САМАРСКИЙ УНИВЕРСИТЕТ
SAMARA UNIVERSITY

Determination of Relative Position and Orientation of Nanosatellites by Video Image Analysis

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Samara University is one of Russia's leading centers of education, science and culture, providing cutting-edge education and research services and social and cultural projects aimed at developing and improving the potential of aerospace and other hi-tech industries in Povolzhsky Federal District and the country

International Partnerships*:*

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- Bradley University (USA)
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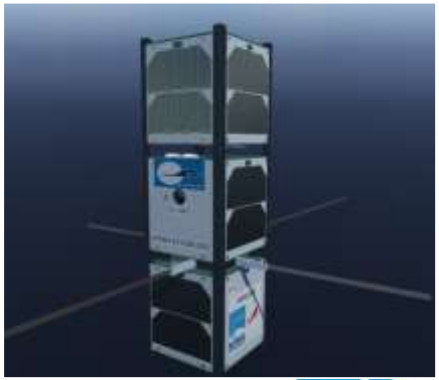
- Sophia Technical University (Bulgaria)
- Purdue University (USA)
- Munich Technical University (Germany)
- Vienna Institute of Information Processing (Austria), and others.

The University has successfully completed contracts with companies from Italy, Finland, France, PRC, Latvia, Lithuania, and Ukraine to deliver to foreign customers technological products developed by Samara University.

Teaching students through design nanosatellites

Head of the space Research Department,
Doctor of Technical Sciences, Professor
I. V. Belokonov



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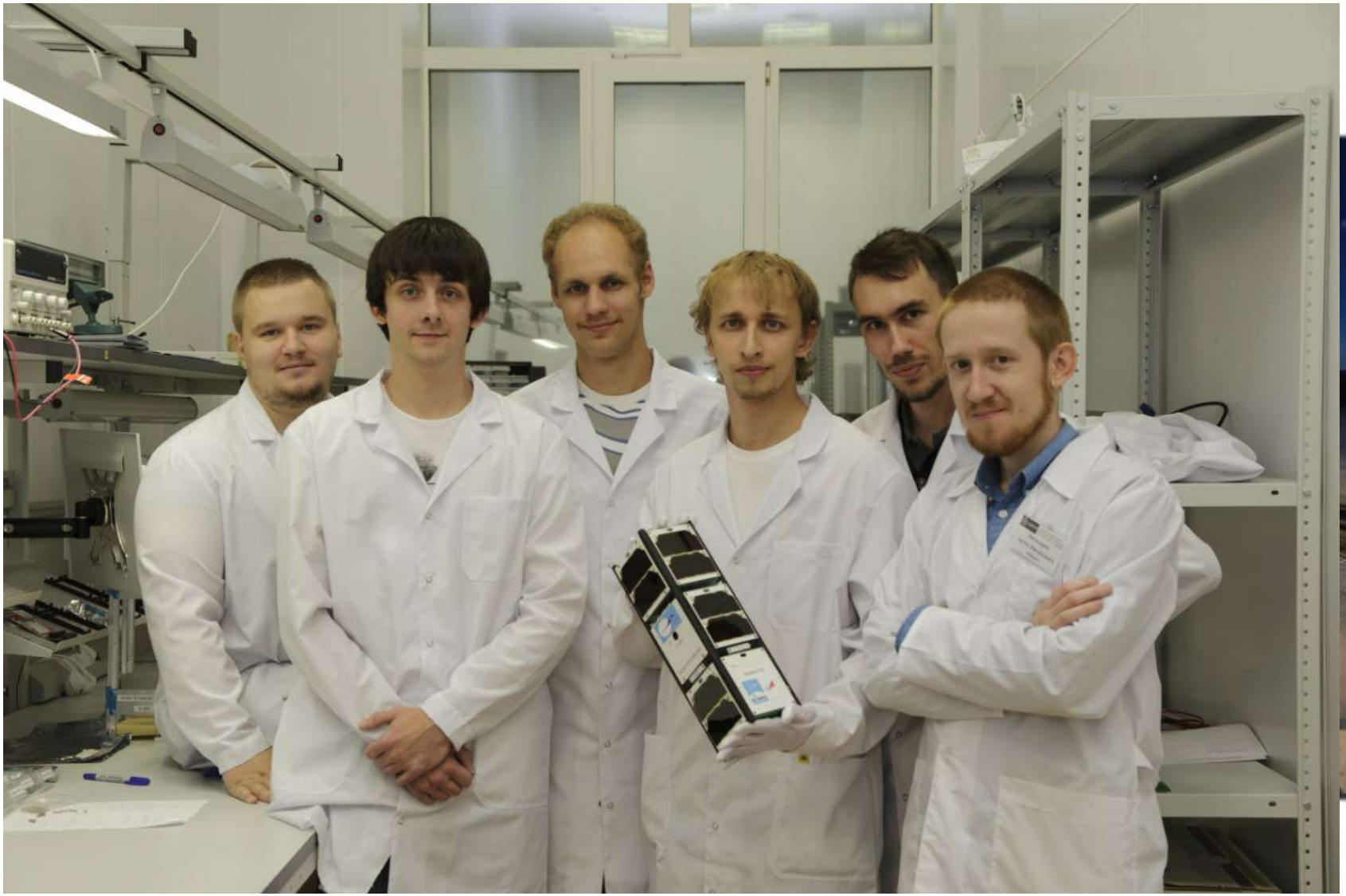

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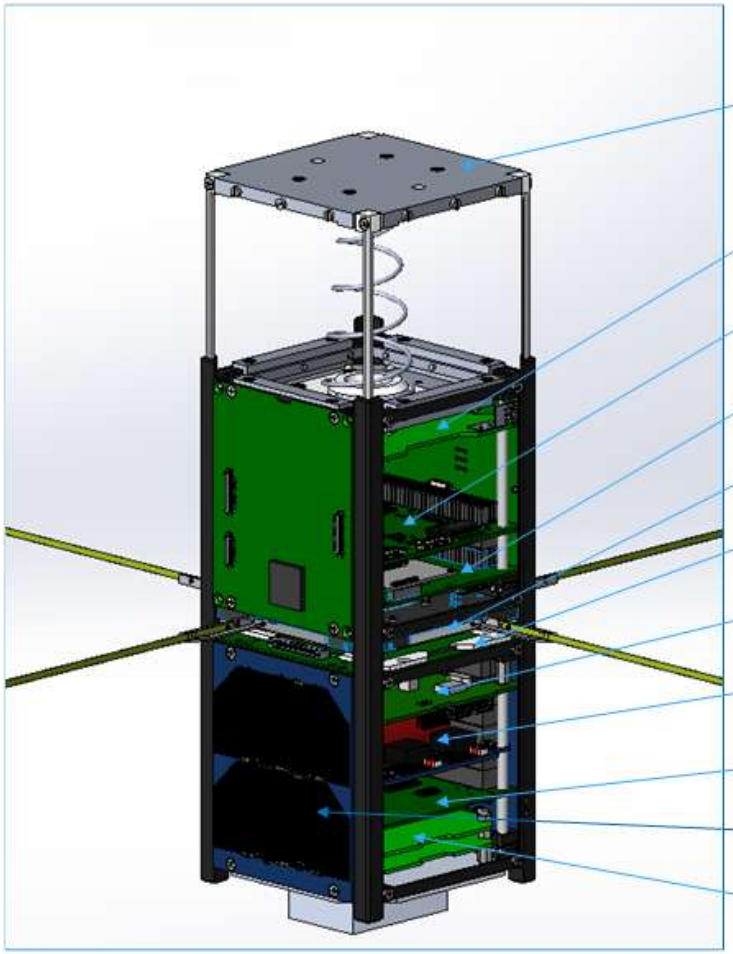
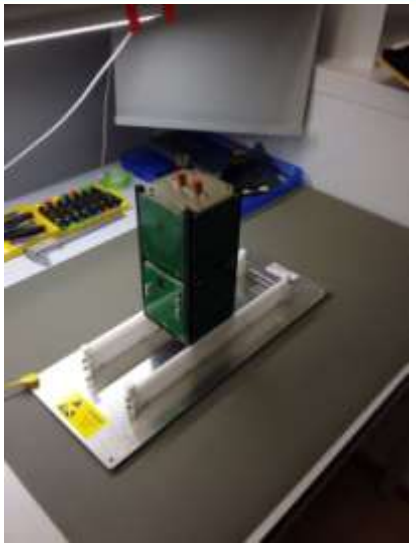
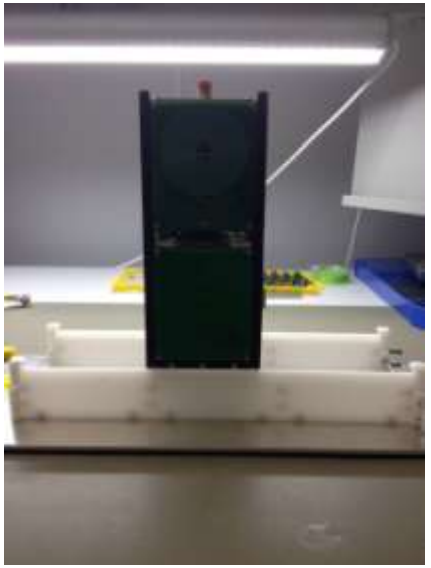


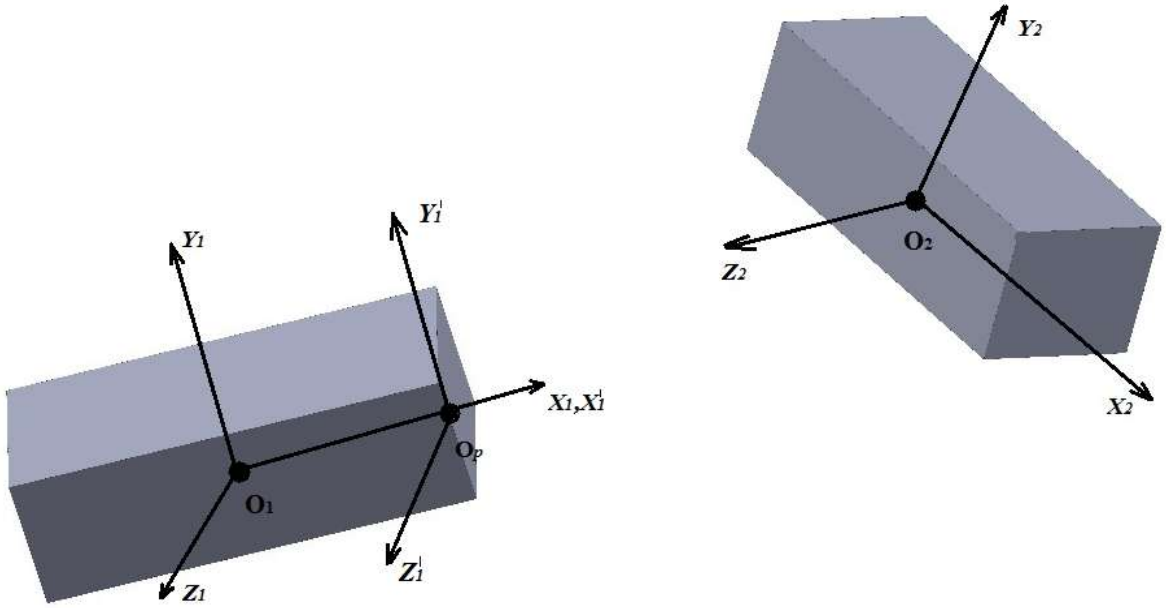
- Aerodynamic Stabilizer
- Aerodynamic Stabilizer Opening System
- OBC
- GPS Reciever
- ANTS
- IGIS
- TRXUV
- EPS
- Payload Integration System
- Solar Panels
- FIPEX Payload



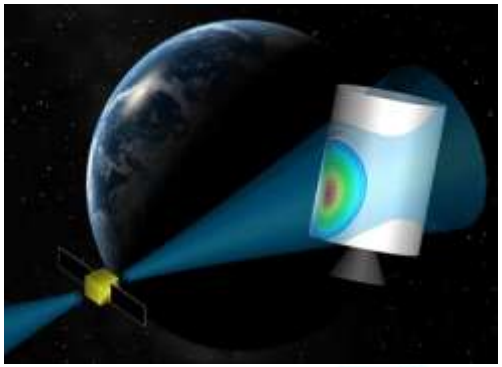


PROBLEM FORMULATION

Currently, actively developed the theme of the formation flight.
In this flight are often used nanosatellite and one of the many methods of relative navigation into this groups may be navigation with video camera.
In this regard, the development of an independent algorithm for determining the navigation parameters from the onboard video equipment is an urgent task



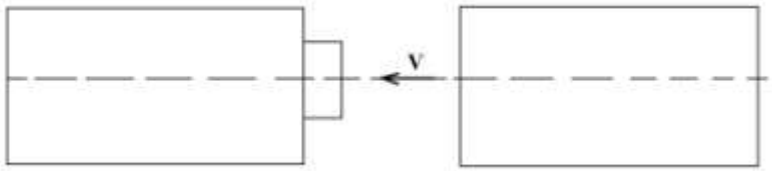
Pic. 1. Used coordinate systems



INITIAL CONDITIONS FOR MODELING

Table 1 – Parameters of the orbit and separation, mass, inertia and dimensional characteristics

Parameters of the orbit	
Height, км	300
Separation parameters	
Angular velocity, deg/s	
ω_x	0
угло	4
	4
Linear velocity, m/s	
	0.01
V_y	0
ω_z	0
Mass, inertia and dimensional characteristics	
Moments of inertia, kg/m³	
V_x	0.0033
I_y , I_z	0.0103
Length, m	0.24
Mass, kg	2

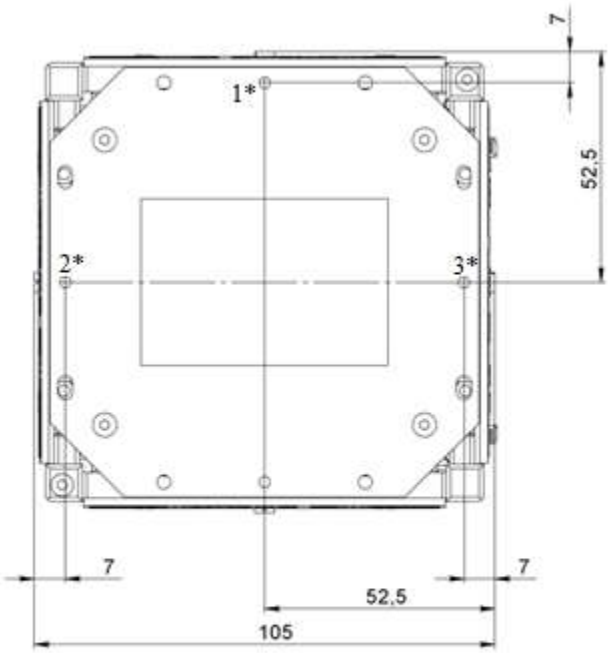


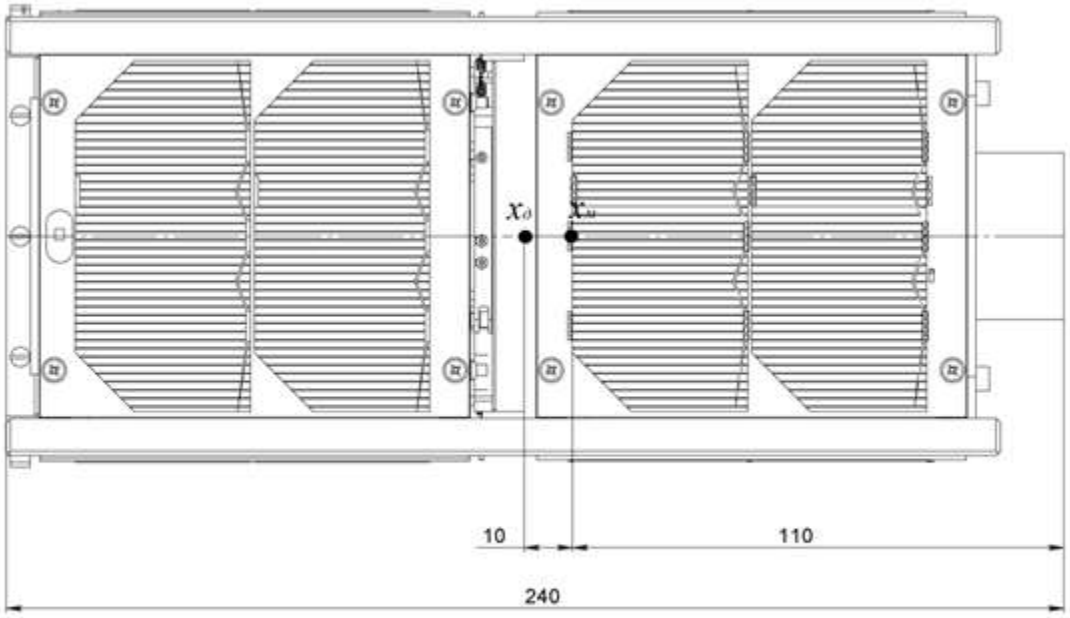
Pic. 2. Separation scheme

Table 2 – Position of the reference points(mm)

№	1	2	3
x_2	92	92	92
y_2	0	-45.5	45.5
z_2	45.5	0	0

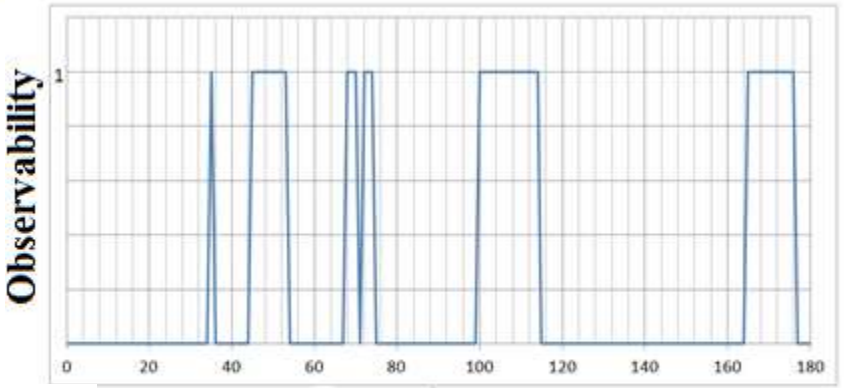
MODELING OBJECT SKETCH



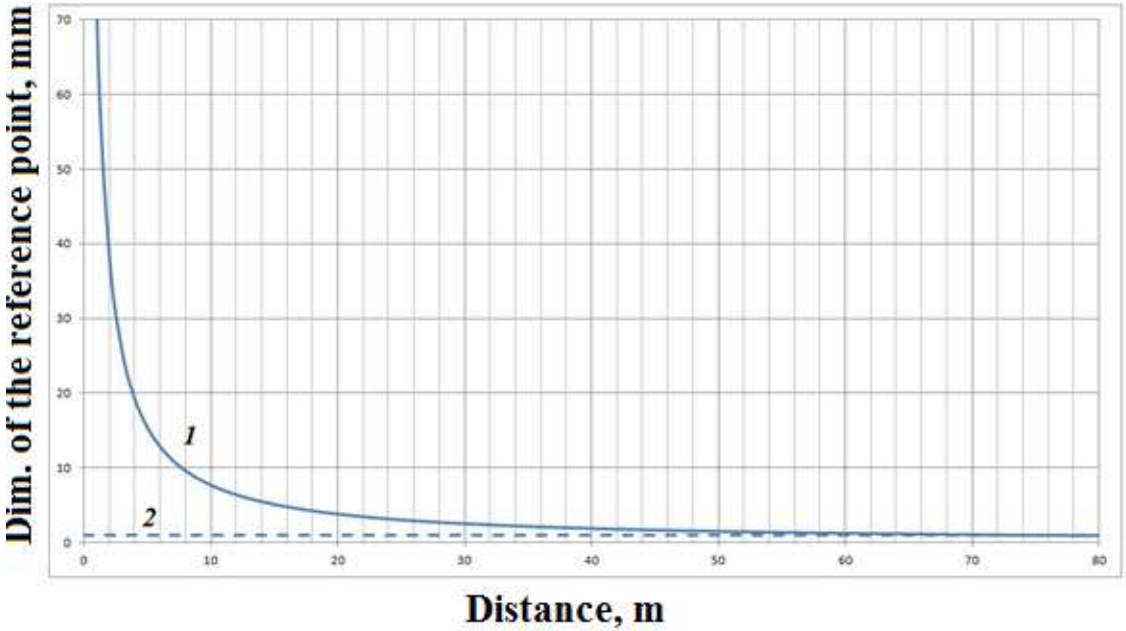


**-Reference points*

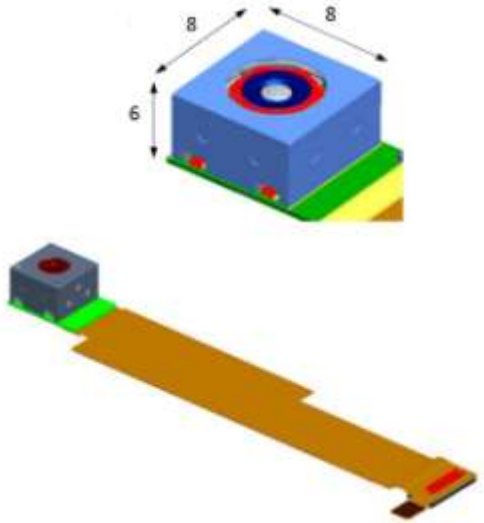
1. *The sensor has a rectangular shape with dimensions 4,8x3,6 mm;*
2. *The focal distance of the camera f=29 mm;*
3. *Camera resolution 640x480;*
4. *Linear size of the reference point W=H=D=20 мм;*
5. *The camera should make >2 snapshots.*



Pic. 3. Dependence observability of the time for the selected camera



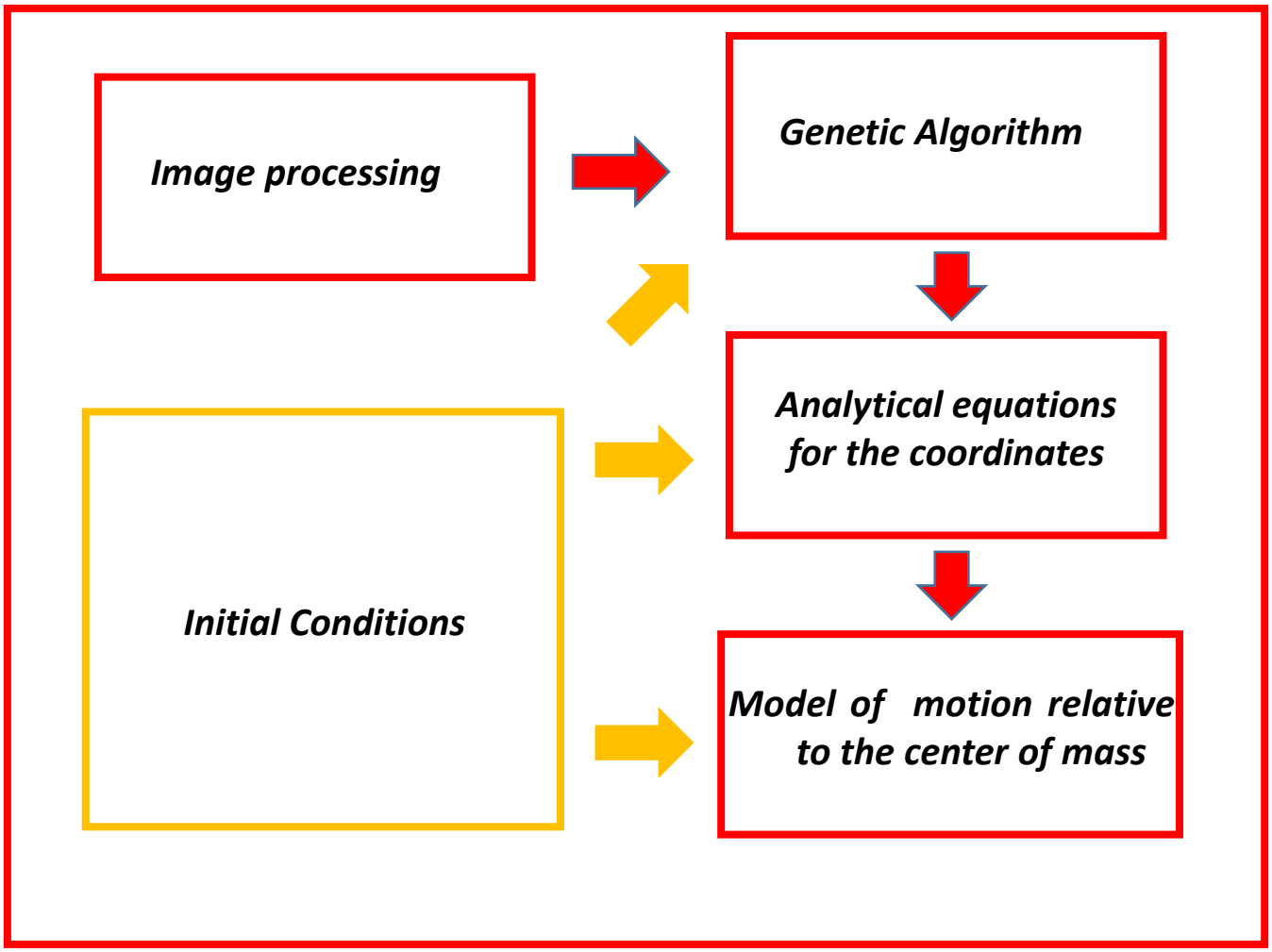
Pic. 4. Dependence benchmark size of the distance between nanosatellites: 1 – dependence; 2 – conventional border



Pic. 5. Selected camera

ALGORITHM OF RELATIVE NAVIGATION

Algorithm structure:

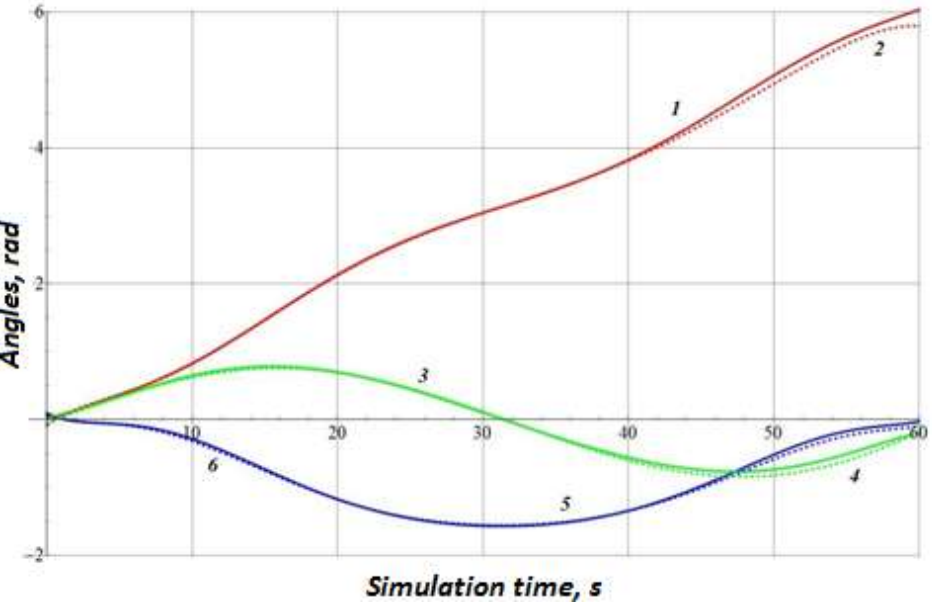


Research method:

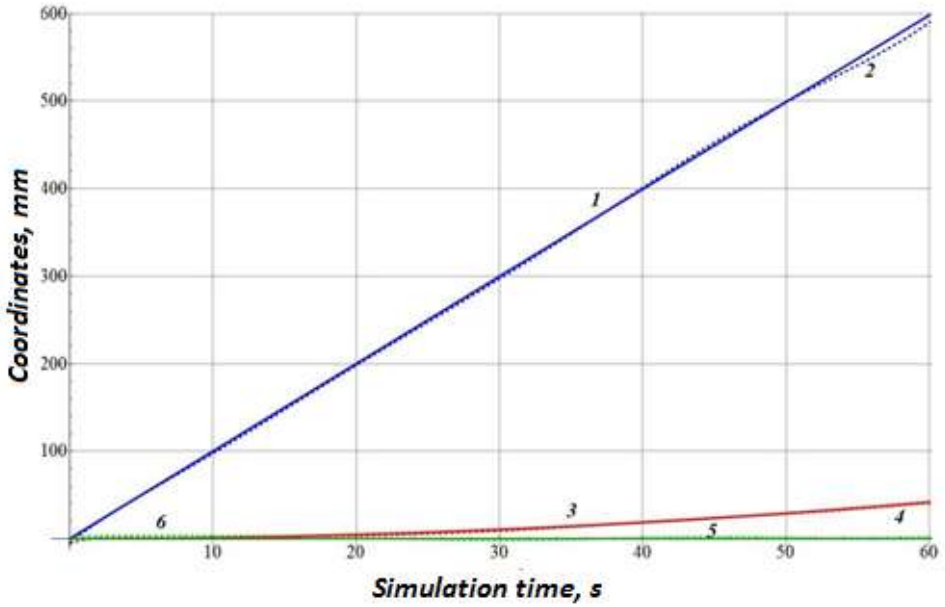
Method Monte Carlo

SIMULATION

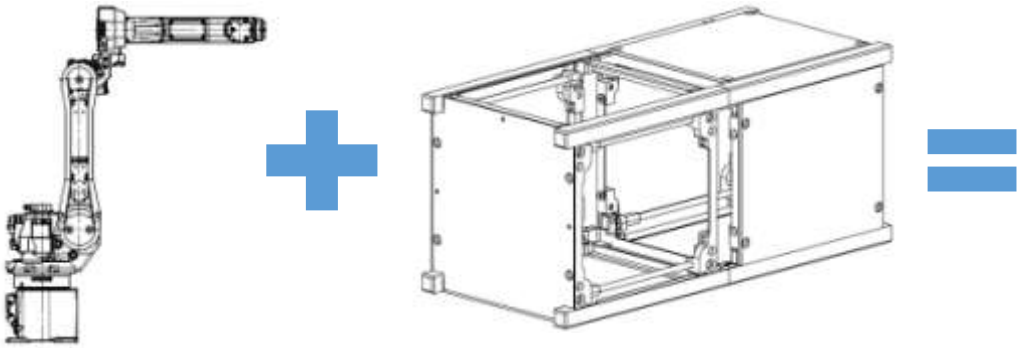
1. *Simulation time t=60 s;*
2. *Second nanosatellite observe by the first nanosatellite through all simulation time;*
3. *Initial population size N=10000;*
4. *Number of model experiments n=400;*

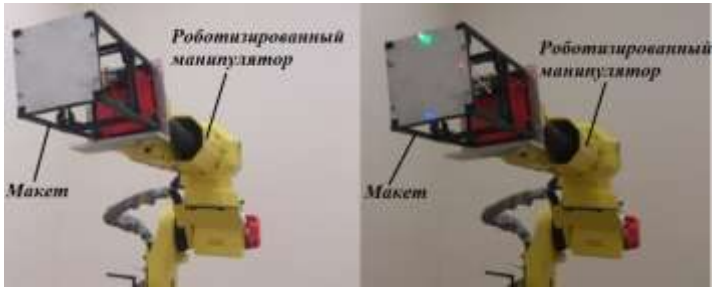


Pic 6. *Изменение углов ориентации:*
1 – initial angle ψ ; 2 – math. expectation of the angle ψ ;
3 – initial angle Θ ; 4 – math. expectation of the angle Θ ;
5 – initial angle φ ; 6 – math. expectation of the angle φ

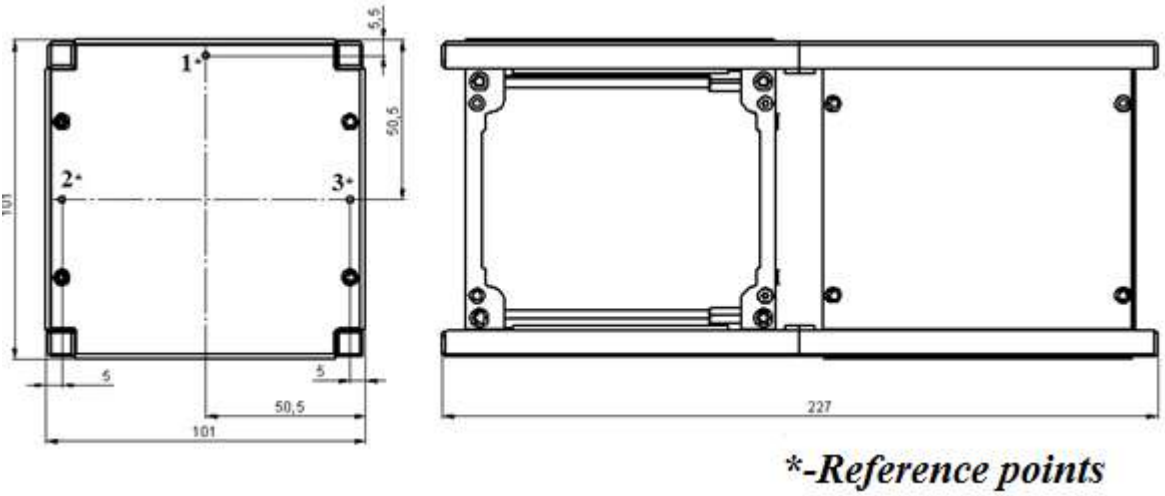


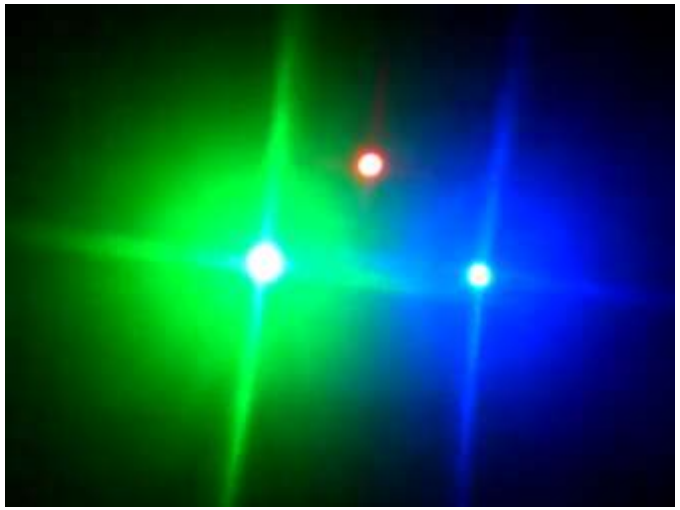
Pic. 7. *Изменение координат центра масс:*
1 – initial coordinate Xc ;
2 – math. expectation of the coordinate Xc ;
3 – initial coordinate Yc ;
4 – math. expectation of the coordinate Yc ;
5 – initial coordinate Zc ;
6 – math. expectation of the coordinate Zc





Pic. 8. Experimental installation

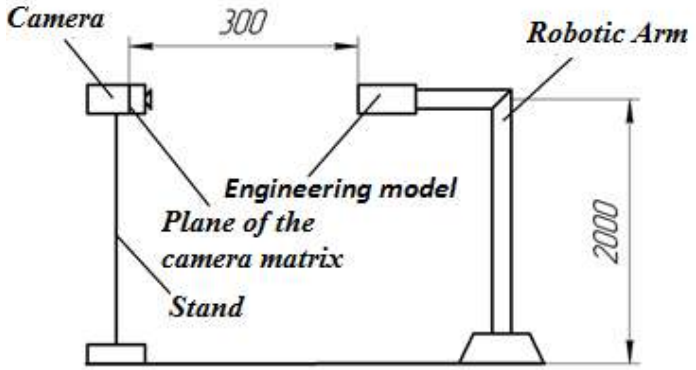




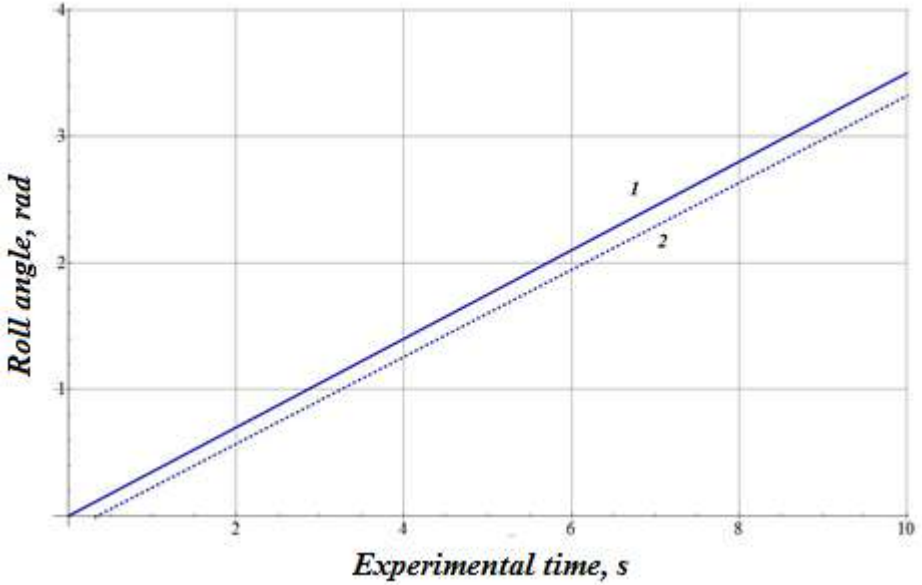
Pic. 9. Dimensions of the engineering model

EXPERIMENTAL RESULTS

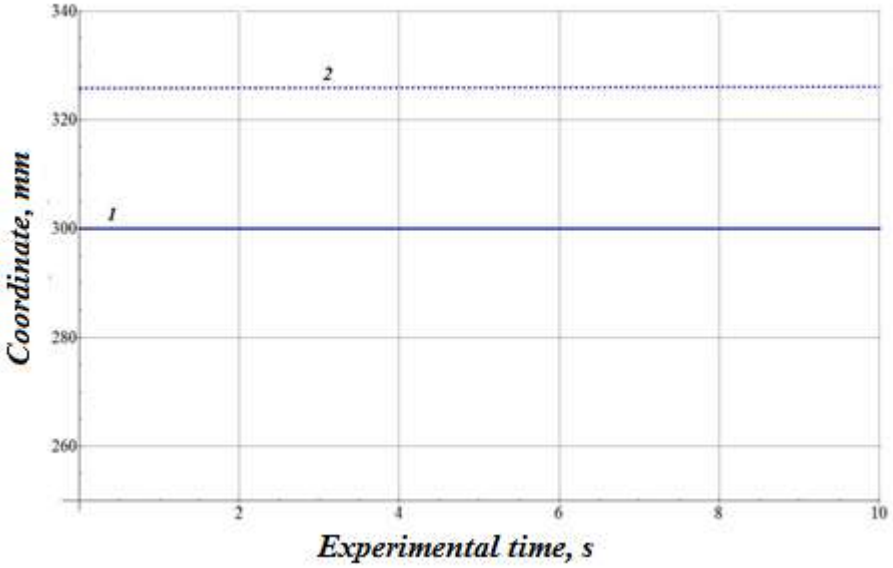
1. Modeling time t=10 s;
2. The distance between the camera and the subject is 300 mm;
3. Angular velocity ω_x =22 °/s, ω_y =0 °/s, ω_z = 0°/s;
4. Number of tests n=10.



Pic. 10. Scheme of the experimental installation



Pic. 11. Changing the roll angle:
1 – initial angle; 2 – math. expectation of the angle



Pic. 12. Changing the coordinate center of the mass:
1 – initial coord.; 2 – math. expectation of the coord.

CONCLUSIONS

1. *An algorithm for finding relative orientation and position was developed;*
2. *Spend a technical analysis of the selected optical camera;*
3. *Was assessed performance of the algorithm on the modeling and on the experiment.*

Did you make your own R-7?

Thanks for your attention!

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