**Short presentation of research projects**


Principal investigator: Prof. Jasna Prpić–Oršić
* 3739 - DECISION SUPPORT SYSTEM FOR GREEN AND SAFE SHIP ROUTING – DESSERT–

Principal investigator: Prof. Anica Trp
* 4095 ENHANCEMENT OF THE HEAT EXCHANGER ENERGY EFFICIENCY – HEXENER

Principal investigator: Prof. Domagoj Lanc
* 8615 - ESTIMATION OF LIMIT LOAD CAPACITY OF ENGINEERING STRUCTURES – LOCAPES

Principal investigator: Prof. Marina Franulović
* 3607 - MODELLING AND SIMULATION IN DEVELOPMENT OF ADVANCED MATERIALS – SIMMAT

Principal investigator: Prof. Gordan Jelenić
* 1732 - FIXED-POLE CONCEPT IN NUMERICAL MODELLING OF COSSERATS' CONTINUUM


Project manager at the Faculty of Engineering: Prof. Roko Dejhalla
* 10044221 - MARITIME ENVIRONMENT-FRIENDLY TRANSPORT SYSTEMS - METRO


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## DECISION SUPPORT SYSTEM FOR GREEN AND SAFE SHIP ROUTING – DESSERT

**Principal investigator (**Prof. Jasna Prpić–Oršić, D. Sc., Faculty of Engineering, University of Rijeka)

### 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.

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# ENHANCEMENT OF THE HEAT EXCHANGER ENERGY EFFICIENCY – HEXENER

**Principal investigator** (Prof. Anica Trp, D. Sc., Faculty of Engineering, University of Rijeka)

**Team members**:
Prof. Kristian Lenić, D. Sc., Prof. Branimir Pavković, D. Sc., Assoc. Prof. Igor Wolf, D. Sc., Assist. Prof. Paolo Blecich, D. Sc., Assist. Prof. Igor Bonefačić, D. Sc., Asist. Prof. Boris Delač, D. Sc., Assist. Prof. Vladimir Glažar, D. Sc., Asist. Josip Batista, Assist. Mateo Kirinčić, Assist. Fran Torbarina, Faculty of Engineering University of Rijeka

## 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

A test system for experimental research of the influence of heat exchanger geometry on heat transfer, has been established. It was used for experimental research on the microchannel fin-and-tube heat exchanger. Measurements have been performed for a wide range of air and water inlet temperatures and velocities. Further, the test system has been adapted and experimental research of influence of operating conditions on heat transfer in fin-and-tube heat exchangers has been carried out. An open type air tunnel is used. The test system consists of air conditioning unit, air ducts, working fluid pipe system and the heat exchanger test zone. Based on experimental investigations, numerical analyses of the influence of heat exchangers geometry as well as operating conditions on heat transfer have been performed. For the purpose of research on latent thermal energy storage, the test system has been established, containing the latent heat storage tank coupled with existing renewable energy system. A vertical shell-and-tube latent heat storage tank was designed, consisting of 19 flat aluminium finned tubes. Inside the tank, a transient heat transfer between the heat transfer fluid and the phase-change material (paraffin RT 25) has been performed, enabling latent heat of melting to be stored. Test systems have been established in the Laboratory for Thermal Measurements at the University of Rijeka, Faculty of Engineering. Results of the investigations have been presented at scientific conferences and published in conference proceedings.
More information about HEXENER is available on the project web page http://www.riteh.uniri.hr/en/science/existing-projects/hexener/


This research has been fully supported by Croatian Science Foundation under the project IP-2019-04-8615.

## ESTIMATION OF LIMIT LOAD CAPACITY OF ENGINEERING STRUCTURES – LOCAPES

**Principal investigator (**Prof. Domagoj Lanc, D. Sc., Faculty of Engineering, University of Rijeka)

**Team members:**
Prof. Goran Turkalj, D. Sc., Prof. Josip Brnić, D. Sc., Assist. Prof. Igor Pešić, D. Sc., Assist. Prof. Sanjin Kršćanski, D. Sc., Assist. Damjan Banić, Assist. Sandra Kvaternik

**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. As a support to the complete model of limit load state assessment, both in normal exploitation conditions as well in limit load states, respecting the many years of experience of the project team and existing scientific equipment, the static and dynamic experimental testing of various structural materials will be carried out. It will refer to the determination of the unavailable mechanical/material parameters, of e.g. some special metal alloys, such as static and dynamic strength in extreme conditions or analysis and monitoring of fatigue cracks as consequence of cyclic fatigue. By this project, experimentally obtained data, will contribute to the creation of new material databases as well as the supplement of existing ones. The final goal of these material databases will be support of the computer simulators as the basic result of the proposed project.


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## MODELLING AND SIMULATION IN DEVELOPMENT OF ADVANCED MATERIALS - SIMMAT

**Principal investigator (**Prof. Marina Franulović, D. Sc., Faculty of Engineering, University of Rijeka)

**Team members:**
Prof. Dražan Kozak, D. Sc., Josip Juraj Strossmayer University of Osijek
Assist. Prof. Kristina Marković, D. Sc., Faculty of Engineering, University of Rijeka
Assist. Matej Gljušćić, mag. ing. nav. arch., Faculty of Engineering, University of Rijeka
Assist. David Liović, mag. ing. mech., Faculty of Engineering, University of Rijeka
Assist. Maja Dundović, mag. ing. mech., Faculty of Engineering, University of Rijeka

**The main research goal is of the project SIMMAT for the 4-year period:**
Determine and conduct the characterization process of composite materials and titanium alloys produced by additive technologies, validate results by testing photoelastic materials and recommend their application

**Theoretical background of the project and the research problems:**
High level of competitiveness in the marketplace today increases importance in the development of new technologies in design of mechanical structures and represents significant challenges for mechanical engineering constructors. The development of new technologies, on one hand, expands the possibilities of optimization of mechanical engineering designs, and on the other hand, as an imperative, raises the need for research of the behavior of innovative materials which can meet the design requirements of these technologies. Besides the design requirements, components have to fulfill the set criteria of strength, rigidity and stability of construction in order to achieve required load-bearing capacity. Considering the need to investigate the behavior of innovative materials, within the framework of the previous research carried out through the project "Development of evolutionary procedures for characterization of biological tissues behavior - BIOMAT", it has been planned to create the preconditions for further improvement of methodology and solutions for the characterization of innovative and unconventional materials and their application in engineering practice. As a result, systematization of information on materials of a broad spectrum of characteristics and application possibilities and the systematization of material models indicate the relevance and need to investigate the behavior of these materials. Special attention is given to the structure of biological materials that is considered through the correlation of matrices and collagen fibers which appears similar to the composite structures. Consequently, with a comprehensive analysis of the potential for the exploration of innovative materials, it directs the proposal of this research to the composite structures. On the other hand, the need to adopt knowledge on the behavior of titanium alloys has been identified and the research of their behavior is recognized as the secondary objective of the proposed research. The development of new technology focuses further on the research on the behavior of these materials produced using additive technologies. Based on the above, the planned research is a continuation of previous research in a way that the developed methodology, efficient for both metallic and biological materials, will be adapted and applied to the characterization, simulation and behavior analyses as well as to acquire the necessary knowledge on the behavior of materials produced by additive technologies.


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

**Principal investigator** (Prof. Gordan Jelenić, D. Sc., University of Rijeka, Faculty of Civil Engineering)

**Team members (Faculty of Civil Engineering, University of Rijeka)**
Academic staff: Dragan Ribarić, Edita Papa Dukić, Nina Čeh
Research Associate: Sara Grbčić
Research Assistant: Laura Žiković

**Project summary**

The Cosserats' (micropolar) continuum theory, which was thoroughly investigated under a part of the recently completed research project CANFAS, also supported by Croatian Science Foundation, is within the present project analysed within the framework of the so-called fixed-pole description with the aim of providing accurate and efficient finite elements for linear and non-linear static and dynamic analysis.
The new fixed-pole elements will be developed by pursuing a set of research objectives consisting of linear and non-linear static and dynamic analysis and parameter identification. The elements developed will not only provide a simulation tool in their own right, but also make an essential pre-requisite for a robust and reliable procedure needed for identification of material parameters from experimental measurements. The finite elements will be tested against a number of bench-mark problems.
A couple of experimental setups will be designed: (i) pure bending of a specimen with pronounced microstructure and (ii) stress concentration around a hole in an infinite strip.

**Research outcome in 2019:**

- Continuation of a part of CANFAS
- Development of a variety of exact benchmark solutions
- Development of standard linear 1D (beam) and 2D (plane stress/strain) micropolar finite elements
- Material parameter tests on 3D-printed specimens
- Experimental analysis of pure bending of metal prisms with artificial microstructure using standard and contactless strain measurement

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## MARITIME ENVIRONMENT-FRIENDLY TRANSPORT SYSTEMS (METRO)

**Project manager at the Faculty of Engineering (**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 Programme enables regional and local stakeholders to exchange knowledge and experiences, to develop and implement pilot action products and services, to support investments by creation of new business models, to test the feasibility of new policies, having as the final aim the improvement of the life quality and conditions of more than 12,4 M citizens living in the Area.

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.

Under this priority, the Italy-Croatia Cooperation Programme addresses key socio-economic challenges and needs within the area that are related to sustainable growth as defined in the Europe 2020 Strategy. Connectivity between the two sides of the sea is not sufficient and as such cannot contribute to stronger cooperation in the field of economic activities, labour mobility or exploitation of education opportunities in the Programme area. Therefore it is important to improve the accessibility of the area by better data sharing and coordination. So the Programme will help to reinforce the ICT application for making open and easier the access to transport info and implement all the intermodal opportunities for the passengers mobility, while investing on ICT management for all freight transport activities. The Programme will also address a strong need to reduce the environmental impact of transport activities by increasing multimodality and shift to most appropriate environmental friendly modes of transport.

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. A total project value is 2,959,605.20 EUR, in which the Faculty of Engineering participates with a share of 215,400.00 EUR. The project will run until June 30, 2021. The project manager at the Faculty of Engineering is prof. Roko Dejhalla.

The project aims to improve environmental sustainability in the maritime transport area, with particular emphasis on maritime transport for tourism purposes in the Northern Adriatic area. The aim of the project is to improve the environmental sustainability of maritime transport, with a particular focus on multimodality and green solutions for coastal transport. 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 (passenger and vehicle transport) ferries and double-ended ferry, which are the most common types of coastal vessels in the Adriatic. From a logistical point of view, the objective of the project would be achieved through defining new routes between the ports of the North Adriatic and a study on the adaptation of the electricity supply infrastructure of ships in smaller ports.

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.