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# CORRELATION AND VALIDATION OF NUMERICAL SIMULATION AND TEST IN THE SPACE INDUSTRY

*Special Session on Credibility of Computational Solid Mechanics Models*

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For several space structures, such as high frequency telecommunication antennas, the requirements for thermo-mechanical deformations become more and more demanding. Besides the structural integrity the in-orbit deformation of an antenna's reflective surface is one of the key parameters in structural antenna design.
In-orbit testing and validation is nearly impossible due to cost and the unique nature of each mission. Also during on-ground testing the space environment a structure is subjected to can only be covered partly, if possible at all. Therefore, numerical simulations are the major tools for the design process and in-orbit performance prediction of a space structure. Nevertheless, these simulations are only accepted if they were correlated and validated using ground test results.
Common practice in space structure design is to judge the quality of simulation and correlation by characteristic numbers or comparison of discrete result points.
Due to the increasing complexity of simulation models and the use of full-field measurement methods it is necessary to implement an advanced validation process [1].

HPS GmbH has developed a multi-beam dual reflector antenna structure for high frequency radio communication satellites (Figure 1) [2]. This antenna reflector has to exhibit inherently very low thermo-mechanical deformations in the range of some 10 micro-meters over a large temperature range. For in-orbit thermo-mechanical distortion prediction, a thermal and mechanical FE model has been established. This allows non-linear thermal analysis to be performed and the temperature distributions to be applied to the mechanical model. Eventually, the resulting full-field deformation of the antenna reflector is obtained (Figure 2).

Figure 1: Multi-beam dual reflector antenna

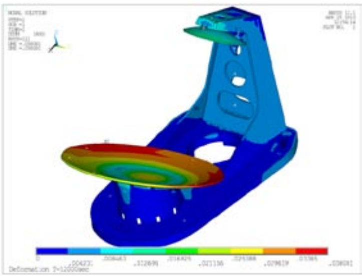

Figure 2: FE Model of the antenna

A so-called thermal-vacuum-cycling test has been performed in a space simulation chamber to test the

antenna's thermal and thermo-mechanical behavior in a vacuum and for different temperature stages. During this test the resulting deformations of the antenna reflector were measured using an full-field ESPI system. From the ESPI system a deformation plot over the complete temperature range is acquired. Similar to these measured plots, full-field deformation data is also obtained from the FE model.
Based on this case study the common approach of simulation and validation and the advanced validation process [1] is described.

With the ESPI system data being in the range of 1.3 million data points, a quantitative model correlation using the full-field data is rather challenging in terms of data post-processing and comparison. Therefore, the common approach applied in [2] was to use selected lines through the data and to compare the measured and calculated results in a qualitative manner.
To update and correlate the FE model several simulation runs with different boundary conditions and model properties are performed and compared to the measured results along the selected lines.

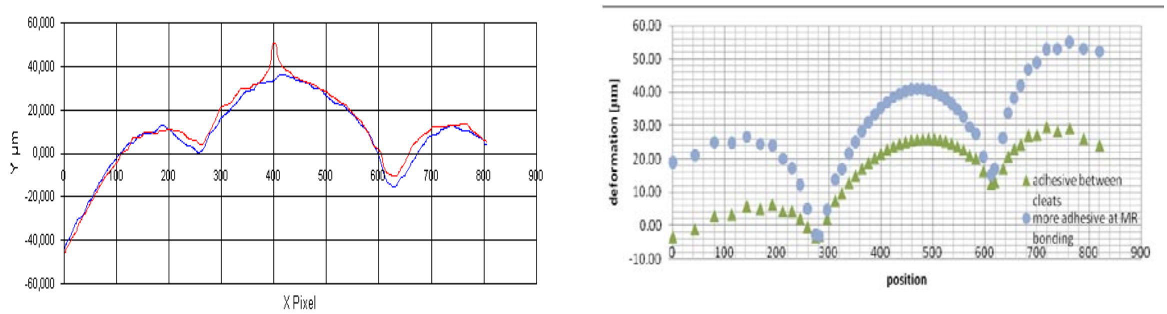

Figure 3: ESPI discrete data (left), FEA discrete data(right)

The available data sets of simulation and test were selected as one of the case studies for the Validation Inter-Laboratory Study within VANESSA [3]. Here, the advanced validation process was applied to the different simulation runs with varying boundary conditions.

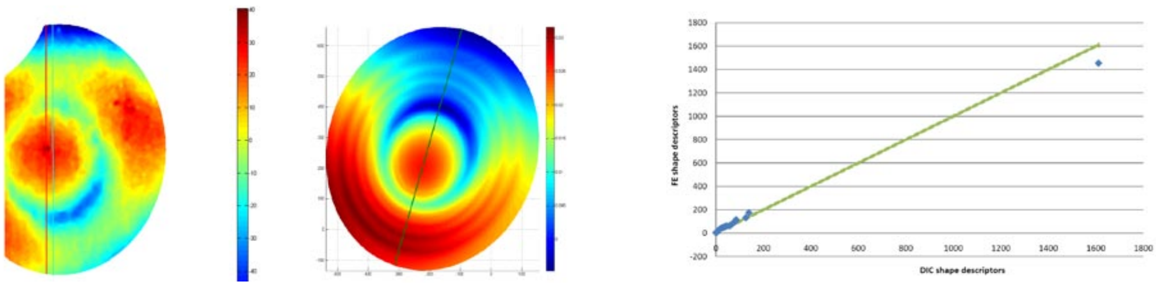

Figure 4: ESPI data (left), FEA data (middle), comparison (right)

## REFERENCES

[1] Sebastian, C., Hack, E., Patterson, E.A., 2013, An approach to the validation of computational solid mechanics models for strain analysis, J. Strain Analysis, 48(1):36-47.
[2] Highly Stable Antenna Technologies (STANT), Executive Summary, ESA/ESTEC Contract N° 22377/09/NL/US, ARTES 5.2.
[3] VANESSA - Validation of Numerical Engineering Simulations: Standardisation Actions, EU Seventh Framework Programme, Grant Agreement NMP3-SA-2012-319116.