Short presentation of research project

HRZZ Croatian Science Foundation

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Principal investigator: Prof. Domagoj Lanc, D. Sc.
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Local project leader at University of Rijeka: Prof. Gordan Jelenić, D. Sc.

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Project manager at the Faculty of Engineering, University of Rijeka: Prof. Roko Dejhalla, D. Sc.

- 10044221 – MARITIME ENVIRONMENT-FRIENDLY TRANSPORT SYSTEMS - METRO

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FIXED-POLE CONCEPT IN NUMERICAL MODELLING OF COSSERATS' CONTINUUM - FIMCOS

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Summary:
The project considers an alternative continuum theory called *Cosserats'* or *micropolar* within the framework of the so-called *fixed-pole description* with the aim of providing accurate and efficient finite elements for numerical simulation and parameter identification.

Objectives:
The finite elements are being developed by pursuing a set of research objectives consisting of linear and non-linear static and dynamic analysis as well as field-method parameter identification. The objectives are planned to be reached through a series of research, training and management activities and communicated to the professionals and general public using a variety of dissemination channels involving scientific journals, thematic conferences, and public events.

Background:
Cosserats' continuum theory is a generalisation of classical Cauchy's theory, in which couple stresses exist at the particle level. It can describe certain experimentally observed phenomena, which the classical theory cannot and is particularly applicable to natural and man-made materials with internal structure. The theory itself is well known, but reliable experimental methods to characterise the material are still missing, as are also robust and reliable numerical procedures, in particular in non-linear analysis. The fixed-pole description relies on defining all the couples that exist in the system with respect to a unique point of reference – the fixed pole – and provides new avenues for development of alternative finite-element interpolation. In 2D and 3D Cosserats' theory, however, it has not been as yet satisfactorily exploited.

Methodology:
Cosserats' theory will be re-written in the fixed-pole description with a specific aim to develop virtual-experiment tools for parameter identification and simulation tools for engineering analysis. The finite-elements will be verified against existing and newly developed analytical solutions and then employed to enable inverse identification of the Cosserat material parameters from a couple of own experimental setups (pure-bending test and stress-concentration test).

Implementation:
The objectives will be reached through a series of research, training and management activities led by the three senior members of the team. Post-doctoral and doctoral researchers are vital members of the team, who are employed on the project full-time and trained to boost their career perspectives through research workshops and study visits.

This research has been fully supported by Croatian Science Foundation under the project IP-2019-04-3607.

MODELLING AND SIMULATION IN DEVELOPMENT OF ADVANCED MATERIALS - SIMMAT

Principal investigator

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Team members

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Project activities through first year resulted in:

A thorough analysis of available data and information sources, which cover the foundations of the observed areas was conducted and a reported. The analysis was conducted in three directions with brief conclusions:

1. Composites (so far lack of scientific work has been recorded on identification of the mechanical properties of additively produced composite structures through loading and unloading of test specimens, which has prevented conclusions about the zones of elasticity, plasticity and deformation range around which the greatest damage is expected. Using optical methods, it is planned to acquire the data on displacements on the test specimens surface and to present resulting deformations and information on the change in the value of the Poisson's ratio with respect to the loading conditions)

2. Titanium alloys (The choice of commercially available titanium alloys in powder form is still very limited. Systematic investigations of static and dynamic mechanical properties of Ti - xCu alloys produced by selective laser melting have not yet been conducted or publicly available. Systematic investigations of mechanical properties are crucial for defining the potential field of application of these advanced additive titanium alloys. Despite the significant difference in the absorption energy of laser radiation and thermal conductivity of titanium and copper, it was found that it is still possible to produce Ti-5Cu and Ti6Al4V - xCu alloys by proper choice of SLM process parameters. The energy density of the laser beam, the final mechanical properties of metallic materials are certainly influenced by the orientation of the test sample, scanning strategy and heat treatment)

3. Photoelastic materials (Experimental tests on photoelastic models produced by additive technologies are justified, given that no test results have been found in the literature on models produced by this technology. It uses photopolymers that are expected to have good optical and mechanical properties combined with selected DLP (Digital Light Processing) additive production technology. The main characteristics of the selected "bottom-up" DLP technology are precision, speed for polymerization of the entire layer at once, specific surface roughness and in case of incomplete polymerization anisotropy of products caused by pixelation of projected photography, dimensional irregularities caused by the necessary supports, and residual stresses that occur during the detachment of the layer from the vessel.)

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DECISION SUPPORT SYSTEM FOR GREEN AND SAFE SHIP ROUTING - DESSERT

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Project summary
The goal of the research in a frame of project DEcision Support System for green and safE ship RouTing – DESSERT is the development of an effective Decision Support System (DSS) is planned for ship captains as well as machine commanders, which would contribute to "greener" and safer navigation of ships. The ultimate impact of such a DSS would be to make human error as small as possible, or to provide responsible persons on board the most credible data and guidance during navigation to reduce environmental pollution and make people and cargo safer.

Research related to the development of DSS will take place in two main directions: energy-efficient navigation along with reduction of greenhouse gas emissions; and increase sailing safety by collision avoidance as well as from timely reactions in the event of flooding.

The objective is to develop decision support system on board taking into accounts the environmental issue, creating a so called safe and eco-efficient or “green” ship. The project team consists of the scientists who are experts in the naval architecture, mechanical engineering, marine engineering field and computational sciences which allow solving this problem multidisciplinary.

This research has been fully supported by Croatian Science Foundation under the project IP-2020-02-3770.

MACHINE LEARNING FOR KNOWLEDGE TRANSFER IN MEDICAL RADIOLOGY

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Project summary:
Medical radiology is often used in clinical analysis to establish a medical diagnosis in a non-invasive manner. By considering the morphological properties of the observed area, clinicians can determine the presence of an injury or a disease without the need for invasive surgery. The purpose of computer-aided diagnosis (CAD) is to help physicians with interpreting the recorded data. Recently, the use of machine learning techniques has begun to grow rapidly in this area, increasing the accuracy of manually-crafted models, or even entirely replacing them. A recent apparent increase in the use of these techniques in medical image analysis has been facilitated due to a wider availability of data, increased computer processing power, and a more significant progress achieved through the use of deep-learning techniques in machine vision applications. This development, in turn, has created the potential for introducing significant changes to biology and medicine, both in the laboratory and in the clinic. One of the essential advantages of machine-learning techniques, in comparison to the filtering techniques, in medicine, lies in their ability to unearth new procedures for diagnosing diseases, such that have been inconceivable so far. Additionally, due to the complexity of modelling specific conditions, closely related to patient's characteristics, machine-learning techniques are increasingly becoming an essential factor in the implementation of personalized medicine in the clinic. The proposed research will advance existing knowledge concerning modelling for medical image analysis, by introducing a common transfer-learning platform for building more accurate predictive models, intended to automate disease and injury detection procedures in medical CAD systems, ultimately resulting in improved health care.

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This research has been supported by the Croatian Science Foundation under the project IP-2016-06-4095.

ENHANCEMENT OF THE HEAT EXCHANGER ENERGY EFFICIENCY - HEXENER

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Project summary
The research topic of the project is enhancement of the heat exchanger energy efficiency. Investigations will focus on the analysis of heat transfer and the enhancement of energy efficiency of various fin and tube heat exchangers, as well as of the latent heat storage unit as a special type of heat exchanger. Scientific research objectives include: numerical and experimental investigation of the influence of the heat exchanger geometry characteristics on the physical process of heat transfer and efficiency, numerical and experimental investigation of the influence of the heat exchanger operating conditions on the physical process of heat transfer and efficiency, numerical and experimental investigation of the influence of the latent heat storage operating conditions, geometry and phase change material characteristics on heat transfer and efficiency, as well as analysis of energy storing in the renewable energy system with the latent heat storage unit. The expected scientific contribution of the research is the increase of the existing scientific knowledge related to the energy efficiency of fin and tube heat exchangers, latent heat storage as a component of the system and the overall system of renewable energy sources with the latent heat storage.

HEXENER accomplishments during recent period
For the purpose of research on the latent thermal energy storage unit, test system has been established, containing the latent heat storage unit coupled with existing renewable energy system. Test system was implemented in the Laboratory for Thermal Measurements of the Department of Thermodynamics and Energy Engineering at the University of Rijeka, Faculty of Engineering. A vertical shell-and-tube latent heat storage unit was designed, consisting of 19 flat finned tubes, each containing 8 longitudinal fins, offset by 45° angle. Heat transfer inside the unit occurs between the heat transfer fluid (HTF) and the phase-change material (PCM, paraffin RT 25), the latter enabling latent heat of melting to be stored. The system consists of 18 kW water-water heat pump, two 300 l inertial tanks, HTF piping system and test zone with hydraulic regulation of HTF inlet temperature as well as measuring equipment. A series of measurements for melting and solidification processes of phase-change material has been performed for various water inlet temperatures. Results of the investigations have been published in scientific journals and conference proceedings.

More information about HEXENER is available on the project web page http://www.riteh.uniri.hr/en/science/research-and-projects/hexener

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NONLOCAL MECHANICAL MODELS OF NANOBEAMS
NonNano

Project Summary: This research project aims to develop advanced non-local models of nanobeams suitable for more realistic simulation of the mechanical behavior of nanostructures. The motivation for this research stems from several shortcomings in the majority of results presented in the literature. Two of them need to be highlighted. A widely used gradient-based non-local beam formulation is prone to paradoxical results when applied to some basic bending problems. The other problem is related to the mechanical properties needed to obtain results similar to those obtained experimentally or by molecular dynamics simulations. The most important mechanical property is the nonlocal parameter, but its exact value for a given material is still subject to many uncertainties. To overcome the above paradoxes, the stress-driven integral formulation is used. This is a new and promising approach that does not suffer from the problems described above. In order to achieve a realistic mechanical behavior, the discrete nature of the nanostructures must be taken into account. Although isothermal deformation of nanobeams will be the starting point, the focus will be on non-isothermal processes. In particular, these will include important extensions to dynamic effects, as well as to composite materials. The resulting formulations will be used to develop a novel non-local beam finite element, which will be implemented in the finite element software Abaqus. The new finite element will be used to perform a series of simulations to obtain topologically optimal structures with tailored properties.

Research Group (all from the University of Rijeka, Faculty of Engineering unless otherwise stated):

Principal investigator:	Prof. Marko Čanađija, D. Sc.
Academic staff:	Assoc. Prof. Marino Brčić, D. Sc., Assist. Prof. Stefan Ivić, D. Sc., Assist. Prof. Ante Skoblar, D. Sc, Lect. Neven Munjas, D. Sc. (Istrian University of Applied Sciences)
Assistants:	Asist. Nikola Anđelić, D. Sc., Asist. Martin Zlatić, mag. ing. mech., Asist. Valentina Košmerl, mag. ing. mech.

Results: Several journal articles were published in the first year of the NonNano project. The publications present analytical non-local beam models targeting composites and homogeneous materials in isothermal and non-isothermal environments, considering both static and dynamic loads. Nikola Anđelić defended his dissertation on graphene-based nanosensor. Valentina Košmerl joined the research group, funded by another HRZZ PhD funding programme.

Journal Papers:

Barretta, R.; Čanađija, M.; Marotti de Sciarra, F. Nonlocal Mechanical Behavior of Layered Nanobeams. Symmetry, 2020, 12, 717.

Barretta, R.; Čanađija, M.; Marotti de Sciarra, F. On thermomechanics of multilayered beams. International Journal of Engineering Science, 2020, Article 103364.

Barretta, R., Čanađija, M., Marotti de Sciarra, F., Skoblar, A., Žigulić, R. Dynamic behavior of nanobeams under axial loads: Integral elasticity modeling and size-dependent eigenfrequencies assessment. Mathematical methods in the applied sciences, 2021, 1–18.

Croatian Science Foundation

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DEVELOPMENT OF MACHINE LEARNING-BASED MODELS FOR MATERIALS BEHAVIOR ESTIMATION - MADEIRA

Principal investigator

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Project team members

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Assist. Prof. Jelena Srnec Novak, D. Sc.
Assist. Lovro Štic
University in Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia
Assist. Prof. Andrej Žerovnik, D. Sc.

Host institution

University of Rijeka, Faculty of Engineering, Rijeka, Croatia

Project duration

2020-2024

Project summary

Materials modeling is a key part of modern product development and computer simulations which are performed in order to improve material utilisation and reduce weight and costs. The main prerequisite for successful materials modeling is knowledge of its behavior and properties. Their experimental determination is the most accurate, but it is long-lasting and expensive, and there is a trend to perform as few experiments as possible. The MADEIRA project addresses the lack of material data and behavior parameters needed for numerical simulations which is one of the major obstacles to wider use of advanced material models in the industry. Proposed research aims at the development of advanced machine learning-based models for estimation of material behavior and related parameters as a solution for mentioned problems. Based on results of materials research and data collected from published sources and results of own experiments, complex relationships between properties and behavior of the materials will be systematically analyzed, identified and mapped at different levels. Existing models for estimation of advanced monotonic, cyclic and fatigue parameters will be improved and new ones developed. Mathematical models of thermal processes of metals and prediction of their mechanical properties after heat treatment will be further improved. The applicability of different machine learning-based methods for estimation of parameters of advanced constitutive material models will be investigated which, due to the large number of required material parameters, are rarely applied in industrial practice. Developed database and predictive models should contribute to the wider application of material behavior modeling and computer simulations, and the established methodological framework and principles of machine learning may be useful and applicable for the development of predictive models in other fields of material research and application.

Project website

http://www.riteh.uniri.hr/znanost/istrazivanje-i-projekti/modeli-procjene-ponasanja-materijala-temeljeni-na-strojnom-ucenju/

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SEPARATION OF PARAMETER INFLUENCE IN ENGINEERING MODELLING AND PARAMETER IDENTIFICATION – SEPAEMPI

Principal investigator : Prof. Ivica Kožar, D. Sc., Faculty of Civil Engineering, University of Rijeka.

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The main goal

The material under consideration is a composite material consisting of high performance concrete matrix with embedded (steel) fibers. In order to make an effective model, parameters have to be identified from experiments, e.g., using inverse procedures. The two main project goals are separation of influence of the friction forces in FRC (Fiber Reinforced Concrete) and relating the 3-point bending and pull-out models for fibers (in FRC). Our parameter identification model is going to separate friction forces from plastic forces (straitening of fibers during pull-out) in bond-slip behaviour of fibers.

Theoretical background

Novelty of the proposed project is development of a procedure that could separate the influence of certain parameters in the model. There are methods that are already used for that purpose but are not suitable for civil engineering materials because they are based on large data sets. Here, we do not have a vast number of test results; we are going to overcome the problem by producing own experiments and procedures based on a combination of deterministic and stochastic material description.

The main difficulty in determination of parameters and loading is that in most cases they could not be directly measured, e.g., wind loads, and similar. In most cases we measure displacements, velocities or accelerations or a combination.

Special procedure has to be formulated for extraction of relevant parameters from indirect measurements, the so called "inverse procedure". The main difficulty with inverse procedure is that it is generally unstable, i.e., sensitive to errors in measurements. The new model presents a generalization of the previous model since now we are dealing with a mixture of deterministic (bending formulation) and stochastic parameters (fiber pull-out behaviour). It is a novel numerical model for steel-fiber reinforced concrete under static and dynamic loading.

Croatian Science Foundation

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ESTIMATION OF LIMIT LOAD CAPACITY OF ENGINEERING STRUCTURES - LOCAPES

(**Principal investigator** Prof. Domagoj Lanc)

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Project summary

The new trends in design, unlike conventional approaches, require the permanent expansion of technical knowledge horizons and the development of new advanced estimation algorithms. Beside the experimental testing as surely the most reliable and most effective approach, numerical simulations, due to considerably lower costs, impose as the necessity. Since the proper choice of materials is of crucial importance in the design phase, experimental determination of material features is extremely important. For some of the conventional materials, mechanical parameters are available in the literature but the emergence of the innovative material requires the new experimental testing. The contribution of this project is partially conceived with this goal. Experimental research of material properties and their behavior, particularly under specific conditions, is of utmost importance for the use of materials under appropriate exploitation conditions.

The large portion of research will be dedicated to the development of new and upgrading of existing numerical simulators for spatial beam structures, with a particular emphasis on thin walled beams made of composite materials e.g. laminates, functionally graded etc. in the extreme conditions such as elevated and reduced temperature and humidity. The main aim of the simulations will be to estimate the load carrying capacity of structure, or to predict the occurrence of the limit state with the respect of the reasons of collapse.

References selection of project first year

1. Brnić, Josip; Kršćanski, Sanjin; Brčić, Marino: Mechanical Behavior Analysis of Stainless Steels Subjected to Uniaxial Stress Tests // IOP conference series. Materials science and engineering, 840 (2020), 1; 012012, 6
2. Lanc, Domagoj; Ivančić, Ivana; Katalenić, Mihael: Buckling analysis of columns made of functionally graded materials via Rayleigh-Ritz method // International scientific journal Mathematical modeling, 1/2020 (2020), 1; 18-21
3. Brnić, Josip; Brčić, Marino; Kršćanski, Sanjin; Niu, Jitai; Chen, Sijie; Gao, Zeng: Deformation Behavior of C15E + C Steel under Different Uniaxial Stress Tests // Metals, 10 (2020), 11; 1445, 19
4. Banić, Damjan; Turkalj, Goran; Lanc, Domagoj; Kvaternik Simonetti, Sandra: Posmično deformabilni gredni model za analizu stabilnosti tankostjenih grednih konstrukcija s kompozitnim poprečnim presjekom // 10. susret Hrvatskog društva za mehaniku, Slavonski Brod, Hrvatska, 2020.
5. Brnić, Josip; Kršćanski, Sanjin; Brčić, Marino: Comparison of responses of different types of steel alloys under the same loading and environmental conditions // Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications, N (2021), 1-9
6. Kršćanski, Sanjin; Brnić, Josip: Virtual Crack Closure as a Method for Calculating Stress Intensity Factor of Cracks in Metallic Specimens // Materials Design and Applications III / da Silva, Lucas F. M. (ur.). Cham: Springer, 2021. str. 29-45
7. Brčić, Marino; Kršćanski, Sanjin; Brnić, Josip: Rotating Bending Fatigue Analysis of Printed Specimens from Assorted Polymer Materials // Polymers, 13 (2021), 7; 1020, 11

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JOINT TRAINING OF NUMERICAL MODELLING OF HIGHLY FLEXIBLE STRUCTURES FOR INDUSTRIAL APPLICATIONS - THREAD

Project beneficiaries:
Martin Luther University Halle-Wittenberg (Germany, Co-ordinator), University of Liège (Belgium), Norwegian University of Science and Technology (Norway), Centrale Supélec (France), University of Seville (Spain), University of Innsbruck (Austria), University of Rijeka (Croatia), Friedrich Alexander University Erlangen-Nuremberg (Germany), Fraunhofer ITWM (Germany), Centre for Computational Continuum Mechanics C3M (Slovenia), École Nationale Supérieure d'Arts et Métiers (France), University of Ljubljana (Slovenia)

University of Rijeka project team:
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Highly flexible slender structures are essential parts of high-performance engineering systems. The complex response of such structures in real operational conditions is far beyond the capabilities of current modelling tools that are at the core of modern product development cycles. THREAD brings together young engineers and mathematicians who will develop mechanical models and numerical methods for designing highly flexible slender structures, and support the development of future virtual prototyping tools for products where such structures have a key role in functional system performance. A group of fourteen Early Stage Researchers (ESRs) receive comprehensive training covering state-of-the-art research topics along the modelling of highly flexible slender structures within their individual research projects as well as valuable transferable skills.

The project to be conducted in Rijeka is entitled *Stable long-term numerical integration of the Cosserat rod problem in large overall motion* and it deals with in-depth non-linear static and dynamic analysis of behaviour of satellite aerials during the launch phase and in the operating conditions. The industrial partner on the project is the Slovenian centre for excellence in space technologies *Space SI* from Ljubljana.

In order to eject a satellite into a stable orbiting motion around the Earth, its carrier rocket needs to attain the 1st cosmic velocity (nearly 30.000 km/h), for which a vast amount of power is needed, making each launch a very costly undertaking. While the satellite mass is an obvious parameter influencing its contribution to the total cost, the volume it occupies within the rocket is also of importance. To reduce this volume, we will numerically analyse the possibility that a satellite is packed within the rocket with its aerials bent, which should straighten without any plastic deformation or damage upon expulsion of the satellite into the orbit. To provide for this, we will develop stable and robust numerical integrators for motion of the satellite aerials both on-board, when they are highly strained and subjected to large inertial forces and high-frequency vibration in a confined space, as well as in its operational orbiting condition, when they experience large spatial rotation.

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MARITIME ENVIRONMENT-FRIENDLY TRANSPORT SYSTEMS - METRO

Project manager at the Faculty of Engineering, University of Rijeka: Prof. Roko Dejhalla, D. Sc.

The Italy-Croatia Cross-Border Cooperation Programme 2014-2020 is the financial instrument supporting the cooperation among the two European Members States territories overlooking the Adriatic Sea. The focus of the priority axis 4 - Maritime Transport - is developing and improving environmentally-friendly (including low noise) and low-carbon transport systems, including inland waterways and maritime transport, ports, multimodal links and airport infrastructure, in order to promote sustainable regional and local mobility. As part of the CBC Programme, on January 1, 2019, the project Maritime Environment-friendly TRanspOrt systems (METRO) was started. The leading partner is the University of Trieste – Department of Engineering and Architecture, while the other partners from Italy are Port Network Authority of the Eastern Adriatic Sea and Wartsila Italia S.p.A. The partners from Croatia are Tehnomont Shipyard Pula d.o.o., University of Rijeka - Faculty of Maritime Studies, University of Rijeka - Faculty of Engineering and Istrian Development Agency - IDA d.o.o.

Considering from a technological standpoint, one of the goals of the project is the development of hybrid short and medium-sized vessels and of interest are Ro-Pax and double-ended ferries, which are the most common types of coastal vessels for passenger and vehicle transport in the Adriatic. The Faculty of Engineering Faculty in Rijeka is included in the project within work package 3 - Hybrid vessels study and demonstrators. The activities of the Faculty of Engineering Faculty in Rijeka specifically refer to the double-ended ferry and Ro-Pax vessel's hull structure and hydrodynamics. The structural analysis is based on the initial structure calculations done by Tehnomont Shipyard Pula d.o.o., which has defined the midship section for both double-ended ferry and RoPax vessel. Based on this, the rest of the structure was defined according to the Bureau Veritas classification society rules. After the overall structure was defined, in order to analyse the structure, the 3D structural models were prepared which were afterwards imported into the software for FEM analysis. Nine different global FEM analyses were run for the double-ended ferry and three for the Ro-Pax vessel. Within the work package the resistance and propulsion characteristics of developed vessels were also determined. The hull forms developed by Tehnomont Shipyard Pula d.o.o. were analyzed using the software for computational fluid dynamics simulation. Both vessels were analyzed both at the model and full scale, and the results indicate favorable hydrodynamic characteristics. Furthermore, for both developed vessels analyses of propulsion characteristics were performed and it can be concluded that both vessels with selected propulsion engines can achieve the predicted speed for navigation on selected routes. Numerical seakeeping analyses of both vessels were also performed in order to check motions and responses of vessels during voyages. For the double ended ferry, which is intended to sail on the route between Brestova and Porozina, wave headings are limited with the wind direction that is dictated by the sea passage Vela Vrata and no significant peaks of motions were found. The RoPax vessel is intended for voyage between Split and Ancona, and no significant motions were found too.

The main result of the METRO project will be the improved quality, safety and environmental sustainability of maritime transport for tourism purposes in the North Adriatic, achieved through enhancing knowledge sharing between industry and academic partners and a more integrated framework for adopting sustainable modes of transport.

More information about METRO is available on the project web sites:

https://www.italy-croatia.eu/web/metro
http://www.riteh.uniri.hr/znanost/istrazivanje-i-projekti/metro/
https://www.facebook.com/MetroEUproject/