



I E G U L D Ī J U M S T A V Ā N Ā K O T N Ē

Overview of scientific results of the project

Reporting period **Nr. 4.**

01.02.2020. - 30.04.2020.

Project: Nr. 1.1.1.1/18/A/133 "Prototype development of transportable in multimodal traffic mobile space test facility "Metamorphosis".

Project promoters: Riga Technical University (Leading Partner), "CRYOGENIC AND VACUUM SYSTEMS" Ltd.

Overall Project Objective: To develop a prototype mobile test facility "Metamorphosis" (MSTF) transported in an intermodal EU traffic environment based on industrial research and to rise MSTF Technological Readiness Level from TRL2 to TRL4 (under European Space Agency (ESA) scale) for further evolution of the project.

Project activities and accomplishments during the reporting period:

Activity 1. Design calculations and design documentation for the elements of prototype structure:

Section 1.1. Calculation of the vacuum system parameters

Calculation of the vacuum parameters:

The calculation of the vacuum parameters variation is completed:

The following dimensions of the vacuum chamber are accepted as the prototype version: diameter of the vacuum chamber is $\varnothing 500$ mm and the length of it is 780 mm. These sizes will be used as base for the further calculations.

Calculations of the maximum and operating pressures for different tests and different prototype operating modes are underway, as well as the possible ranges of their changes, based on the specified dimensions of the vacuum chamber.

The task solution to determine the gas composition and to determine the gas load in the vacuum chamber is performed based on the specified dimensions of the vacuum chamber. The changes of these parameters can occurred during various tests.

Different calculations are underway to determine the technical requirements for vacuum safety valves, check valves, compensators and vacuum pumping equipment, electrical, cryogenic and optical inputs, for the accepted dimensions of the vacuum chamber.

Correction and improvement of designed concept is performing based on the result of market data analysis about available vacuum equipment, which can be applied to specific dimensions of a vacuum chamber prototype. Calculation of the required pumping speed for pre-vacuum and high-pressure pumping equipment. Determination of technical requirements for vacuum measuring instruments.

Technical requirements for a Solar simulator, requirements for placing a test object in the prototype vacuum chamber, requirements for the introduction of Solar radiation are identified.

Thermophysical calculation:

Development of the thermal model continues. Sketches of the mock-ups composition were developed: a model of inserted cryogenic screens into a vacuum chamber, taking into account the input of Solar radiation, that modeling the placement of equipment and prototype components, taking into account testing in the certain gas environment.

Determination of the technical requirements for infrared sources and cryogenic screens is performed as well as the hydraulic calculation of the cryogenic prototype system parameter. A study of the technical parameters of the optical inputs and the study of the technical requirements of cryogenic screens are performed, taking into account the projection of the Solar simulator spot.

Sketches of a vacuum chamber prototype model were developed to help making calculation of vacuum system variants of the prototype and analysis of the prototype vacuum chamber tightness.

Continuing definition of technical requirements to technical requirements for cryogenic pumps and valves within the framework of thermophysical calculations of cryogenic prototype systems as well as analysis of technical properties of materials for the production of cryogenic screens and investigation of properties of different vacuum sealing variants.

Making of data collection and analysis of world experience in the field of cryogenic and vacuum systems and creation of cryogenic and vacuum connections in transport and analysis of modern cryogenic technical solutions.

Section 1.2. Strength calculation

Static strength calculation was performed (version 1.0). Clarifications to the technical specifications have been initiated to calculate the strength and stability of the vacuum chamber housing. Development of the composition sketches was begun. The analysis of standards and technical literature on typical vibrations and other dynamic loads on objects moving in EU intermodal transport is continued. The static loading scheme of prototype elements has been developed.

Section 1.3. Development of design documentation set

Based on the results of the prototype vacuum system and static strength calculations, the determination of the external appearance of the prototype construction elements has been started and the development of sketches for the creation of design documentation as well.

Section 1.4. Development of 3D CAD model of prototype construction elements

An analysis of standards and industry methodologies in the field of 3D modeling of complex equipment and systems has been performed. Based on the results of the analysis and previous calculations, the requirements for the prototype of 3D CAD model are determined.

Activity 2. Prototype software development:

Section 2.1. Development of prototype working algorithm

Based on the analysis of test types, design of test program templates is continuing, in accordance with the requirements of the ESA ECSS standard, for test types to be performed using MSTF.

Algorithmization of the testing process based on the developed testing program templates is continuing as well as the test algorithm, which used the Solar radiation simulator, taking into account the assumed dimensions of the vacuum chamber prototype and the possibility to place the test object.

Section 2.2. Prototype software and hardware development

Determination of requirements for software determination of technical parameters of hardware components are in the development.

Activity 3. Production of structural elements and assembly of prototypes

Section 3.1. Production of prototype construction elements

Turbo-molecular pumps is in a process of determination and comparison of their technical parameters based on vacuum chamber dimensions and cryogenic pump market is analyzed. Comparison of economic performance of vacuum gauges and turbo-molecular pumps ceteris paribus is performing and determination of technical requirements for heat field measuring instruments and information processing system as well.

In process of determination technical specifications: for vacuum valves, valves, compensators and vacuum extraction equipment, as well as for electrical, cryogenic and optical inputs.

Activity 4. Industrial research and prototype testing

Section 4.1. Stability tests of the prototype structure under operating conditions

Based on the test algorithm, the development of a test program and methodological manual was started. During the implementation of the project, the literature and world experience in the operation of high vacuum pumping systems in vehicles were studied; this experience indicates that there is a high probability of collapse and pressure drop due to unpredictable shocks and vibrations.

It is quite difficult to model real intermodal transport conditions that differ from each other, such as ferry conditions and different road conditions. A technical decision was made to replace the tests of the prototype and its components on a vibrating stand and to carry out full-scale tests in multimodal transport instead of this type of test by placing the prototype in a car supplied by the project partner.

This technical solution is expected to significantly improve the reliability of the tests and to convincingly demonstrate the possibility of using the prototype in intermodal transport.