Zorana Jeli
Associate Professor
University of Belgrade
Faculty of Mechanical Engineering

Misa Stojicevic
Teaching Assistant
University of Belgrade
Faculty of Mechanical Engineering

Ivana Cvetkovic
M.Sc.
University of Belgrade
Faculty of Mechanical Engineering

Alina Duta
Associate Professor
University of Craiova
Faculty of Mechanical Engineering
Romania

Dragos-Laurentiu Popa
Associate Professor
University of Craiova
Faculty of Mechanical Engineering
Romania

A 3d Analysis of Geometrical Factors and Their Influence on Air Flow Around a Satellite Dish

This paper deals with the geometrical characteristics and their influence on the functionality and safety of satellite dishes. Within the paper, a number of 3D models of satellite dishes were formed. All models were established in the software program SolidWorks, and the same software package was used for the analysis of the air flow over the satellite antenna for the conditions at the territory of Belgrade. The analysis of the model provides an insight into the geometrical characteristics of the satellite dishes which would be the most appropriate to adopt in accordance with the requirements of the final product functionality and security.
The analysis is based on laboratory tests, which were conducted on satellite dishes. On that occasion, it was concluded that the geometrical characteristics of the antenna itself greatly affect the functionality and safety. In order to simplify and to make a better financial approach to designing the final product-satellite dish, a basic analysis was carried out on the 3D models whose geometric characteristics can be changed . The models were analyzed to yield an optimal solution, since it is possible to get the final product.
The paper justifies forming a 3D model and analysing it, and shows the simplicity of the product geometry changes. The obtained final product is to a very large extent functional since it has been tested in the conditions -+-close to the real system where the product should operate.

Keywords: *3D model, fluid analysis, geometry of satellite dish, SolidWorks.*

1. INTRODUCTION

A long time of experience in design leads to the inevitable conclusion that the process of design of technical systems demands conducting certain analyses, which are often carried out at the level of mathematical calculations. Over time very powerful methods of mathematical modelling and design were developed for this purpose. Although it is a quite successful representation of reality, the mathematical model is not the best method of illustrating the real technical system [1].

Another way of illustrating the work of the technical system is the formation of the prototype and its analysis in the laboratory. This method is one of the closest ways to check the functionality of the real technical system, but economically very challenging, since it is expensive.

With the development of computer and software techniques the method of analysis of the 3D model has appeared [2]. This method is affordable, quite close to the real system, and allows a large number of changes on the spot, without a lot of unnecessary elements [3].

Received: March 2016, Accepted: October 2016
Correspondence to: Dr Zorana Jeli
Faculty of Mechanical Engineering,
Kraljice Marije 16, 11120 Belgrade 35, Serbia
E-mail: zjeli@mas.bg.ac.rs
doi:10.5937/fmet1702262J

2. INPUT PARAMETRES FOR 3D MODELING

A 3D CAD model of the satellite antenna is formed by the method of reverse engineering, which is made opposing air in the conditions of use of the technical system [4-5]. The simulation model is based on the factor of the speed of the airflow and the data are valid for the area in which the device is used.

The primary real model on which laboratory testing was carried out has been questioned by several factors [6-7]. Due to the amount of work in this study, it was not possible to include all the iterations that have been tested on a real model, and the simulation is performed only for some specific parameters.

The real-technical system satellite antenna was examined at the Aviation Technical Institute in Belgrade (VTI) [8], the fact of the wind opposing. Antennas were made of perforated metal, calotte diameter parabolic 3m [9].

The ability to these antennas move in space of is large: the azimuth (AZIMUT) angle is from -83.30 to 800, and the angle of elevation (ELEVACIJA) is from 140 to 87.20 (Figure 1).

Antenna testing was conducted in a small wind tunnel diffuser to place their cross-section to flow around the antenna without major obstacles. The cross-section was 26.34m2, while the surface of the antenna was 7.07m2. A detailed description of the preparation apparatus in the laboratory space is not discussed in more detail in the paper, because this is not the main goal of the research, but we mention it to demonstrate the effectiveness of the established methods of developing technical systems. The details of the experiments can be found in [9] and the documentation of VTI Belgrade. Defining the position of the antenna was carried out according to Figure 1.

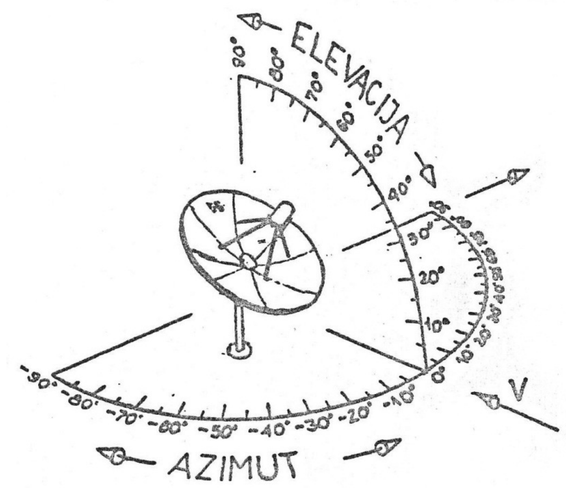

Figure 1. Corners displacement satellite dishes (Source: Puharic. (2008) [9])

The measurements were carried out as follows:

The velocity of air stream at the point where the antenna was set was determined by establishing the air velocity in the test section of wind tunnel and diffuser. Then, by measuring air velocity, the measurement system in proper working part and sharing with established relationships the speed of the air velocity in the vicinity of the antenna was determined. The measurement of dynamic pressures in the test section and around the satellite dish was done via the difference between total and static pressure.

$$q_{rd} = \frac{1}{2}\rho V_{rd}^2 \qquad (1)$$

and

$$q_{rd} = \frac{1}{2}\rho V_{rd}^2 \qquad (2)$$

Gives relation

$$\frac{q_{rd}}{q_d} = \frac{V_{rd}^2}{V_d^2} \qquad (3)$$

or

$$\frac{V_{rd}}{V_d} = \sqrt{\frac{q_{rd}}{q_d}} \qquad (4)$$

where

q_d– dynamic pressure in the diffuser around the antenna

q_{rd}– *dynamic pressure in the test section*

V_d– velocity air diffuser around the antenna

V_{rd}– air velocity *in the test section*

And for ρ=0.1212 kg/m^{4}s^2 by measurement receives next results (Table 1).

Table 1. Results for ρ=0.1212 kg/m^{4}s^2 by measurement (Source: Puharic (2008)[9])

No. Measurement	1	2	3	4
qrd Pa	1422	1586	1961	2370
qd Pa	404	451	561	671
Vrd m/s	48.92	51.66	57.45	63.15
Vd m/s	23.073	27.548	30.724	33.652
Vrd/Vd	1.876	1.875	1.87	1.877

Table 2. Results for ρ=0.1212 kg/m^{4}s^2 by measurement (Source: Puharic (2008)[9])

No. measurement	Azimuth (^{0})	Voltage (V)
1	70	0,18
2	60	0,45
3	50	0,73
4	40	1,01
5	30	1,29
6	20	1,57
7	10	1,85
8	0	2,14
9	-10	2,41
10	-20	2,69
11	-30	2,96
12	-40	3,25
13	-50	3,52
14	-60	3,8
15	-70	4,09
16	-80	4,36

Mean value of the ratio of the speed of air currents adopts V_{rd}/V_d= 1.8743, so that by measuring air velocity in the test section of the aero tunnel we get:

$$V_{r,d} = \sqrt{\frac{145 \cdot 10^6 HT}{B(255000 - 099H)}} \qquad (5)$$

or

$$V_d = \frac{1}{1.8743}\sqrt{\frac{145 \cdot 10^6 HT}{B(255000 - 099H)}} \qquad (6)$$

where

B - barometric pressure

H - pressure difference at the intersection of two collectors

T - air temperature.

In Table 2 and Figure 2 graphics are the results obtained by setting the angle of azimuth electric motor.

Defining the position calotte parabolic satellite antenna to the direction of air flow is conducted through the azimuth and elevation angles. The initial position of the antenna, represented in Figure 3, with the aerodynamic forces ((Rx, Ry and Rz) and moments (Mx, My and Mz) measured to the point you set in the centre of the balance. The coordinate system starting at this point is defined in Figure 3.

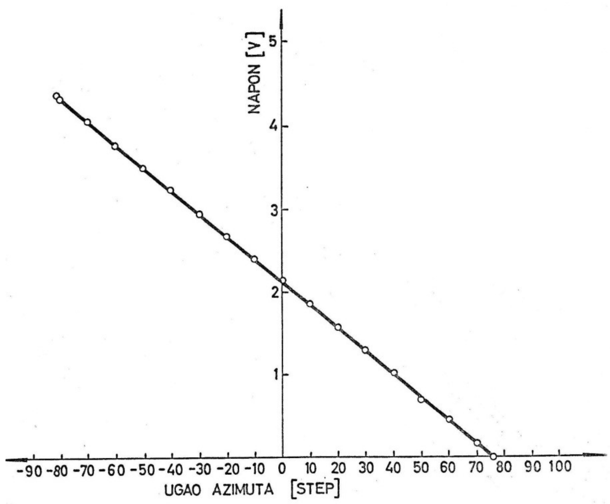

Figure 2. Results based on Table 2 (Source: Puharic. (2008) [9])

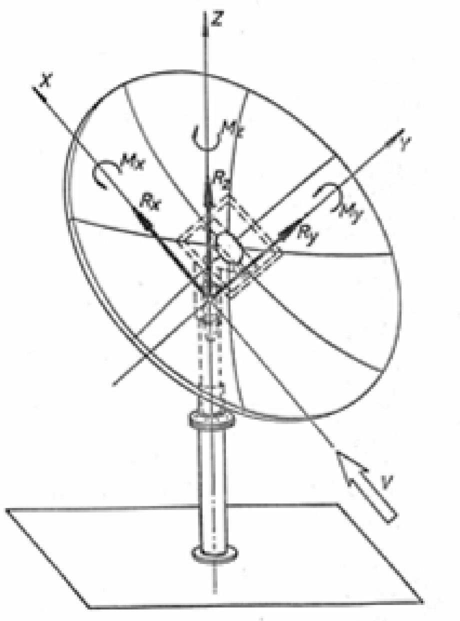

Figure 3. Geometrical and output parameters used on satellite antenna dish (Source: Puharic. (2008) [9])

3. SET OF SATELLITE DISHES, AIR OPPOSING

Lot satellite dish, which is a 3D CAD model obtained via reverse engineering, has been investigated in the exercise of its functions. Taking into account the technical function of the assembly which is directly related to the transmission of waves, it was considered necessary to perform an analysis of the air flow past the eye of the satellite dish. For this type of assembly it is very important that under the influence of air currents, by their nature large jammers, it cannot perform its basic function [10].

To successfully carry out the analysis of flow past satellite dish, it is necessary to define the climatic conditions in which some of the technical system needs to perform its function. According to data from the Hydro-meteorological Institute of Serbia, "Koshava wind is one of the characteristics of the climate of the city of Belgrade, the southeast wind-finale, whose speed is 25-43 km/h and its hit single, it can amount to up to 130 km/h". According to the accord with the winds and currents of air finale, it belongs to strong or very strong winds with hurricane gusts.

The satellite antena in this study was designed in SolidWorks 2011 software tool (Figure 4) and passed through a simulation tool flow SolidFlow (located in the professional package SolidWorks 2011) [4]. The results obtained by the simulation were compared with the results of tests of the real models of the satellite antenna that is made at the Aeronautical Technical Institute in Belgrade. The testing of the real model was performed in detail at the Aero-technical institute. All the details will be presented in this paper, while the results of the tests used as reference data in assessing performance of making the model after simulation was made.

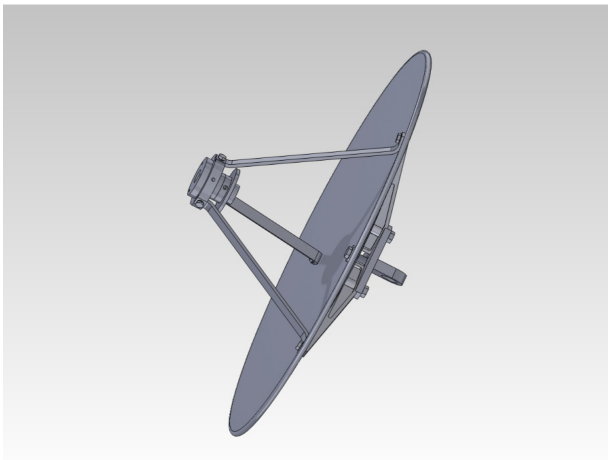

Figure 4. 3D model of satellite antenna (Source: Jeli (2012)[11])

Flow of opposing air was analyzed in SolidFlow tool for certain angles of azimuth and elevation. This view has impressive streamlines and accurately provides values for the real test of the model. It is in tabular and graphical representations of large scale. Necessary data on the examined technical system are received according to the colour chart is determined by the user (for its aesthetic obtain).

4. RESULTS OF AIR OPPOSING SIMULATION

Tables 3 and 4 show the results of tests of the antenna. Table 3 contains the results obtained by the simulation method, and Table 4 the results obtained in the real model tested in laboratory conditions. Both tables are made by using the following Input data:

Elevation angle:	UGLEV=14
Atmospheric pressure	B=100433,30 Pa
Temperature	t=302,8 K

When the results of Tables 3 and 4 are compared in parallel, it can be seen that compared to the same value of the input data (elevation angle, azimuth angle, wind speed, temperature, atmospheric pressure) the results obtained after disputed considering parameters (velocity, component aerodynamic force and moment after coordinates) have large deviations. Of course, the simulation results were obtained in the "ideal" conditions, but, since the frame of the test flows in the wind tunnel, there is no possibility that the conditions can be absolutely "idealize".

Table 3:The results of test flow of air around the satellite dish in 3D computer simulation (Source: Jeli (2012) [11])

Azimuth (0)	V[m/s]	Rx [N]	Ry[N]	Rz [N]	Mx [Nm]	My [Nm]	Mz [N]
-80	23.43	-297.504	-276.103	-1131.79	-809.21	-260.772	274.928
-60	21.73	-991.556	-576.682	-1968.11	-1333.63	390.362	562.89
-40	19.53	-1067.52	-735.501	-986.472	-357.501	185.295	728.554
-20	18.15	-1463.39	-416.114	-570.971	-393.978	95.4848	939.763
0	17.91	1343.46	-380.596	1.19797	-62.09265	-62.0554	298.292
20	18.15	-1387.26	-427.394	573.81	384.774	-184.827	792.761
40	19.92	-1310.79	-461.695	1210.2	848.024	-226.579	831.296
60	22.09	-1017.55	-587.256	1995.04	1344.94	-376.501	567.287
80	22.38	-315.534	-304.356	1185.26	798.6	287.774	387.322

Table 4: The results of test flow of air around the satellite dish in the wind tunnel simulation (Source: Puharic (2008) [9])

Azimuth (0)	V[m/s]	Rx [N]	Ry[N]	Rz [N]	Mx [Nm]	My [Nm]	Mz [N]
-80	23.43	-312.379	-278.864	-1120.479	-793.021	-265.936	291.424
-60	21.73	-1011.387	-570.915	-1928.75	-1320.29	409.881	585.406
-40	19.53	-1099.546	-772.276	-966.743	-357.501	192.707	713.983
-20	18.15	-1448.756	-428.597	-576.681	-393.978	964.396	930.365
0	17.91	1370.329	-399.628	122.193	-63.955	-63.917	307.241
20	18.15	-1401.133	-418.846	596.762	400.001	-182.979	832.399
40	19.92	-1337.006	-452.461	1234.404	865.007	-228.845	847.922
60	22.09	-1048.077	-593.129	2094.792	1412.187	-384.031	589.978
80	22.38	-325.001	-313.487	1161.555	790.614	299.285	379.576

In this way, it is proved that the method of test flow in the virtual reality is very effective, but not too challenging. The equipment used in the real experiment is cumbersome and it requires a very serious level of preparation of the experiment and the final result set. Testing the system in SolidFlow software package only requires certain skills that must be mastered by the designer who performs the technical development of the system. Of course, a prerequisite for obtaining high quality and proper test results is the proper formation of the 3D model. In this paper, the model for the formation of the methodology was obtained in PhD [11] dissertation, the results once again proved the correctness of the above methodology.

Figures 5-13 contain the representations of air flow past the eye of the satellite antenna with the values of the air pressure on the antenna itself and the values that are considered in the tabulations. These images were downloaded directly from the monitor screen in the simulations performed.

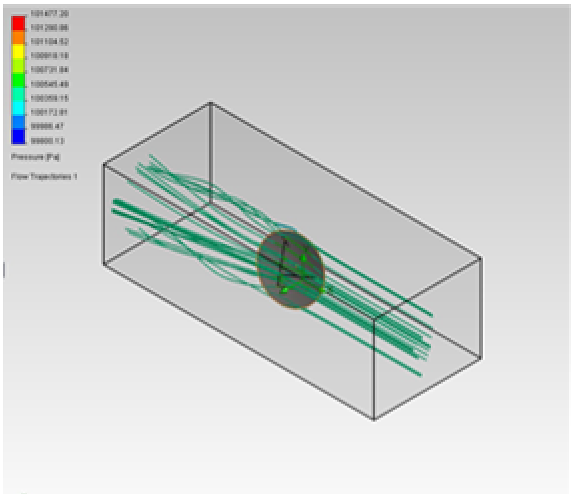

Figure 5. Opposing AZIM=-80.00^0

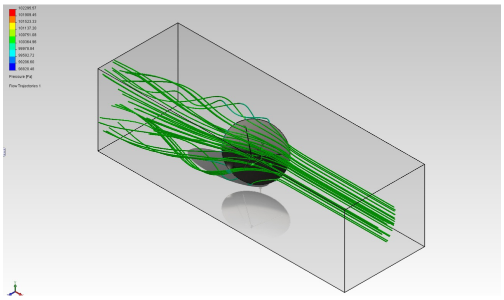

Figure 6 Opposing AZIM=-60.00^0

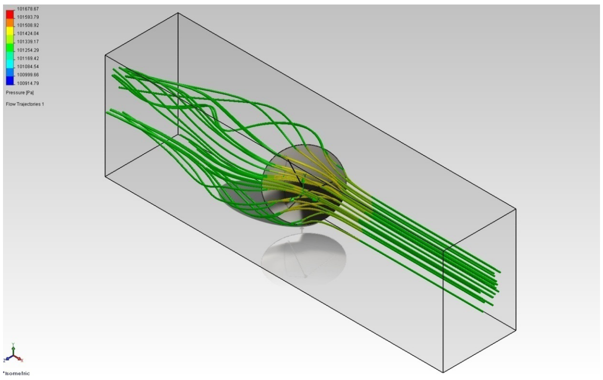

Figure 7 Opposing AZIM=-40.00^0

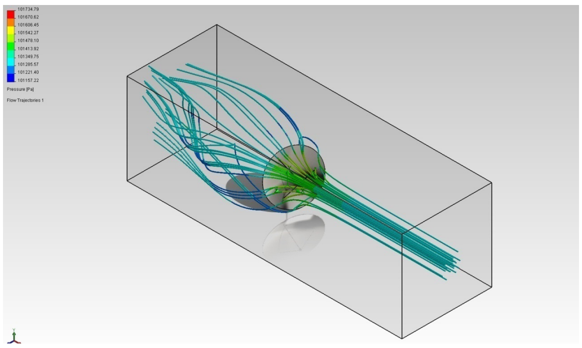

Figure 8 Opposing AZIM=-20.00^0

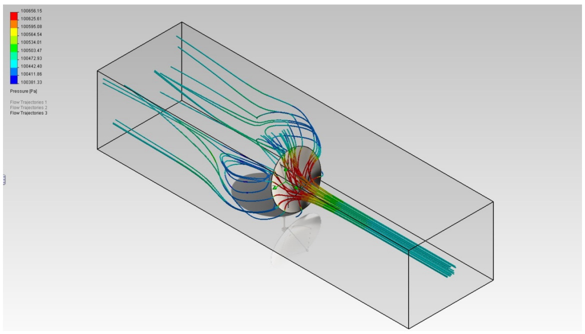

Figure 9 Opposing AZIM=-0.00^0

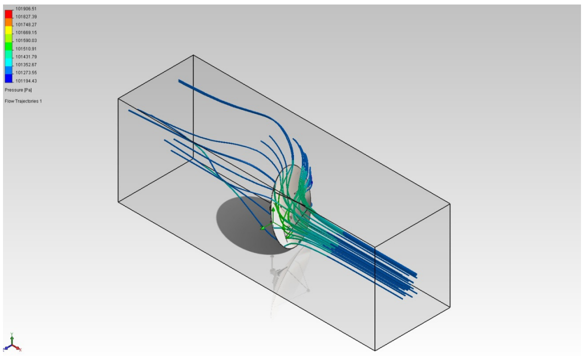

Figure 10 Opposing AZIM=20.00^0

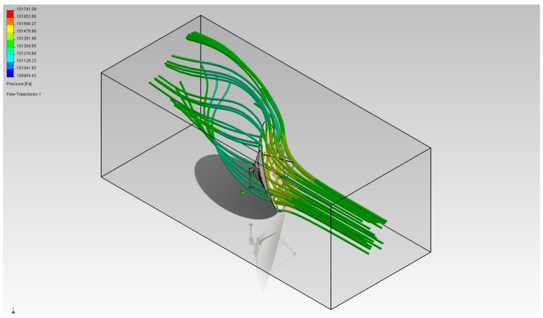

Figure 11 Opposing AZIM=40.00^0

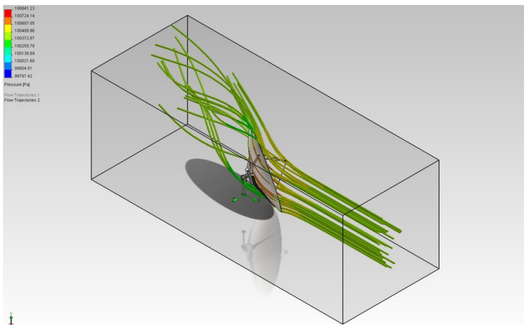

Figure12 Opposing AZIM=60.00^0

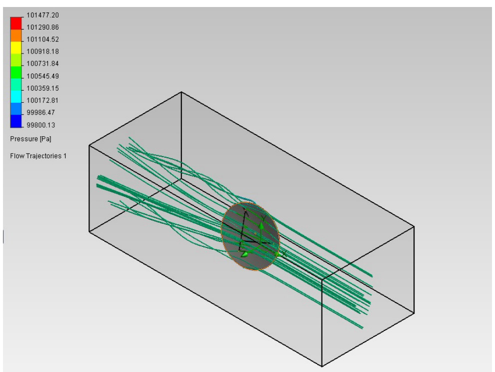

Figure 13 Opposing AZIM=80.00^0

5. CONCLUSION

By comparing the simulation results obtained in the laboratory it can be concluded that the model 3D CAD satellite dish was set up properly, and that the results are very close to reality (it is impossible to be the same). Once again the three-dimensional visual efficiency and ease of development of technical systems in the virtual space have been shown. Therefore, it can be concluded that this model captures the reality of the technical system of most of all known types of models.

ACKNOWLEDGEMENTS

This work was financially supported by the Ministry of Science and Technological Development of the Republic of Serbia through project No. TR 35011.

REFERENCES

[1] Narciso M., Piera M. A, Guasch: A Methodology for Solving Logistic Optimization Problems through Simulation, Simulation, Society for Modeling and Simulation International (SCS), vol.86 № 5-6, pp. 369-389, 2010.

[2] Jeli Z. Stojicevic M.: Examination of the 3D Model of Satellite Antenna Dish-Fluid Flow Air Analysis Belgrade, SMMM 2014 pp. 65, 2014.

[3] O'Neill E., Conlan O., Lewis D.: Modelling and Simulation to Assist Context Aware System Design, Simulation, Society for Modelling and Simulation International (SCS), Vol. 87 №1-2, pp. 149-170, 2011.

[4] Arsham H.: Modlenig and Simulation for Product Design Process, Simulation, Society for Modeling and Simulation International (SCS), vol.89, Issue 2, pp. 139-155, February 2013.

[5] Balci O.: A Life Cucle for Modeling and Simulation (SCS), vol.88, Issue 7, pp. 870-883, July 2012.

[6] Damljanović, D., Rašuo, B.: Testing of Calibration Models in Order to Certify the Overall Reliability of the Trisonic Blowdown Wind Tunnel of VTI, FME Transactions, Vol. 38 No 4, pp. 167-172, 2010.

[7] Rašuo, B.: Scaling between Wind Tunnels–Results Accuracy in Two-Dimensional Testing, Transactions of the Japan Society for Aeronautical & Space Sciences, Vol. 55, No. 2, pp 109-115, 2012.

[8] Damljanović, D., Isaković, J., Rašuo, B.: T-38 Wind-Tunnel Data Quality Assurance Based on Testing of a Standard Model, Journal of Aircraft, AIAA, Vol. 50, Issue 4, pp. 1141-1149, July 2013.

[9] Puharic M.: Testing of buildings in the subsonic wind tunnel, Military Technical Institute Belgrade, Cumulative scientific information Vol. 1, 2008.

[10] Jintao L., Shuhong L., Yuekun S., Yulin W.,Lequin W.:Three Dimensional Flow Simulation of Load Rejection of a Prototype Pump-turbin, Engineering with Computers, An International Journal for Simulation-Based Engineering, Springer, Vol. 29, Issue 4, pp. 417-426, October 2013.

[11] Jeli Z.: Graphics communications and virtual reality in development of technical systems, PhD dissertation, University of Belgrade (in Serbian), 2012.

ЗД АНАЛИЗА ГЕОМЕТРИЈСКИХ ФАКТОРА И ЊИХОВО УТИЦАЊЕ НА ОПСТРУЈАВАЊЕ ВАЗДУХА ОКО САТЕЛИТСКЕ АНТЕНЕ

З. Јели, М. Стојићевић, И. Цветковић, А. Дута, Д. Попа

Овај рад се бави проблематиком геометријских карактеристика сателитске антене и утицајем тих карактеристика на функционалност и безбедност. У оквиру рада је извршено формирање одређеног броја 3D модела сателитске антене. Сви модели су формирани у софтверском програму SolidWorks, и у истом програмском пакету извршене су анализе опструјавања ваздуха око антене за услове на територији града Београда. Анализом модела дошло се до закључка као би било најсврсисходније прила–годити геометријске карактеристике сателитске антене да би коначан производ испуњавао функци–оналне и безбедносне захтеве.
Анализа је базирана на лабораторијским испитивањима, која су спроведена на сателитским антенама. Том приликом дошло се до закључка да геометријске карактеристике саме антене у великој мери утичу на функционалност и безбедност производа. Ради једноставнијег и, у крајњој мери, финансијски оправданијег приступа изради коначног производа-сателитске антене, основна анализа је извршена на 3D моделима, на којима су рађене промене геометријских карактеристика. Модели су анализирани и добијено је оптимално решење, од кога може да се направи коначан производ. Рад показује оправданост формирања 3D модела, његове анализе и показује једноставност промене геометрије производа. У веома великој мери добија се коначни производ који је испитан у условима блиским реалном систему у ком производ треба да функционише.