Project: Technologies for Testing and Validation of the Structure, and Modified Hybrid Rocket Motor for Suborbital Launcher. Acronym STRAC

Contract Project nr. 35/2012 Financed by State Budget - Space Technology and Advanced Research - STAR, Contracting Authority Romanian Space Agency (ROSA), Period 2012-2015

Coordinator: Polytechnic University of Bucharest - Aeronautical and Space Research Center (UPB-CCAS), **Partners:** S.C. STRAERO S.A. – Institute for Theoretical and Experimental Analysis of Aeronautical Structures and S.C. “Electromecanica Ploiesti” S.A.

The main objective of the project was the manufacturing of the small testing suborbital launcher capable to reach 100-150 km altitude high with a 5-10 kg useful load. For accomplish this objective, the project team had to develop constructive and technical solutions for: modified hybrid engine (MHRM), the structure of suborbital launcher (including the separation system of the booster and steps) and the command and navigation system (secondary objectives).

STRAERO was involved in the solution resolving, accordingly with the experience in the field of numerical analysis and testing of the structures:

T1. Requirements and technical specifications for static and dynamic loads on the structure

T2. Defining the functional and "stress" requirements for the launcher's structure

T3. Finite element model analysis of the structure (preliminary design) as well as of the critic elements of the structure (detailed design)

T4. Instrumentation of the launcher for structural testing

T5. Structure testing in conditions of quasi static load and dynamic loads. Testing report de development

T6. Testing technology validation of the MHRM equipped launcher

T7. Dissemination: participating to technical-scientific activities.

Stages of the project:

Stage 1 – Technical specifications, structural tests, definition of the structural elements of the suborbital launcher. Specifications and constructive solution of the MHRM

Stage 2 – Aerodynamic tests determinations, definition of the requirements and structure of the launcher elements model. Development of the calculus model, design and manufacturing of the MHRM

Stage 3 – Establish the calculus loads, Structural modeling, analysis of the results. Establishing the testing program, design of the MHRM demonstrator

Stage 4 – Mounting the launcher on the test stand and applying the instrumentation. Static and dynamic tests, experimental report.

Dissemination of the results:

"THERMO-GAS DYNAMIC ANALYSIS OF UPPER-STAGE ROCKET ENGINE NOZZLE", THE 17th INTERNATIONAL CONFERENCE "SCIENTIFIC RESEARCH AND EDUCATION IN THE AIR FORCE" AFASES 2015, May 28 – 30, 2015, "HENRI COANDĂ" AIR FORCE ACADEMY, Brașov, Romania

„HEAT TRANSFER AND THERMAL STRESS ANALYSIS OF WATER COOLING JACKET FOR ROCKET EXHAUST SYSTEMS", 1st INTERNATIONAL CONFERCENCE SEA-CONF 2015 14-16 May, 2015, Constanta, Romania

„STRUCTURAL TESTING AND VALIDATION OF GUIDED SUBORBITAL LAUNCHER", 3rd INTERNATIONAL WORKSHOP ON NUMERICAL MODELLING IN AEROSPACE SCIENCES NMAS 2015, 06-07 May 2015, Bucharest, Romania

Vibration tests, quasi static tests of the rocket were done on a assembled stand with universal specific devices. There were used strain gauges with 120Ω±35% resistance, with gauge factor 2.04, thermal compensation gauges and Bruel&Kjaer 4507B-005 accelerometers. The results of the measurements were used for local loads determinations of the rocket and due to determination of the nature and the size of the loads the acting on the rocket.

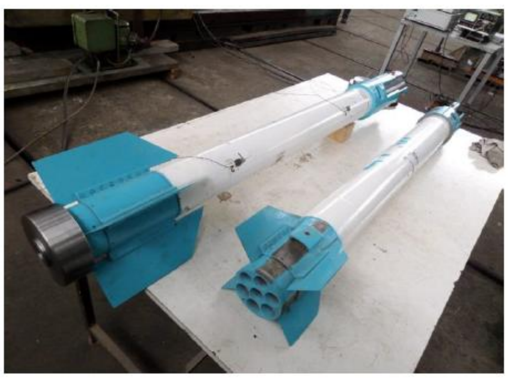

Fig. 1 Positioning the strain gauges on the first portion of the rocket

Fig. 2 The strain gauge on the first portion of the rocket (detail)

Fig. 3 The mini accelerator A Bruel&Kjaer 4507B-005 mounted on useful load

Fig. 4 Data acquisition equipment and signal generation

Fig. 5 Positioning the rocket launcher

Fig. 6 Fixing the rocket launcher on the testing stand

The strength testing of the launcher to thrust force of the engine was made through a direct simulation method, in which the testing machine component act with a set force with a generator signal which simulates the thrust force of the rocket engine. Thrust force F was applied on horizontal plane on the SLT type rocket, this thrust was 3000N value. The test took place through a fix point simulation that will be on the rocket body simulation. The quasi static test has specially importance on the suborbital launcher design by determining the Eigen modes because during the flight there must be avoided the frequencies that are closely on value with the Eigen modes of the rocket. There was used the hammer method "Impact Hammer Modal Testing", which produce a perfect impulse by knowing the time of the contact which influences the predominant frequency. The dynamic tests were made on the mechanical unequipped assembly and on the unequipped rocket engine with hybrid combustion received from the manufacturer, were subjected to strength dynamic tests on applied forces on the rocket at launching from the ground. On fig. 7 is represented the traction force diagram in which is noticeable the variation of the thrust force reaches a maxim value of 3000N after 0.1s from the ignition after that the value is stabilizing to 20500-21500N on time interval 0.6-1.8s from the ignition. On the last interval 1.8-2s the thrust falls rapidly to 0N. The rocket testing on thrust of the engine was made through direct simulation method by testing machine by a set force acting on it with a generator signal which action exactly like the thrust of the rocket engine.

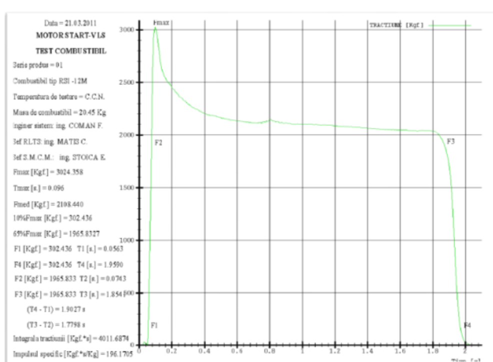

Fig. 7 Traction diagram of the rocket engine stage I and II

Validation of the test technology for suborbital equipped launcher.

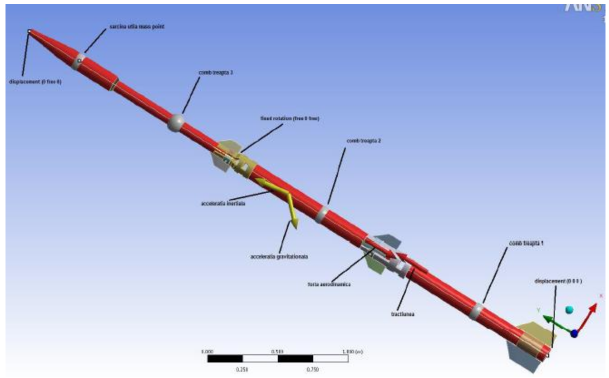

Fig. 8 Launcher isometric view

Finite element analysis was developed for structural analysis of the suborbital launcher, with elements that allow structural meshing for results accuracy, by using Shell181, Solid186 and Solid 187 elements. Joining the components of the assemble were used contact elements such as Conta 174 and Target170, which allows the contact simulation and the 3D surface sliding defined by Target170 element and deformed surfaces defined by this type of element. This elements are on the surface of 2D solids or on Shell surfaces meshed by type 2 elements and has the same characteristics with the structure that are connected with.

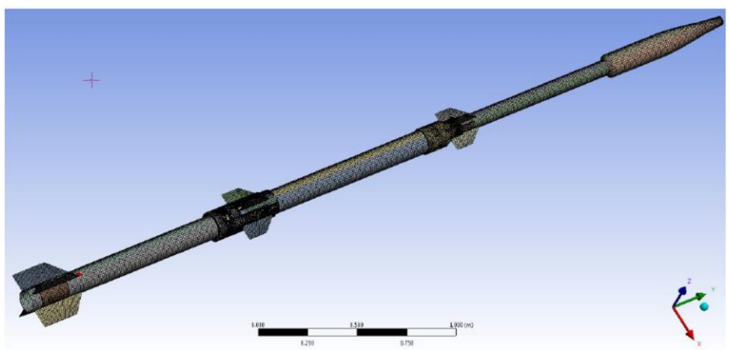

Fig. 9 Finite element meshing of the launcher. Isometric view

The results obtained after finite element numerical analysis are presented below.

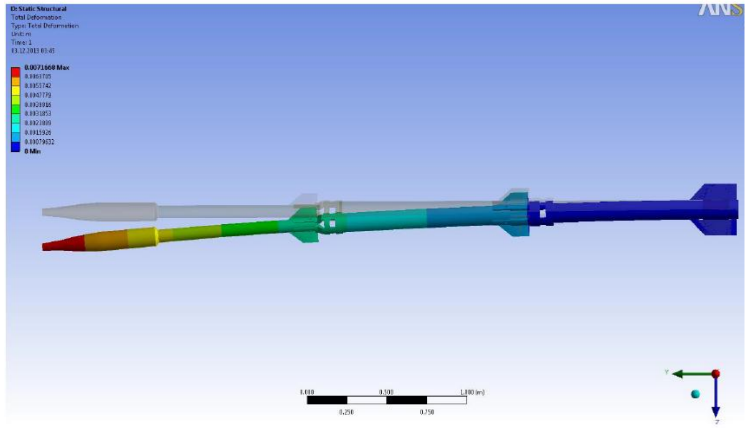

Fig. 10 Maximum displacement in the front of the launcher

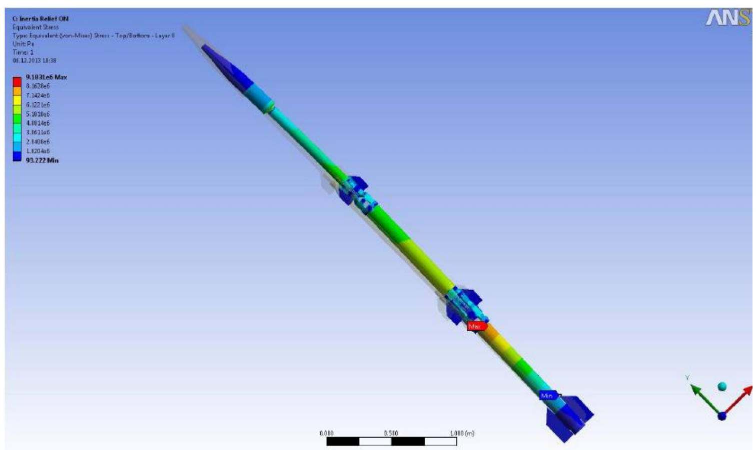

Fig. 11 Von-Mises tensions for linear solution

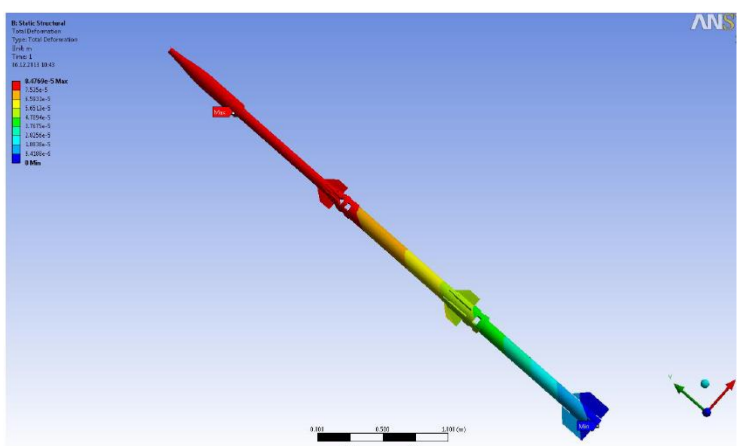

Fig. 12 Total deformation resulted from nonlinear static solution