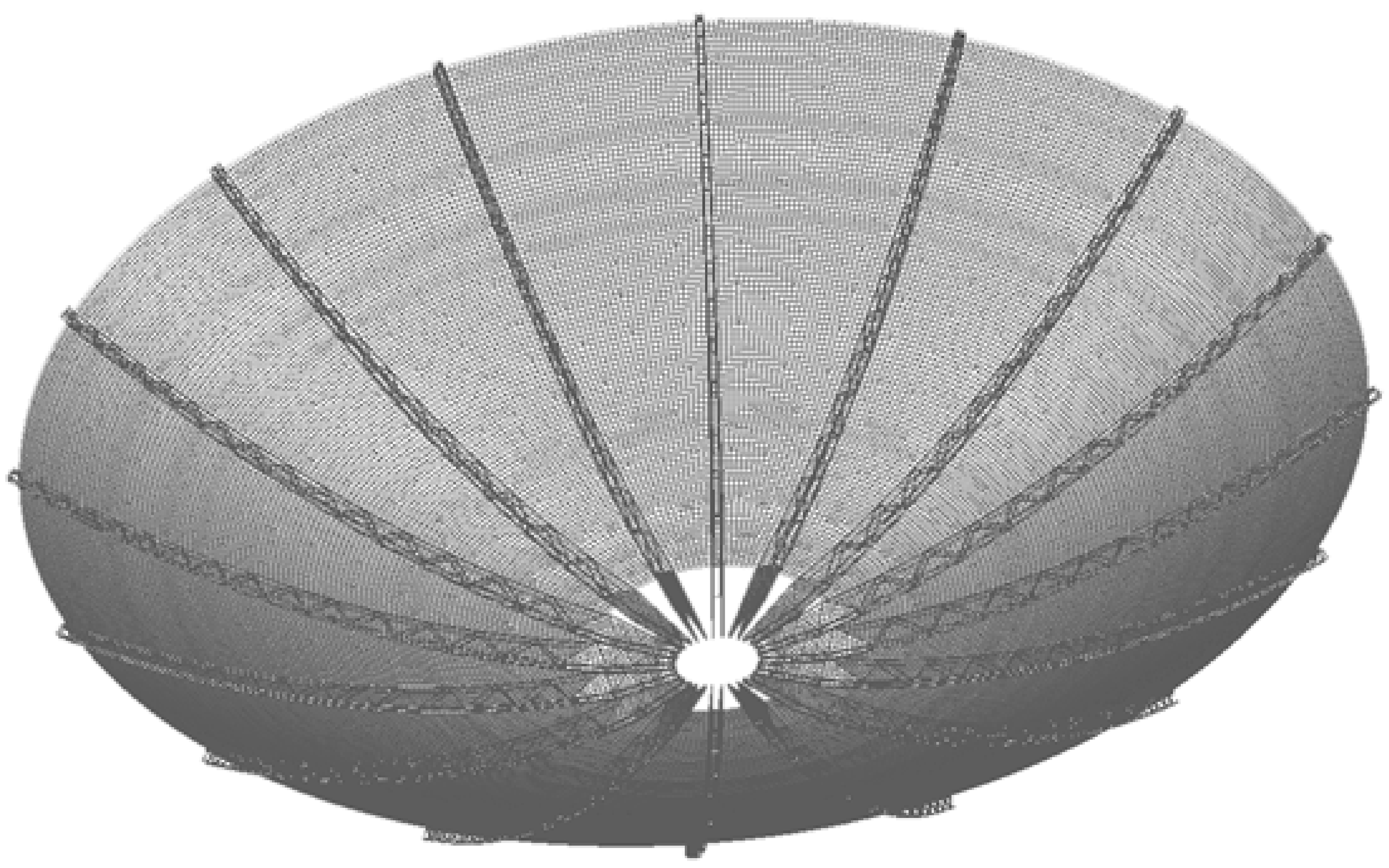
SURFACE ACCURACY ANALYSIS OF RIGID REFLECTOR IN MECHANICAL AND THERMAL LOADING

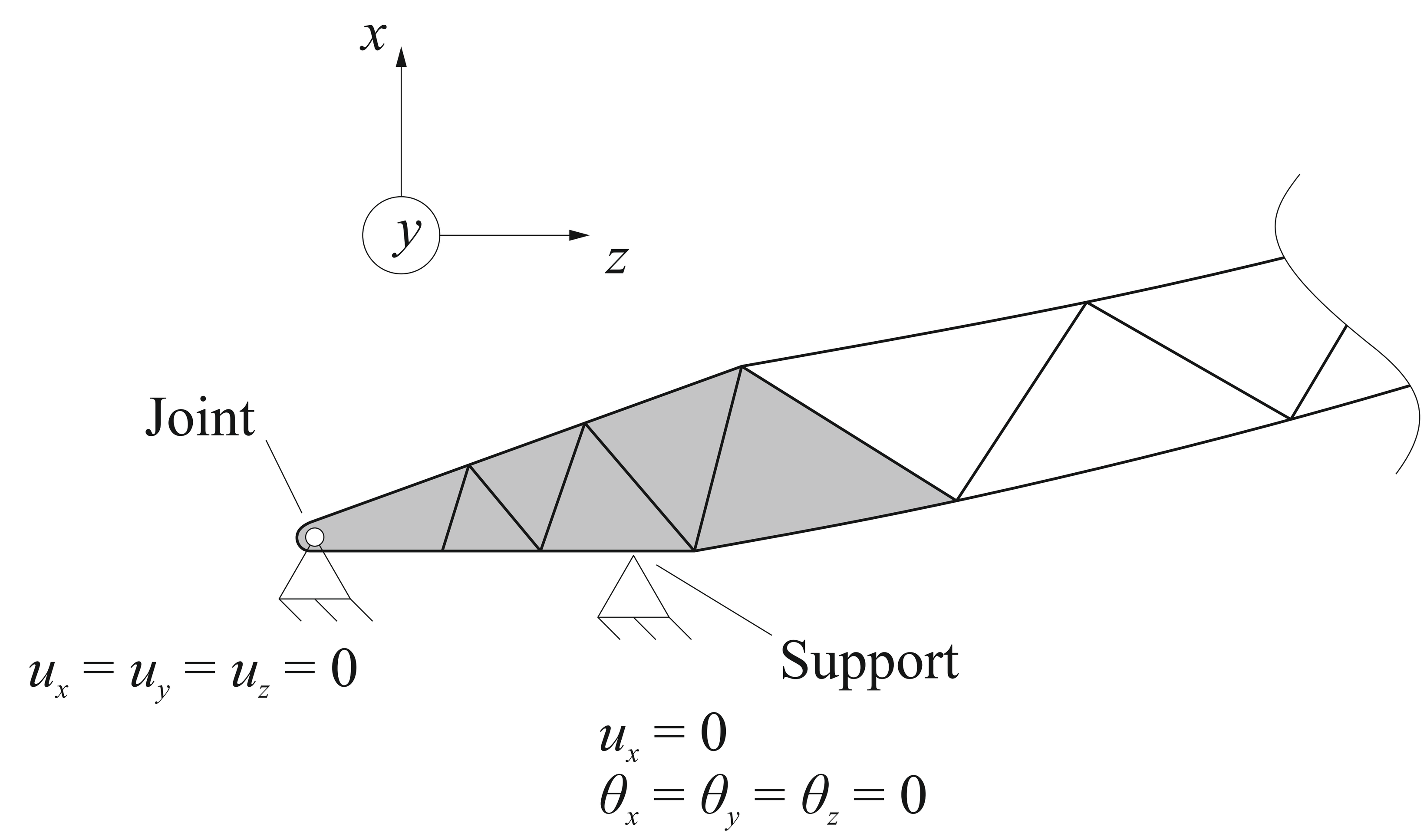
Moskvichev E.V.[1], Khakhlenkova A.A.[2]
[1]*Institute of Computational Technologies SB RAS, P.O. box 25515, Krasnoyarsk, 660049, Russia, jugr@icm.krasn.ru.*
[2]*Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia, anja-nja-ha@yandex.ru.*

In the designs of deployable space reflectors the reflective face is traditionally represented by a metallized mesh. One of the main drawbacks of the mesh reflector is the requirement of its tension to ensure the necessary surface accuracy. This is achieved by using a large number of precision spokes and cable-stayed elements which can constitute a significant mass of the reflector. To reduce the weight, while simultaneously increasing its rigidity and the surface accuracy, the concepts of flexible precision reflectors are being developed. In these concepts, thin shells made of composite materials are used as the reflective face.

An example of such structions is a transformable precision large-scale reflector of space antennas, developed jointly by JSC Information Satellite Systems Reshetnev, Reshetnev Siberian State University of Science and Technology and SDTB “Nauka” ICT SB RAS. The antenna design is a transformable axisymmetric parabolic reflector. The reflective face is a thin shell made of a carbon fiber reinforced polymer composite. The reflector unfolds due to the deployment drive mechanism and the stored elastic strain energy of the composite shell.

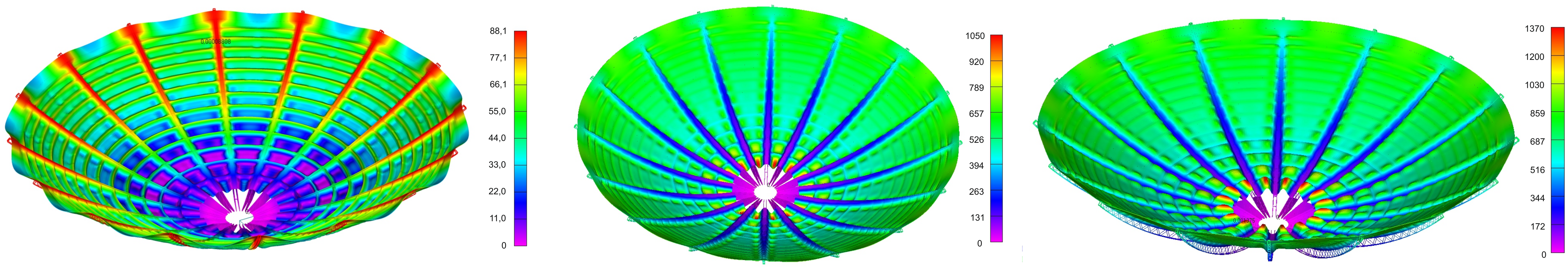


The finite-element model of the reflector



Boundary conditions used for the modeling

One of the key tasks at the design stage of the reflector was the estimation of the geometric stability and surface accuracy of the reflective face. The geometric stability was defined by the root-mean-square deviation (RMS) of the reflective face from its original shape. This parameter characterizes the reflector deformations caused by mechanical and thermal loads. A limited list of loads was considered, in order to evaluate the proposed concept of the reflector regarding the required RMS value. The force of Earth's gravity was considered as the mechanical load during ground tests of the reflector. Also the effect of forces caused by tension of the stiffening ring located on the periphery of the reflector was studied. Temperature deformations of the reflective face from solar heating and cooling during the stay of the reflector in the shade were considered as thermal loads.



(a) (b) (c)

Displacements of the reflective face under gravity load (a), at a temperature of +125 °C (b), at a temperature of -150 °C © [μm]

Simulation of deformations of the reflector under the above loads was carried out by the finite element method. The reflector was modeled being in the deployed position. The range of RMS calculated values under various loads was from 0.02 to 0.18 mm. This allowed providing the required accuracy of the reflective face for the given reflector design. Thus, the use of a rigid composite shell as a reflective face is promising and requires further study. One of the next tasks that need to be solved is to evaluate the strength of the reflective face during its folding into the transport position.

ACKNOWLEDGMENTS

This work was done during the complex project and was financially supported by the Russian Federation Government (Ministry of Education and Science of the Russian Federation). Contract № 02.G25.31.0147.