. The dissymmetry approach makes it possible to determine the area of possible managerial decisions for the targeted change in the state of the static and dynamic parts and achieve the level of mobile equilibrium, in which non-production costs may be the lowest.

Application of entropy approach allows obtaining probabilistic assessment of stability of the DMP. This paper uses the definition of entropy in accordance with the probability measure of the set of states according to the axiomatic probability of A. N. Kolmogorov (Kolmogorov, 1987). Probabilistic assessment of the state of static and dynamic parts indicates the need for changes. It can be the need in increase of the potential of the dynamic part in accordance with modern requirements, or increase in the static part, or the need to move to a higher system level of digitalization.

Figure shows the structural diagram of DMP management based on dissymmetry (Parfenova and Semenov, 2015). Structural diagram includes following elements: 1 – registration of current and reference values of the parameters of the DMP, the static part (SP), the dynamic part (DP); 2 – assessment of the current state of the static and dynamic parts; 3 – determination of the reference indicators of the DMP at the current time; 4 – comparison of current and calculated (reference) values of the parameters; 5 – assessment of deviations of the current values from the reference values of the parameters; 6 – classification of situations; 7 – analysis of causal relationships; 8 – grouping and summarizing data concerning the state of the SP; 9 – assessment of the influence of the SP on the degree of criticality of the current situation; 10 – assessment of the state of the SP; 11 – grouping and generalization of data concerning to the state of the DP in accordance with the current production situation; 12 – assessment of the impact of the DP on the degree of criticality of the current situation; 13 – assessment of the state of the DP; 14 – making management decisions; 15 – determining the function of the consequences of made decisions; 16 – approval and implementation of decisions; 17 – making management decisions in targeted changes of the static and dynamic parts; 18 – assessment of the state of the DP with consideration of the generated decisions; 19 – evaluation of the level of misalignment of the changed state of

the SP in relation to the state of the DP; 20 – assessment of the state of the SP in accordance with the generated decisions; 21 – estimation of the level of misalignment of the changed state of the DP with respect to the state of the SP.

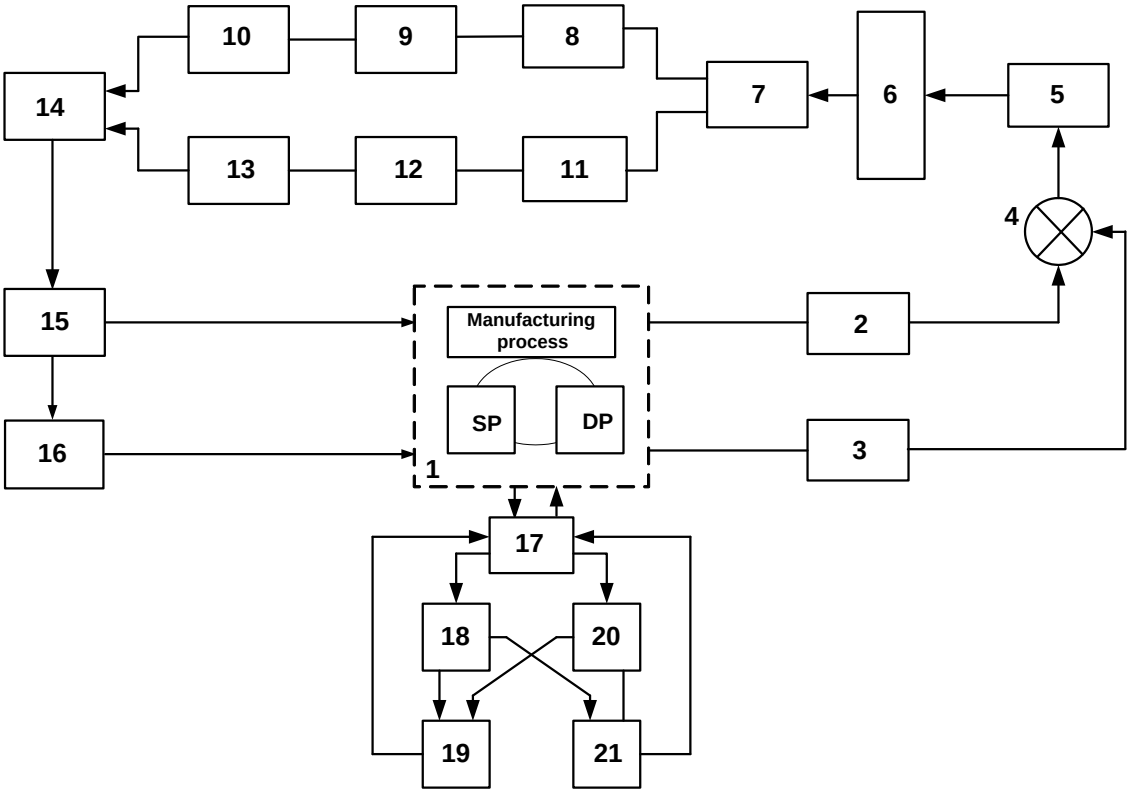

Figure 1. Structural diagram of the digital manufacturing process management mechanism on the basis of dissymmetry

Two limiting states of the DMP are considered:

- standard state S_1 – management is implemented in accordance with the regulation of information and intellectual support by means of ICT;
- state of emergency S_2 – management is implemented in case of violation in the rules for information and intellectual support by means of ICT.

S_1 and S_2 are characterized by the probabilities $P_1(t)$ and $P_2(t)$.

Let us denote the density of flows of events:

w – that contribute to the transition of the DMP from a standard state to an emergency;

m – that contribute to the transition of the DMP from an emergency to a standard state.

The current state of the manufacturing process can be represented by the system of equations of Kolmogorov (Kolmogorov A. N., 1987):

$$dP_1(t) / dt = - wP_1(t) + mP_2(t), \quad (1)$$

$$dP_2(t) / dt = - wP_1(t) - mP_2(t),$$

$$P_1(t) + P_2(t) = 1. \quad (2)$$

The solution (1) is expressed by the formula:

$$-\frac{1}{w+m} ln|m - (w + m)P_1(t)| + C = t. \quad (3)$$

For $t = t_0^*$ we obtain

$$C = t_0^* + \frac{1}{w+m} ln|m - (w + m)P_1(t_0^*)|. \quad (4)$$

Based on (3) and taking into account (4) it is possible to estimate the time interval $t - t_0^*$, for which the probability $P_1(t)$ at the current estimates of the density of event flows will change to the permissible value $P_1(t_0^*)$:

$$t - t_0^* = \frac{1}{w+m} ln \frac{|m - (w+m)P_1(t_0^*)|}{|m - (w+m)P_1(t)|}.$$

The proposed model allows reducing the entropy of emerging situations, determining the point of phase transition of the DMP from one qualitative state to another qualitative state with the lowest non-production costs, determine the area of possible management decisions and acceptable time for their implementation.

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TRANSNATIONAL RIS3 OBSERVATORY MODEL FOR SMART SPECIALISATION MONITORING ON REGIONAL, NATIONAL AND EUROPEAN LEVEL

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Keywords: Smart Specialisation, Monitoring, RIS3 observatory, Transnational Model, Regional development

Smart Specialisation approach is regarded as one of the key pillars in the funding period 2014–2020 of the European Union in order to enhance innovation capacity in Europe. The NUTS-2 level regions evaluate their implementation and rethink their individual strategies for the upcoming funding period 2021–2027 by using their individually developed monitoring systems. For a sufficient comparison of regional performance with regard to the Smart Specialisation approach, the existing monitoring systems seem to lack any comparability. The European regions act like islands when setting up, implement and monitor their Smart Specialisation strategies. Another circumstance detaining a comparable monitoring across Europe is the existence of partly regional and partly national Smart Specialisation strategies.

In the frame of the EU project SMART_watch, part-financed by the European Regional Development Fund (ERDF) within the INTERREG Central Europe Programme 2014–2020, the present paper provides a model approach to set up a monitoring system for all European regions including consideration of regional, national and European preferences. The so-called "Transnational RIS3 observatory model" increases the comparison of regional performance with respect to the Smart Specialisation approach and includes the individual economic background of the regions. Thus, the derived model addresses next to the missing theoretical concepts regarding Smart Specialisation monitoring also a practical approach applicable in the political discourse on European, national and regional level.

The research approach follows qualitative analysis (case studies) of the SMART_watch project regions. The analysis of 10 regions were used to indicate the main obstacles and provide solutions that are adoptable on any European regions on NUTS-2 level and beyond. Due to the low amount of research proposals in this particular field, the conducted model is based on theoretical concepts from cluster, benchmarking and monitoring strategies.

The developed model in the paper offers also recommendations for future implementation processes in the frame of Smart Specialisation to ensure improvements in the upcoming funding period. Practically, the innovative model and its recommendations can be used as a strategic guide for all actors in the Smart Specialisation processes and especially for the responsible policy maker on European level to improve the Smart Specialisation monitoring across Europe and thereby to foster the regional economic and innovative performance.

APPROACHES TO EVALUATION OF BANKS' FINANCIAL SUSTAINABILITY

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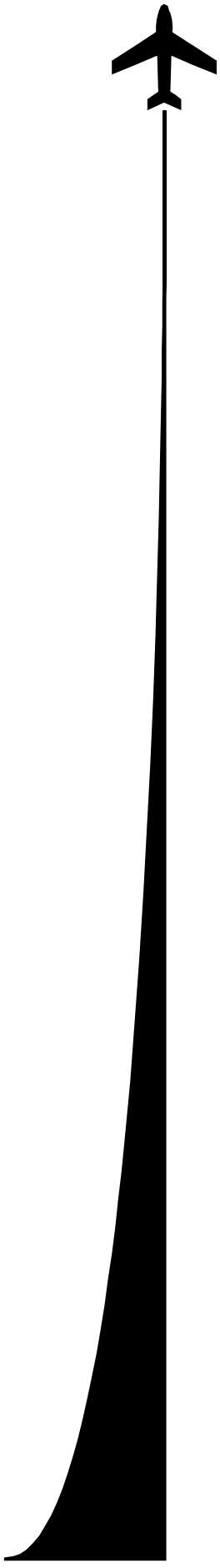
Keywords: Financial sustainability, Commercial banks, Evaluation system, Rating

Financial sustainability of a bank characterizes its ability to profitable activity pro-vided that all commitments made to the bank are fulfilled in a timely and all regulato-ry requirements are met. Financial stability of the bank is assessed by all its interest-ed parties: shareholders, managers, clients, counterparty banks, investors, regulator and the state. As a rule, these processes use a set of indicators, which can be divided into two large groups: financial indicators and business characteristics. Key financial indicators include capital adequacy, asset quality, composition and structure of the resource base, liquidity, risks, profitability and efficiency. They are all quantified and calculated from accounting reports. On the other hand, there are business characteris-tics, among which the quality of management, bank competitive position on the mar-ket, image of bank, bank 's credit history and business reputation. Business character-istics allow to take into account the impact on the bank 's sustainability of such events of its activity, the financial consequences of which are difficult to estimate on the basis of financial information only. However, these events can generally significantly affect the bank 's future cash flows. Therefore, it is necessary to use both financial indicators and its business characteristics to assess the bank 's financial sustainability. In this paper, the authors proposed a scoring methodology for the assessment of a bank, based on the CAMEL evaluation system, made calculations, using this method-ology as well as defined rating of Latvian commercial banks. Using the CAMEL methodology, the authors evaluate 5 important parameters in the activity of banks, namely, capital adequacy (C), asset quality (A), management level (M), earnings (E) and liquidity (L). The importance of each parameter was determining based on ex-perts' opinions and assessments of commercial banks. To obtain experts' opinions and assessments authors have conducted a survey among banks' specialists.



Education and Training in Engineering

DIGILOG PROJECT: DIGITALLY SUPPORTED AND VIRTUAL STUDY PRACTICES FOR MODERN LOGISTIC SYSTEMS

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Keywords: DIGILOG project, Digitalization, Transport and Logistics, e-learning

Digitalization of Transport and Logistics (T&L) is one of the key pillars of the European Digital Single Market strategy. Creation of the Single European Transport Area, from one hand, and development of Common European Education Area, from another hand, are the basis for DIGILOG (Digitally supported and virtual study practices for modern logistic systems) project supported by INTERREG Central Baltic programme. Digitalization, international approach and networking for cross-institutional study are the main priorities for development of new study modules within the frame of DIGILOG project. Enhancing e-learning and cross-curricular opportunities in universities and vocation education institutions is a way to harmonize the content of over countries, and to prepare students and trainees for working in digital and multinational environment. The DIGILOG project aims to foster interchange and cooperation between education and training systems within the frame of digitalisation of T&L under new strategy of European Union - Single European Transport Area. The partners of project are TTK University of Applied Sciences (Estonia), Häme University of Applied Sciences (Finland), Transport and Telecommunication Institute (Latvia), The Swedish National Road and Transport Research Institute (Sweden).

The main intellectual outputs of the project are described in the paper:

- Virtual and open cross-study curricula for digital environment of transport and logistics systems based on Carpe Diem learning design process;
- E-learning game-based technology for training and education of transport and logistics specialists;
- Video exercises for study of train traffic and safety management issues using simulation tools.

Main tasks, main area of activities and the main priorities of the planned study module are described in the paper.

THE ENROLLMENT MARKETING PLAYBOOK: EMPLOYING ENROLLMENT MARKETING STRATEGIES INTO STUDENT-CENTRIC, CUSTOMER SERVICE-ORIENTED RECRUITING ENVIRONMENT

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Keywords: Enrollment Marketing, Student Funnel, Marketing, Enrollment Management**,** Recruiting

Higher Education Institutions must allocate institutional resources into student-centric and customer service-oriented enrollment enhancing initiatives. Universities invest enormous funds into creating successful student experiences nevertheless still fail to meet enrollment numbers. Institutions must stay on recruiting course while rethinking enrollment marketing strategies and recognizing the significance of student funnel. Today, students and their families dictate the course of strategic marketing approaches in student enrollment management. Therefore, student admissions processes must be re-designed.

Today, when never developing and sustaining effective student funnel is critical. Many institutions struggle with ineffective recruiting data management and the speed of communications. Institutions invest a lot in boosting their market visibility, yet, forget that boosting the image does not recruit students. Most marketing campaigns will not be seen without strategically calculated STP marketing. Make no mistake that students want personal attention. A time of mass marketing in student enrollment is over. Institutions must concentrate on building strong customer relationships, strong brand awareness and creating data-driven relationships.

The objective of the study is to identify effective marketing strategies to constantly shifting student demographics. There is a huge demographic student drop that enrollment marketers must understand. They must review, analyze and generate tactics from it. Those tactics are direct indications of how institutions build student funnels. Besides, institutions must use aggressive requirements and commitments from various activities, which must constantly build and maintain recruiting student pool.

The study facilitates understanding today's enrollment marketing environment where institutions are using prohibited practices in student enrollment management, which has become a phenomenon, whether we call it a strategic marketing approach or not. The truth is that institutions, domestically and internationally are using aggressive enrollment marketing strategies. The study underlines the importance of communication and marketing speed in student enrollment management and its impact on establishing strong student funnel. It is essential to mention the role of retention in student funnel.

The study will conduct customer funnel analysis though the marketing funnel where recruiting and retention dynamics will be analyzed. The study will analyze to showcase how crucial it is to build a strong customer bond between students, marketing and admissions specialist. The study will analyze the marketing Macroenvironment that will focus on demographic analysis. It is vital to understand the consumer buying process.

The study uses a mixed-method, combination of qualitative and quantitative methods. Results from observations will be analyzed to demonstrate and support the main question. The survey obtains data from students and enrollment representatives to underline the role of employing effective recruiting strategies while building enrollment student funnel.

Data collection and analysis in the study provides significant evidence for creating the Enrollment Marketing Playbook. The enrollment marketing playbook assists institutions to balance strength and weakness in marketing and admissions initiatives. The study summarizes and recommends guidelines to anticipate and predict potential enrollment numbers. It outlines strategies that need to be used in Student-centric, Customer Service-oriented Recruiting Environment. And lastly showcases, the astonishing role of speed in student recruiting.

TOWARDS INNOVATIVE EDUCATION: DEVELOPING DIGITAL LEARNING STRATEGY IN A MODERN UNIVERSITY

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Keywords: Higher education, strategy, digitally enriched curriculum, innovative methods

In consequence of technological advances escorted by social changes, higher education stands now on the threshold of substantial renovation. New individualized and personalized pedagogical approaches, which are accompanied by the development of novel modes and methods of educational provision, are aimed at enhancing the involvement of people of different ages and backgrounds in higher education by creating more flexible learning opportunities associated with digital transformation of education. Modern universities have to create long-term institutional strategies for high-quality education and research with due account for recent developments in the global higher education market, including the so-called "digital strategies" designed in accordance with the goals and objectives set in a university's strategic plan. Digital strategies embrace a set of institutional methodologies, practices and tools for delivering a digitally enriched curriculum.

This paper aims at exploring the novel approaches, innovative educational methods and techniques utilized by a university in the frame of its digital strategy, for creating a supportive digital learning environment that would stimulate the development of transversal skills necessary for the contemporary knowledge-based economy.

The following objectives were formulated by the author: 1) to study recent developments in the higher education sector in the context of its modernisation; 2) to examine digital learning strategies that can be developed by a univer-sity for building a supportive digital learning environment; 3) to describe novel educational methods and techniques applied by a uni-versity in the frame of creating a constructive digital learning environment.

The following research methods were used by the author: 1) review of the EU official documents dedicated to recent developments in European higher education; 2) analysis of digital learning strategies of randomly chosen universities aimed at building a supportive digital learning environment.

Research implications suggest how the research findings may be used by the management for designing an effective digital strategy in the framework of a comprehensive institutional strategy aimed at reaching academic and research excellence.

THE IMPACT OF TECHNOLOGY-MEDIATED INTERACTION: EXPLORING NEW CHANNELS FOR EFFECTIVE STUDENT-LECTURER COMMUNICATIONS IN TIMES OF DISRUPTION

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Keywords: Communication, Technology-mediated Interaction, Virtual Classroom, New Reality

The Covid-19 has affected and continues to impact the global educational systems. Many Institutions were not ready to face a new reality. Furthermore, pandemic impacted global micro and macro environments. The consequences of disturbance are profound that will need the time to recover. Everything will go back to normal, however, with "New reality".

To teach and communicate in a normal, face-to-face classroom environment demands a special set of skills. It allows for creating special teacher-student relationships. With the Covid-19, the process of teaching and communication moved into virtual platforms. Zoom, Cisco WebEx, Google Meet, Big Blue Button, Microsoft teams, and so on, are just a few out of many. Technology-mediated interaction became a significant medium for teaching and communication.

Teaching various virtual platforms demands distinct interaction and engagement. If affects both, students, and teachers. Different learning and teaching styles, online and computer skills, managing learning software and so on., mandates full facilitation of learning. Though, were students and teachers ready for the sudden change? Hence, going back to normal "new reality", will entail institutions to equip teachers and students with the best tools for learning.

The success of a virtual student-teacher relationship cannot be achieved without proper communication. While computer screen isolated students and teachers, communication-enabled collaboration and sharing of learning beyond the roadblocks. Verbal, non-verbal, written, and visual communication attained new significance. Communication must be created beyond the barriers.

The research aims to study the impact of technology-mediated interaction and explore new channels for effective student-lecturer communications in times of disruption. Sooner or later, learning will go back to usual normal, however, it will not be the same. Teaching and communication in a new normal will demand efficient traditional and virtual classroom management.

To accomplish a research aim, first, the research intends to explore synchronous vs. asynchronous teaching to facilitate class sessions remotely. The study discusses the advantages and disadvantages of technology-mediated learning. Second, the research examines the major tools and functions of virtual platforms for effective classroom engagement, conversations, and participation. The study offers comparisons between live classes vs. pre-recorded vs. no video classes to draw valuable recommendations. And lastly, the research underlines the major troubleshooting tips, and how to manage them successfully. Together, students and teachers must meet overall educational learning outcomes, whether traditional or virtual. Technology- mediated interaction must become an advantage rather than a disadvantage in times of disruption.

The research applies quantitative and qualitative methods. Theoretical data is obtained and analyzed from the available literature. The study proposes to conduct peer interviews and obtain

research data on participants' experiences working in times of disruption. Several lecturers will be randomly selected for the peer interviews. Besides, the study conducts an online survey to obtain valuable information on technology-mediated interaction among students and lecturers. An online survey will ask rating, drop down, and multiple-choice style questions.

The results expect to fill the vacuum in teaching and computer-mediated communication in times of disruption. To adapt to quickly changing circumstances, educational institutions must focus on adapting their teams, goals, content, and offerings to the new reality. The research showcases the impact of technology-mediated interaction on learning. It underlines the significance of student-lecturer communications for effective classroom interactions. The research provides recommendations for universities to help to navigate in challenging times. Going back to normal means that universities must live with a new reality. Students and teachers must be equipped with the best tools to facilitate the best teaching and communication. Together, institutions, lecturers, and students must build and maintain valuable customer relationships.

SUPPLY CHAIN MANAGEMENT AND LOGISTIC DEVELOPMENT IN INTERNATIONAL CONTEXT: CHALLENGE FOR CROSS-NATIONAL EDUCATION

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Keywords: Curriculum development, Supply Chain Management, Logistics, double degree diploma

Today's geopolitical situation and Trans-European Transport Network's (TEN-T) regional initiatives are linking the region's logistics sector's needs closer together than ever. Due to the cross-border nature of the transport and joint need of regional enterprises for further integration with the European market there is a need to reduce fragmentation education in such an important area as Supply Chain Management and Logistics and requests an integrated approach to fulfil the requirements with variation in the didactical methodologies of on-campus, off-campus and blended learning approaches to achieve volatile market needs and learning-outcomes.

The authors were involved in the development of curricula for a double degree diploma in the field of Supply Chain Management and Logistics, as a pilot project of the practical use of tools for algorithm-based automation of curriculum development.

The purpose of the curricula development was threefold. First target was matching national, international, academic, non-academic and professional needs and requirements of learning-outcomes-orientated curricula and qualifications development for increasing readiness for working in the single European labour market.

Second aim was supporting the identification and satisfaction of learning needs for development of key competencies in all stages from early childhood and throughout life.

Third target was to implement up-to-date didactical methodologies of on-campus, off-campus and blended learning approaches for theoretical and practical modules to achieve volatile market needs and learning-outcomes.

VIRTUAL CAMPUS JOURNEY PERSONALIZATION

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Keywords: Visitor Journey, Customization, Personalization, Omni Channels, Campus Journey

Virtual Campus Journey applications are newly introduced to education institutes to improve the service delivery and brand promotion similar to retail e-commerce market place (EAB, 2020). Virtual journey comes hand-in-hand with the omni channel concept (Huré *et al.*, 2017) of seamless shopping experience of chosen channels (Barwitz *et al.*, 2018). These applications are taking advantage of the smartphone technology to provide easy to use any-where- any-time accessible collection of information services within a mobile App (Piotrowicz *et al.*, 2014).

Virtual journeys are available in popular e-commerce retail shopping sites. In Amazon it is named as 'my journey'. My journey is a system generated customized visitor's history of contact with products ordered from most to least visited by the customer. Customization take into account the touch points of visitor's contact with products at display in the site and do not take into account the preferences of a customer. It makes the assumption that a visited touch points are customers most preferred items in contrast to customized visitor journey, what visitor prefers to visit as a personal choice is not taken into account (Yu *et al.*, 2014).

A virtual campus tour is a journey through services such as news, sports facilities, email, library, courses and learning management, cafeterias, and many more. Also provide a significant impact on prospective student's choosing of the campus for their future studies (Rebaque-Rivas *et al.*, 2015, 2019).

This research concentrates on the active campus population of students, faculty, and staff to explore whether personalized virtual journey maps are preferred by the campus population above the system generated virtual journey map customization.

The research methodology consists of: A literature review on characteristics, concepts, principles behind journey maps, and how customization and personalization is defined within virtual journey maps. The process of benchmarking of Times top 100 universities to select 36 virtual campus journey applications to identify main characteristics and the implementation of customization or personalization within. A survey is conducted at LUT to evaluate the campus population's preference between virtual journey map personalization and customization.

The final conclusion is that the campus population prefer the flexibility to arrange their virtual journey map services by themselves. This research introduces the novel concept of personalized virtual campus journey maps for education institutes.

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NEW CHALLENGES FOR THE ENGINEERING EDUCATION SYSTEM AND WAYS OF THEIR SOLUTIONS

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Keywords: engineering education, digitalization, virtual and augmented reality, student motivation

Globalization and openness of the world in case of the emergency situations can lead to collapse in many areas and, as a result, to imbalance of economic systems. In such conditions, the educational system should maintain the stability, give an ability to overcome inertia, be flexible enough from the viewpoint of educational methods and technologies as well as the management of processes. Besides that, it should ensure the preparation of specialists who are ready to answer the challenges of the time and to work in critical conditions.

This paper analyses problems faced by the engineering education system in the era of global upheaval and issues to be solved, also their possible solutions are presented. The engineering education system has been improved in recent years through the use of e-learning. At the same time, the growing complexity of technics and technologies requires from students to develop skills of creative thinking, willingness to make informed effective decisions, social responsibility and eco-thinking.

Despite the fact that new forms of teaching have appeared in recent years, teaching staff of the most universities is still committed to the traditional forms of lecturing and organization of laboratory classes. Therefore, many of them experience stress under unusual external circumstances. It confirms the necessity to test various resources in advance, combining traditional and new ways of teaching.

Nowdays, there are many teaching tools and techniques in the field of education, including engineering. Technologies, such as virtual and augmented reality, digital twins, smart education, can improve the educational environment, increase the motivation of students and prepare them for life in the digital age. (Makarova *et al.*, 2018a) Taking into account the growing need of careful attitude to nature and natural resourses, the educational system should develop ideas of eco-thinking and social responsibility among students. Thereby, the following questions were formulated: (1) What changes in the management system of university, department and educational process should be implemented in order to increase efficiency during critical situations? (2) What changes in educational content are needed to ensure the necessary quality of education as well as involvement and motivation of students? (3) How will it be possible to use the experience gained after the crisis time?

In the author's opinion, the most effective tool to manage reactively the learning process as a complex system is a feedback. (Makarova *et al.*, 2018b) Since the educational system is very inert due to the length of the learning process, effective feedback could be an approach to overcome this inertia. The way to implement a feedback between teachers and students will be a key factor to determine the quality of educational process and student involvement. In order that teachers have a real opportunity to control the quality of this process, it is necessary to identify objective criteria for the assessment of quality in the context of the differentiation of motivational attributes. In addition, this way provides for teaching staff a possibility to evaluate the effectiveness of a particular method to influence on the motivational criteria. Such a system will be more objective

and will help to identify certain problems for an individual student or a group of students as well as within the framework of a training course or any section of a subject.

To make a correct assessment, the evaluation criteria were identified, which could be formalized, and also motivational characteristics were classified, which could have an influence on the quality improvement. As a case study, different student's groups were selected to compare their involvement in the process with traditional and online forms of learning, their performance and the impact of the learning form on the projects quality prepared by students.

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IT-PLATFORM FOR ALGORITHM-BASED AUTOMATION OF ACADEMIC STUDY PROGRAM DEVELOPMENT

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Keywords: Curriculum Development, Academic Study Programs, Automation, Natural Language Processing, Open Source, Artificial Intelligence, IT-Platform

The academic study program development process of universities in Europe and around the world is following similar approaches. There exist several workflows, from four step approaches up to seven step approaches. All of them have similar procedures with added and deleted elements. Although these frameworks exist, universities are following their own strict rules for developing new curricula. These rules differ from each other. Applying their own curriculum development processes, the work is still be done manually. It is missing an automated engine to build up modular curriculas in an intelligent way. This paper is focusing on the implementation of a concept for algorithm-based, automated curriculum development. To fulfill this task, a standardized process out of the existing approaches has been developed. In this concept, a methodology for the modularization of curriculum content was implemented. Therefore, a database model (knowledge-database) has been created. Combining these elements with artificial intelligence matching algorithms such as Natural Language Processing and an IT-platform based on open source modules leads to a suitable methodology for the implementation of an automated curriculum development process. Future research activities will focus on the development of a technological demonstrator for the described approach.

THE STUDY OF STUDENTS' OPINION ON LEARNING ONLINE IN THE SELF-ISOLATION PERIOD

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Keywords: COVID-19, study process, self-isolation, online learning, students' satisfaction

Covid-19 pandemic gave rise to a lot of problems in the work of Higher Education Institutions all over the world. The difficulties concerned the predicament in the study process organisation (Marinoni, Van't Land, Jensen, 2020). In connection with the emergency situation the governments of most countries made a decision to suspend all types of contact training sessions in the lecture halls and laboratories in order to curb the spread of COVID-19. All the reading halls, libraries were closed. This measure caused the difficulty in the organisation of different kinds of field trips in organisations.

Higher Education Institutions, as providers of education services where full-time education is the standard mode of education, reacted in diverse ways: from giving no response at all or to the strategy of full social isolation at home or on campus, and a rapid restruction of study programmes that would be suitable for the conditions of online education (Crawford *et al*., 2020; BBC News, 2020; Krishnamurthy, 2020). There were a lot of diverse discussions held, questionnaires were conducted, and scientific research on this problem started.

A lot of questions, which needed close consideration and making quick decisions, arose. The most urgent and important question was: what methods and forms of edu-cation to use in the period of COVID-19 pandemic, which ones will be the most effective? How to conduct tutorials practical and laboratory works? Another important issue under discussion was the psychological state of the students who were forced to change their habitual way of life and studies: to stay indoors, to spend all the scheduled study hours at the computer. Another important psychological aspect is isolation when there is no real interaction with other students (chat rooms are not taken into consideration), when students feel partially deprived of everything that actually constituted their personal environment. The situation with foreign students, who really found themselves in total isolation) needs a lot of special attention.

Besides that, a lot of lecturers and tutors discuss the question how to raise students' motivation for studies, how to help them with time management in the period of self-directed learning activities.

One more important issue is how to assist the teaching staff most of whom, though digitally literate, do not have enough experience and relevant methodical work-outs to teach on line. They have to restruct all the materials to suit the demands of online education and in order to provide an effective feedback on the part of the students.

The main aim of the present research is the study of the particular features of the study process, the difficulties that both students and the teaching staff come across in the course of self-isolation time and studies online. The research was conducted by the teaching staff of the Chair of Humanities in the Transport and Telecommunication Institute. The empiric method was used. The questionnaire was compiled and offered to students. The authors offer several recommendations which are aimed at the improvement of the study process in the changing conditions.

The knowledge of the problems and the difficulties which the students face will help the teaching staff to adapt the existing teaching practice to an online frame, and proceeding from the experience we have acquired during the self-isolation period, to improve the existing methods and to introduce new methods how to support the students in self-guided learning, which approach to choose and how to facilitate collaboration. We sincerely hope that the results of our research might be interesting and useful for other Higher Education Institutions.

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NURTURING M-LEARNING FOR PROFESSIONAL DEVELOPMENT THROUGH ONLINE DIGITAL COMMUNICATIONAL CHANNELS DURING COVID-19 PANDEMIC

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Development of the technology has its impact on every aspect of human life. 21st century being called the "Information Era" underlines the importance of the technology and online communicational channels.

M-learning has been defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices" (Crompton, 2013). As stated by Trique et al. (2018) after emerging the smartphones a lot of other technological things have moved to the shade of the history (Trique & Ali, 2018). Mobile devices being easily accessible and usable makes learning process more interesting and desirable. Besides, internet marketing and online communicational channels being developed continuously have been supporting and motivating people interested in professional development.

The world now is digital. Nowadays society spend more time on internet as it was in the past. According to statista.com (Clement, 2020) unique mobile users in April 2020 were 4.2 billion and active mobile social media users were 3.76 billion worldwide. In the annual data of 2019, 132 minutes were indicated as the daily time spent average via mobile. (Clement, 2019)

Digital transformation created monumental opportunities for all businesses globally. Digital world, becoming faster and easier, gives society numerous possibilities to benefit from it. Using digital online communicational channels increase brand's online visibility. Social media marketing channels such as: Facebook, Instagram and LinkedIn assist companies to reach their potential customers. Being active on social media increases customer engagement, build and maintain strong relationship toward customers. There are various organic and paid online channels that stimulate customer involvement in the offered campaigns.

Demand on M-learning has been dramatically increased under conditions of the world lockdown caused by the novel coronavirus. Furthermore, so-called "network society" and organizations have identified the significance of M-learning, that was less demanding previously.

The current article is going to investigate, how have the online communicational channels stimulated M-learning during world pandemic COVID-19.

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TELEPRESENCE ROBOT AS A TEACHER'S ASSISTANT UNDER PANDEMIC CONDITIONS

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Keywords: telepresence robot, teacher, pandemic

A coronavirus pandemic has affected almost all areas of people's lives. It adjusted the work of educational institutions. In particular, Latvian universities were forced to reformat the educational process urgently: all full-time classes were temporarily transferred into the online environment.

Distance learning can be quite effective; nevertheless, the difficulty is the organization and conduction of laboratory and practical classes. Under the conditions of weakening the strict quarantine regime, the universities might allow students to attend practical classes in person. To do this, it is necessary to reorganize the training rooms following the observance of security measures by ensuring sufficient physical space between practicing students. However, the teacher remains the most vulnerable in these conditions, since it is almost impossible to be in compliance with all the requirements of the social distance in classroom, when the interaction with students is essential. Besides, to reduce the risk of infection, the student groups are divided into subgroups and seated in different audiences, so the teacher physically cannot give attention to all students.

The use of the Telepresence Robots might be the solution for this situation. Some educational institutions use Telepresence Robots, but mainly as a potential solution that allows the students to attend the classes remotely, in case they do not have the opportunity to participate in person for various reasons. For example, Double, Beam and Kubi models have shown good results while being tested in the training process (Bell, 2017; Cheung *et al.*, 2018). However, these robots can also increase the efficiency of laboratory exercises, and not only in the remote mode. They can also be successfully used by the teacher face-to-face with students in complex epidemiological conditions. Thanks to Telepresence Robots, the following features will be used:

- The teacher can see, hear and talk with students while remaining in his own place or even remotely, while controlling the point of view.
- With the help of the Telepresence Robot, the teacher can move around the audience and observe the actions of students from several viewing points, not only single.
- Moving from classroom to classroom, the teacher can provide the laboratory classes in different rooms at the same time.
- The presence of a video transmission channel from teacher to students allows the teacher to demonstrate the correct methods of working with laboratory equipment, observing the conditions of social distance.
- Moreover, the Telepresence Robots permit to avoid the problem of asynchronous learning, which is typical for distance format. Immediate feedback from the teacher will help to prevent the formation of psychological turmoil, anxiety and insecurity in students caused by a sense of alienation and isolation.

Certainly, the use of Telepresence Robots requires certain conditions:

- It is necessary to carry out the system installation and technical support for various classrooms, which requires additional time and resources.
- The remote use of robots involves WiFi employment and a high-speed Internet connection.
- It is necessary to train teachers to manage the robot and technical staff – to solve the potential technological problems.

- And, certainly, ensure the compliance with safety regulations.

Despite some apparent difficulties, the Telepresence Robots can bring undoubted benefits to simplify and automate the learning process in pandemic circumstances. The teacher will not be at risk of contracting the virus. For students, in addition to protecting their health, the use of the Telepresence Robots can create the effect of an active physical presence of a teacher in the lecture hall and will not be associated with many psychological and ethical problems that arise when using robotic lecturers, robots-companions, etc (Sharkey, 2016).

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