RESEARCH AND NEW TECHNOLOGY DEVELOPMENT PROJECTS
FOR THE AEROSPACE INDUSTRY

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The company offers to collaborate in conducting two R&D projects aimed at developing innovative digital technologies for the machine-building industry. Both R&D projects are based on three Russian patents (RU2563063, RU149949, and RU2609571).

1. **R&D Project *Developing and Introducing Technology for Large-Size Functional Monocoque (LFM) Fabrication Outside of the Terrestrial Atmosphere.***

Relevance and novelty: for the first time ever, rocket and space equipment production and extraterrestrial macroengineering will be moved off of the Earth. This is like sending the first man into space.

No proactive short- or long-term space exploration is possible without developing special-purpose earth orbital infrastructure: cargo platforms, storage, production, residential, scientific, and other large-size functional modules. From a structural point of view, this infrastructure will rely on large-size *solid monocoque* shells of various shapes: cylindrical, spherical, etc. The monocoques are meant to have large dimensions with standard sizes anywhere from dozens to several hundred meters, and at a low cost while ensuring adequate strength.

Moving the technological process of LFM production off of the Earth will allow launch vehicles (LV) to be used only for delivering work materials, that is, cheap steel wire, into space. Per our calculations, the expected rate (time) for manufacturing a cylindrical LFM with hemispheres at the ends, with a length of 250 m and a diameter of 50 m, is 19 days (with one robot operating 24/7). LFM wall thickness: 1 mm. It is assumed that several robots will be operating simultaneously.
In our opinion, the extraterrestrial LFM production technique that employs the new technology will be more efficient than delivering individual parts and assembling them outside the terrestrial atmosphere (please note that the most advanced LV have certain restrictions on the orbit payload weight and size). It should also be noted that the assembly requires human participation. This is where the *human factor* impact on the assembly quality comes from. Equipping the assembled LFM with life support facilities, attitude control and other systems can be implemented subsequently, module by module.

The fully automated technique under development is based on an additive technology of surfacing structures with profiled wire of a small thickness (0.5 to 2.0 mm) using a 300 W pulsed laser. Since the melt will be cooled in open space, it is assumed that the formation of an amorphous metal structure is possible. Amorphous metals are several-fold stronger and more flexible.

Purpose: to develop an industrial technology for large-size functional monocoque fabrication outside the terrestrial atmosphere with standard sizes *from dozens to several hundred meters* in order to build special-purpose infrastructure including residential, warehouse, cargo, production, and other units that ensure the development of space programs in Russia and foreign countries in the short and long term.

The R&D stages and expected results are provided in the R&D Reference Justification, 2018 (upon request).

Duration: 2018 to 2026.

2. R&D PROJECT *DEVELOPMENT AND INTRODUCTION OF MULTILAYERED FUNCTIONAL MONOCOQUE FABRICATION TECHNOLOGY*

<u>Relevance and novelty</u>: in the engineering field today, particularly in the aircraft industry, the most promising technology is that of manufacturing aircraft wings and fuselages from composite materials. The main advantages of using composite materials in lieu of metals are: high strength, lower weight, better resistance to aggressive environments.

However, composite techniques have their own serious drawbacks. Compared to the same part made from metal, the part made of composite materials is *several times more expensive*. The manufacturing process for a composite part is characterized by a low degree of automation as many processes require manual labor. The ecological compatibility of composite structures is also a point of issue.

The proposed specific additive technique of multilayered metal monocoque fabrication will redefine traditional design and manufacturing methods for products such as aircraft fuselages and helicopter hulls, launch vehicle hulls, pressure hulls for submersibles, and many other monocoque-based designs.

The novelty of the proposed technique is that it becomes possible to manufacture, for example, aircraft fuselages nose-to-tail as a solid multilayer metal shell of almost any geometry with almost no manual labor involved. The multilayering of a monocoque means that the load-bearing solid shell merges from the inside into load-bearing elements of the same material (or at the designer's choice). Moreover, there is an option to manufacture a non-standard frame of structural rings, longerons, and stringers, and make a framework in the form of a netting of load-bearing elements at different angles. And all these come as an integrated structural element! If desired, you can add subsequent layers of shells and load-bearing elements. Moreover, both the shell and the load-bearing elements can vary the thickness with changes in the rigidity of structural elements, or be made of a polymer material, thus forming a polymer metal structure. A wing made in the same way is connected to the fuselage via a flange connection, and the airframe is ready.

The opportunities the new method offers are not limited to the above. It is possible to manufacture individual elements of the airframe structure, such as a fairing, from a polymer with integrated metal elements: an antenna, wiring and even electronic elements – "a smart shell."

<u>Purpose</u>: developing an industrial technology for automated multilayer monocoque fabrication in the form of solid metal shells which, if necessary, merge from the inside into load-bearing elements and, further, in accordance with the multilayering requirements – without a single rivet, welding, gluing or any connecting elements.

It is assumed that the process equipment under terrestrial atmospheric conditions will allow for manufacturing multilayer monocoque designs of *the required length* and a diameter of up to 10 meters with an accuracy of 0.15 mm.

The R&D stages and expected results are provided in the R&D project *DEVELOPMENT AND INTRODUCTION OF MULTILAYERED FUNCTIONAL MONOCOQUE FABRICATION TECHNOLOGY*, 2016 (upon request).

Duration: 2018 to 2020.