"NMAS 2022"

25 - 26 May 2022 | Bucharest, Romania

Romanian Space Agency
ROSA

INCAS – National Institute for Aerospace Research "Elie Carafoli"
(under the Aegis of The Romanian Academy)

"Politehnica" University of Bucharest
UPB

8th International Workshop on Numerical Modelling in Aerospace Sciences

BOOK OF ABSTRACTS

8th International Workshop on Numerical Modelling in Aerospace Sciences,

"NMAS 2022"

25 - 26 May 2022, Bucharest, Romania

Workshop will be held in Bucharest, at INCAS, B-dul Iuliu Maniu no. 220, sector 6.

BOOK OF ABSTRACTS

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TOPICS

1 – Launchers propulsion technologies and simulations of rocket engines
2 – Flight dynamics simulation
3 – Modelling of structural problems in aerospace airframes
4 – System design for small satellites

Keynote

Progress and applications of ARI_Boom software for sonic boom prediction

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Abstract: *In order to fully consider the impact of real atmospheric environment and improve prediction accuracy of the sonic boom during the design of civil supersonic aircraft, the prediction tool ARI_Boom was developed in ARI based on the hybrid near/far field numerical simulation technology. ARI_Boom includes near-field CFD numerical simulation, real atmospheric model, ray tracing, far-field propagation, super boom prediction, ground sensitivity assessment and other modules. The basic principles, numerical methods and verification of each module are briefly introduced. Specially the effects of atmosphere on the sonic boom propagation characteristics are simulated based on the waveform parameter method, Augmented Burgers equation, multi-dimensional KZK model respectively. Finally, the near future development direction of ARI_Boom has been discussed.*

Key Words: *supersonic civil aircraft, numerical simulation, sonic boom, Ari_Boom, superboom, real atmospheric environment*

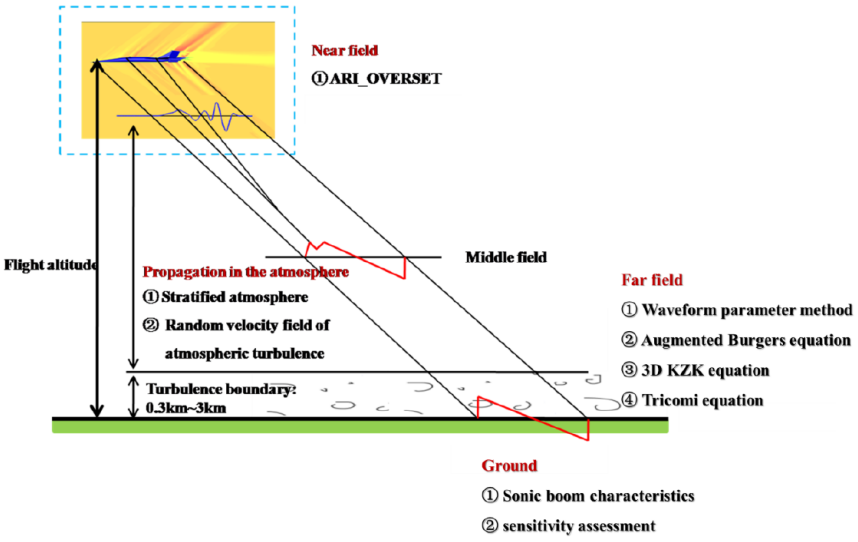

Figure 1. The illustration of the main function modules of ARI_Boom

Microstructural Design of Two-Phase Composites by using Finite Element Analyses with Greedy and Simulate Annealing Algorithms

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Abstract: *With the development of additive manufacturing, it becomes possible to print materials with prescribed microstructure. This requires the development of microstructural design techniques that allow for the optimization of macroscopic properties, while taking into account compositional and manufacturing constraints. This article compares two optimization techniques, simulated annealing and the Greedy algorithm, in the context of the microstructural design problem. To demonstrate their performance, we consider a two-dimensional composite composed from two elastic phases at given volume fraction and optimize the spatial distribution of the two phases such to minimize the overall anisotropy. The optimal configurations for this problem are determined by a brute force approach in which all possible configurations are evaluated; these are used as reference solutions for the two optimization algorithms evaluated. We conclude that simulated annealing is superior to the Greedy algorithm both in terms of the probability of identifying the best solution and in terms of the total computational effort required.*

Event associated with of the workshop

European Project Semester - Student Session

Unmanned Aerial System with endurance light structures for special missions' operation

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Abstract: *The purpose of this research is to highlight the importance of Unmanned Aerial vehicles (UAV), and to research and to develop a better way of producing parts from composite materials at a reliable quality and at a faster way than the current manufacturing methods. Composite materials play a major part in weight reduction while keeping structural rigidity. For a long time, manufacturing parts of composite materials was a challenge. This paper will discuss ways of manufacturing with composite materials and give a recommendation for a specific case.*

Additive manufacturing and coatings by direct energy deposition for aerospace application

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Abstract: *This paper is about additive manufacturing processes and the Direct Metal Deposition (DMD) in particular. The purpose of this project is to find out optimized parameters of the DMD-machine, that is used in the laboratory of the industrial partner INCAS, to build a turbine blade. The challenge of this and other additive manufacturing processes is the variety of different parameters that can be changed. Each parameter has an influence on the quality of the final product, which requires many tests and the right conclusions to be drawn from them.*

Workshop Sections

1 – Launchers propulsion technologies and simulations of rocket engines
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Design and Analysis of a Flight Simulator based on a Robotic Motion Platform

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Abstract: *Nowadays, the aerospace industry places a high focus on safety procedures and equipment, which leads to the development of increasingly durable and stable systems. While the avionics systems themselves are increasingly safer, the human factor is another element which can have a high impact on the overall safety of a flight and should be taken into account. This paper presents a real-time flight simulator, which increases the fidelity of the effects various aircraft dynamics have on a potential pilot and focuses the training sessions on improving human performance. The six degrees of freedom flight simulator comprises an industrial robotic arm on which the cockpit is placed, a central processing unit on which the software runs, command instruments, and a VR headset that serves as a display for the user. The architecture of RoFSim is designed in such a manner in order to simulate with high fidelity the change in attitude and velocity upon performing certain manoeuvres, which helps the pilot understand the effects his actions will have in-flight on the real aircraft. Furthermore, because the simulator's display is a VR headset, various aircraft models and weather condition settings for the training session can be chosen. Compared to the static platform flight simulators, RoFSim is intended to be a versatile, low-cost tool which is designed to improve human performance. Pilot physiological parameters are measured using exploratory data analysis techniques during the training sessions.*

Key Words: *Flight Simulator, Robotic-arm, 6DoF, VR, Motion Control, Human Factors*

Workspace Optimization of a Flight Simulator based on a Robotic Motion Platform

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***Abstract**: RoFSim is a flight simulator mounted on an ABB 7600 robot arm with six degrees of freedom and an additional 7th degree of freedom provided by a linear track giving a higher advantage over the Stewart platform. As it can move in a more dynamic range, there are still some limitations due to safety reasons. Its joint angle ranges are strictly limited due to external, internal factors and safety reasons. In order to make the whole system move in an indicated direction without hitting any proximal object and to keep the pilot and entire system safer, it is necessary to redefine the hardware and software limits of each joint of the robotic arm. This work presents the approach to workspace optimization of the robotic motion platform in three ways: Hardware joint angle limitation, no collision limitation, and Software joint angle limitation. After all the constraints were applied, the robot's working space was limited to create a safe simulation environment.*

***Key Words**: Flight Simulator, Robotic-arm, RobotStudio, Workspace Optimization, Joint angle limitation*

Spring-in simulation of a large scale demonstrator CFRP wing box

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***Abstract**: Based on a new manufacturing technology, one of the goals of ELADINE project was to develop a Finite Element Numerical Model to replicate the manufacturing process of a 7 m composite wing demonstrator. The main objective of the FE model was to predict in a reasonable margin of error the spring-in phenomena that occurs in the skin-spars assembly of the wing. The FEM model respect the geometrical constraints of the CAD model and replicate as precise as possible the geometrical characteristics of the parts that may influence the final geometry of the assembly.*

The Numerical Model developed in the ELADINE Project is a transient multiphysics model. It includes a mathematical model to simulate the curing and cure shrinkage process, thermal analysis, to simulate temperature field at different moments of the manufacturing, thermal expansion effects, and structural analysis to simulate the part distortion due to curing in the condition of a thermal field variation.

To simulate the distortion effects, the Numerical Model also considers variable material data as a function of cure degree.

Aerodynamic Optimization of Subsonic Aircraft Configuration

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Abstract: *Aerodynamic optimization is already a must in aircraft design due to the high-performance requirements, but the large number of parameters and the model used to evaluate performances can generate difficulties in implementation. This study aims to present a method to design an aircraft configuration that can be used in the conceptual phase of aircraft design.*
The proposed method uses the genetic algorithm (Matlab GA) to find the optimal design, and semi-empirical methods (Digital DATCOM) to evaluate the aerodynamic performances. The parametrization technique used to design aircraft configurations implies a large number of parameters that afford changes of fuselage, wing, empennage and propulsion system. To develop feasible aircraft configurations, linear and nonlinear constraints were used for geometry and stability criteria.
The objective function of the optimization procedure was to minimize the energy consumption by reducing the overall drag of the aircraft. Furthermore, to validate the optimal configuration and to ensure the global minimum is found, it's presented a comparison of results obtained with different population sizes. The results obtained show the solution convergence, the parameters of optimal configuration, the impact of each parameter on the resulted configuration and the aerodynamic performances of the optimal geometry both the static performances and the dynamic performances.

Key Words: *Aerodynamic optimization, Digital DATCOM, Semi-empirical methods, subsonic aircraft, Genetic Algorithm*

2Space team rocket design and analysis for EuRoC competition

Cătălin Constantin CHELMUȘ*[1], Trifu Marius CONSTANTIN[1], Andrei Mădălin GRIGORE[1], Robert Mihai IONIȚĂ[1], Andrei Cristian MANDOC[1], Constantin Romica STOICA[1]

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Abstract: *Team 2Space built a 2.49 m high rocket powered by a commercial solid fuel motor with the purpose of reaching an altitude of 9.000 m. The rocket has two electronic systems that contains different pressure and acceleration sensors. After the flight, the data received on the ground station in real time will be compared with the data recorded by the sensors on the internal*

memory of the PCBs after the application of the post-processing filters. The rocket design makes the airframe lighter by using carbon composites. The structure has only one stage that will be splitted into two sections: one containing the motor, centering rings, fin attachment rings, fins and a motor stopper, while the other one has the recovery system and the electronics module. The cone has the payload that consists of four 0.5U units of experimental sensors. The design is made to reach high altitudes in ideal conditions and the team already made a few test flights for different subsystems with smaller rockets and different launch scenarios to achieve the desired apogee in different meteorological conditions with no active control. During flight, the avionics will store data on a local memory and will send it to the ground station using a custom-made antenna, from where the data will be uploaded to the internet.

Key Words: *Rocket, EuRoC, solid propulsion, maximum altitude, parachute, telemetry, datalogger*

Parametric study of the effect of passive vortex generators on wing aerodynamic performance

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Abstract: *Flow separation at high angles of attack causes performance degradation on aircraft performance and operational capability. To overcome this, a viable solution represents the use of vortex generators as a way of delaying the separation point on aircraft wings. As the air flows along the top of the wing, a region of adverse pressure gradient occurs. These devices control the flow by improving the motion performance of the fluid in the boundary layer region facilitating the exchange of the momentum from the outer flow to the inner one. The downstream development of the vortices behind the vortex generator transports energy from the outer flow into the boundary layer, thus, allowing the airflow to withstand the adverse pressure gradient longer. The performance of a vortex generator is determined by several parameters such as height, length, or the rotation angle relative to the flow direction. In the present work, a parametric study of such a control method is carried out using a high-fidelity CFD analysis. Then, an outline of the methodology that was used is presented together with a logical schema of the entire process. After that, relative quantities such as wall shear stress and turbulent kinetic energy were plotted, and the corresponding conclusions were drawn.*

Key Words: *Vortex generators, boundary layer control, computational fluid dynamics, turbulent kinetic energy*

Notes Regarding the Loads Induced by Gusts on Airplane Structures

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Abstract: *The current paper discusses some analyses of the loads induced by vertical gusts on the structrues on aircraft executing logitudinal maneuvers. Basic aspects related to the standard calculations of the gust loads are discussed, and standard calculated loads are compared with simulated responses (both linear and nonlinear) on the longitudinal channel of an airplane flying within a vertical gust. The longitudinal equations of symmetric flight of the airplane are written to include the effect of the wind and load factors along the structure are calculated using both the nonlinear and the liearized equations.*

Key Words: *Gust, Structures, Gust loads, vertical wind, numerical integration, flight dynamics*

Demonstrator for Technologies Validation (DTV) free-flights results

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Abstract: *INCAS has been developing a reusable vertical take-off and vertical landing testing platform, called DTV – Demonstrator for Technologies Validation, a project in collaboration with the European Space Agency, under the Future Launchers Preparatory Program (FLPP).*
The platform is currently operational after the successful acceptance flight testing campaign organized in August 2021 at INCAS Măneciu in Prahova, which is INCAS main testing facility for space-related applications. In the frame of the project, a Flight Simulator was developed at INCAS containing a high-fidelity Plant model, guidance profiles and control strategies for the reusable platform, as well as the flight software.
The aim of this paper is to present a comparison between simulation results and flight test recorded data for the full validation of the GNC design and flight software.
The telemetry flight data confirms that the adopted control methodology and strategy is suitable for the control of a reusable testing platform for space applications and DTV can be used as an in-flight test bed for potential European stakeholders.

VTVL Engine Attachment Structural Optimization

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***Abstract**: Vertical takeoff and vertical landing (VTVL) is a subject of international interest at the moment with increased activity towards developing this type of technology. In order to keep up with the increasingly complex requirements of aerospace vehicles while maintaining a fair ratio between strength and mass, various calculation methods have begun to gain ground in the industry, including structural optimization, respectively topological optimization. Topology optimization is a powerful tool that can be used from the concept phase in order to obtain a fundamental design approach. This activity is very useful in obtaining information about the optimal material distribution in the defined volume in order to define the most efficient desired shape in terms of strength and stiffness. In this paper, we perform the topological optimization of the engine attachment structure which has the role of fixing it on a vehicle with vertical takeoff and landing (VTVL), and then in regards to the manufacturing constraints to achieve a capable product design that can be produced with additive manufacturing technologies. The analysis is fulfilled using the finite element method, starting from a pre-analyzed initial model, and then modified in order to perform the optimization analysis of the desired part, resulting in the final concept.*

***Key Words**: topology optimization, structural optimization, manufacturing constraints, VTVL, finite element model, additive manufacturing*

Military aircraft: LED lights for high-speed take-offs, landing, and taxi

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***Abstract:** This paper presents the authors' recent documentary research on the benefits of using Military aircraft LED lighting products for high-speed take-offs, landings, and taxiing. LED lighting products offer numerous advantages over conventional incandescent aircraft bulb lighting (Halogen and Xenon bulb-based lighting technologies). From the point of view of energy consumption, LED lighting products are ten times more efficient than incandescent lighting, designed and produced to consume much less electricity than conventional lighting, and require no*

external hi-voltage power supply. LED lights maintain their full light output even at lower aircraft engine rotation. The LED lights are solid-state mounted devices that can tolerate high levels of shock and vibration without failing. The LED lights for high-speed take-offs, landings, and taxis offer extraordinary performance that will truly transform the flying experience during nighttime.

Key Words: *LED, LED lights, high-speed take-off, landing, taxi, military aircraft*

Neural Reflex Networks for Automating Quadcopter Drone Obstacle Avoidance

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Abstract: *The physically modelled neural and nervous networks pioneered more than two decades ago by Mark Tilden, E.A. Rietman and collaborators, M. Ashkenazi et al. have proven to be a robust and interesting way to obtain powerful emergent behavior by utilizing neuromimetic circuitry. Using a physical representation of biologic neurons, both motor (NU) and cortical (NV) these structures mimic simple reflex arcs present in a large number of evolved organisms. The simple circuits using logic gate oscillators wired as integrators or pulse delay loops with sensors coupled as current injectors or variable resistors of different types demonstrated unexpected emergent „survival" behaviors when connected in chains or loops of several neurons. Mark Tilden calls the simplest functional unit of such looped structures „bicores"-as two neurons linked together in a loop already generate meaningful behavior when their inputs are linked to appropriate sensors. These powerful neuromimetic machines allow for a robust implementation of automated responses in autonomous or semi-autonomous robots. Quadcopters are a very good target for neural network control/stabilization because of their unique flight dynamics and normal control procedures. Obstacle avoidance and stabilization are simple tasks for a well-tuned physical neural network.*

Key Words: *Reflex neural network, quadcopter, drone, physically implemented neural network, reflex control of a quadcopter, neural network stabilization*

Supersonic-hypersonic ramp-lip intakes optimization in calorically and thermally perfect gas

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Abstract: *Robust inviscid optimization formulations are explored within calorically perfect and thermally perfect gas models for planar supersonic-hypersonic intakes that combine external ramp compression and internal compression. While pure external compression may rely on a large number of ramps, mixt compression will use a limited number of external and internal ramps. Mixt intakes bring a clear advantage as frontal area on one hand and one the other hand considering viscous effects, they will expose to the flow shorter solid walls on the various ramps, enabling a reduced boundary layer development. Proper parametrization enables external compression optimization without geometrical constraints. The numerical procedure relies on conjugate gradient method. In order to prove the robustness, optimization is performed on multiple cases, regenerating pressure recovery curves as in references, providing a functional tool for engineering work.*

Key *Words:* *Numerical optimization, Supersonic planar intake, Internal and external compression*

Wernher Von Braun's Pioneering Work in Modelling and Testing Liquid Propellants Rockets

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Abstract: *This paper presents a view on how Dr. Wernher Von Braun laid the basis for realistic modelling and testing liquid propellants rockets, by his PhD Thesis – a secret document in 1934, which remained classified until 1960. Understanding that better mathematical modelling is needed if these rockets are to become spaceflight vehicles, he clarified in his thesis essential issues like: maximum achievable rocket speed; Laval nozzle thrust gain; polytropic processes in the combustion chamber and nozzle; influence of equilibrium and dissociation reactions; original*

measurement systems for rockets test stand; engineering solutions adequate for series production of combustion chamber /reactive nozzle assembly. The thesis provided theoretical and experimental basis for a new concept of rocket, having: lightweight structure; low tanks pressure; high pressure pumps and injectors; low start speed; rocket stabilization by gyroscopic means or by active jet controls; longer engine burning time; higher jet speed. Numerous tests made even with a fully assembled rocket (the "Aggregate-I"), improved mathematical model accuracy (e.g. the maximum achievable altitude predicted for "Aggregate-II" rocket was confirmed later in flight tests).

Key Words: *Von Braun, liquid propellant rocket testing, combustion, dissociation, flight stability*

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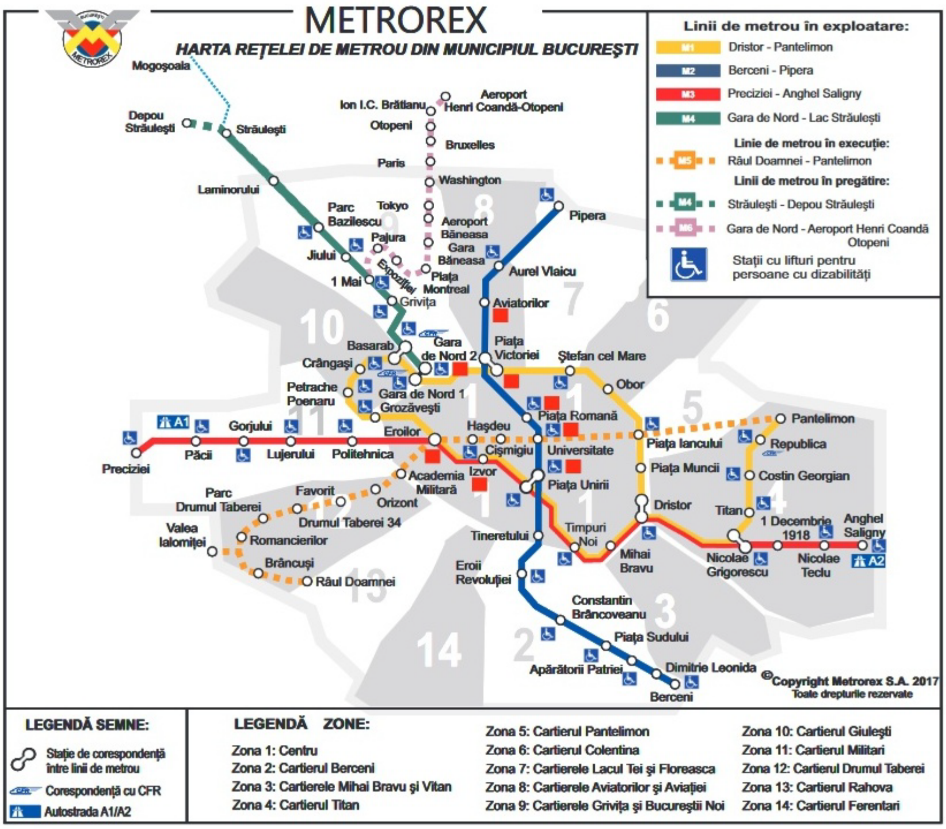

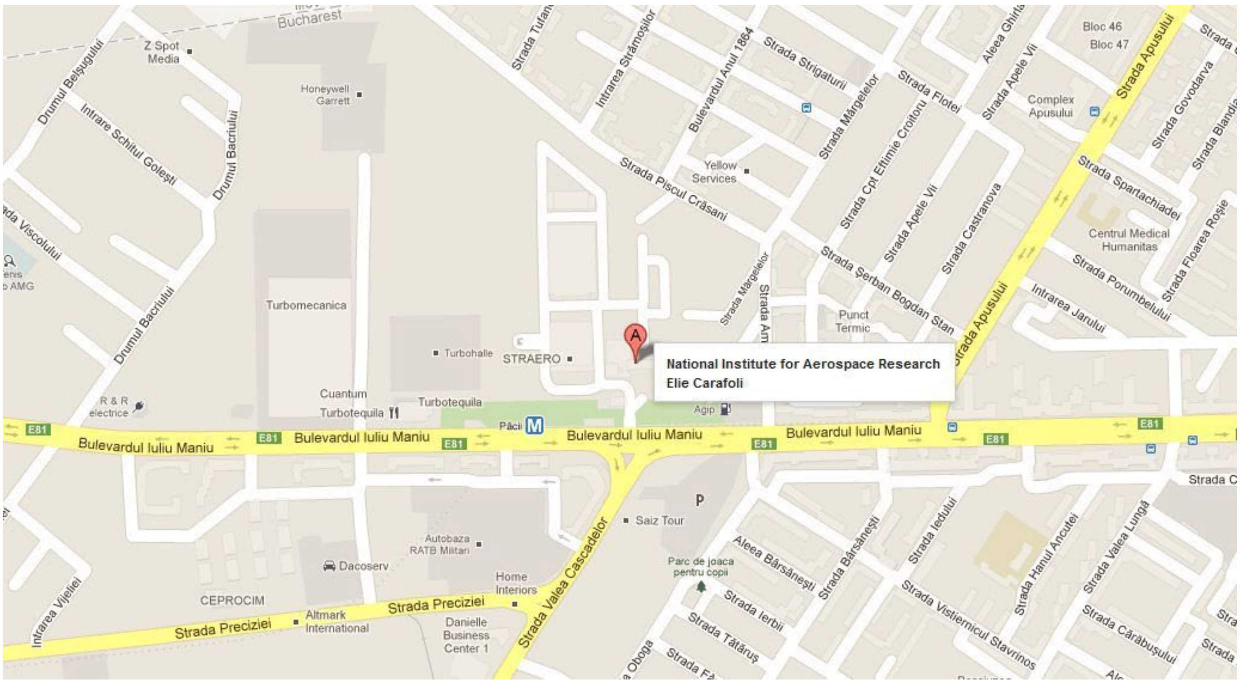

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