*1, 2, 3... 26 - Presentation slides. (clk) - where you need to point with a laser pointer. On defense I have 3 sheets A1: sheet 1 - Illustration; sheet 2 - assembly drawing; sheet 3 - for the assembly drawing. And 7 sheets of A4 specifications.*

1

Hello, Dear members of the Attestation Commission. Your attention is invited to a graduation project on the stabilization of a video camera for UAVs.

2

There are currently public safety concerns on the roads. This problem is solved with the help of numerous sensors (clk) and various passive elements that are installed along the track. (clk) However, this does not always allow you to act quickly in search of violators and victims in the event of accidents on the roads. Therefore, systems have recently appeared that are installed on flying drones for quick and prompt response to such situations.

3

There are projects in the world in this regard. For example, Skywalker with its X8 Flying Wing (clk) drone or DJI with its Matrice 300 RTK multicopter. (clk) A comparative analysis is presented on slide 3. As the analysis shows, the former provide a high range, but cannot offer a variety of task solutions. The latter are able to provide flexibility, provide great opportunities for solving problems, but have a short duration of work.

To eliminate the shortcomings of both types of system based on the off-the-shelf FV-31 Cypher VTOL (clk) vertical takeoff and landing UAV market , the task was to develop a flexible and multifunctional video camera stabilization platform for work in police units.

4

The purpose of my project is to create a complex system for tracking ground objects, such as buildings and structures, ground vehicles and people. (clk) The following requirements are imposed on the complex.

5

To achieve this goal, (clk) the following tasks were set, presented on the slide and on **1 sheet** .

As part of solving **the first** task, it was necessary to determine the structure and control systems of the “video camera stabilizer unit”. Hereafter, we will simply refer to it as "BSV". Based on the presented requirements, I propose the following structure of the BSV.

6

The main devices are: (clk)

1. UAV with an empty faired head for BSV
2. Camcorder Stabilizer Unit
3. Mode switching mechanism
4. Video camera system
5. Control system
6. Unit power

7

Sheet 1 and slide show the structure of the BSV management system.

There are 4 levels in my proposed structure:

The highest level of control (clk) - at this level, decision planning and behavior planning work, and includes various finite automaton algorithms and machine learning algorithms.

Strategic management level (clk) - includes the work of planning the trajectory and building a map of the area.

Tactical control level (clk) - includes the distribution of control signals to a separate drive, and also implements a mode switching signal;

Executive level (clk) - at this level, drive mechanisms and various sensors operate.

In this work, only (clk) executive and tactical levels were worked out.

8

In this project, a 3-degree BSV with the possibility of folding into the UAV fuselage for flight in 2 modes is proposed. In aircraft mode (clk), the product is inside the UAV, the system is located on the front of the fuselage. The security camera looks strictly straight through the transparent case. All links in this mode do not move. In multicopter (clk) mode , the unit descends to increase visibility.

Such a scheme allows the UAV to follow fast cars, as well as hover in the air to track stationary objects.

9

In the course of solving **the second** task, it is necessary to select modules that include (clk) a conventional and long-range camera, a thermal imager and a laser rangefinder. There are various products on the market for this.

10

For example, you can take (clk) ready-made modules from a smartphone, but the system is closed, so it is impossible to produce products based on them. (clk) Ready-made camcorder stabilizer modules on the market do not make it as compact as we would like. In conclusion, it was decided to take ready-made sensor modules and develop a video camera stabilizer on our own.

eleven

As part of **the third** task, energy and adjustment calculations were made for the drive of this BSV. The value of precision (clk) comes from the fact that you need to provide a clear image. No fluff or grease. The required value for the drives that the video camera puts forward was estimated (clk) by the approximate analytical method shown on the slide.

12

As a result, it is possible to derive (clk) the kinematic diagram of the BSV, (clk) the required accuracy of the system, the range of mobility and the mass of the load.

13

According to the results of the energy calculation for a separate transmission, engines with different capacities were selected. As an adjustment calculation, consider (clk) the arm swing drive.

14

Taking into account the peculiarities of the operation of the UAV video camera stabilizer, namely, the study of small details from a long distance is required, it was necessary to ensure the following requirements for the organization of the drive control system. The controller must provide **two** orders of astatism in terms of the control action and **one** order in terms of the disturbing action, and the steady-state error in terms of the control and the disturbing action is equal to 0.

Therefore, our controller has a motor control circuit based on the principle of slave control with 3 loops: (clk) position, speed and current. Includes the following types of controllers: (clk) PI current controller, PI speed controller and PI position controller.

15

My task was to determine the coefficients of these controllers (clk) and build a model in the Matlab/Simulink software environment for further research. Since the drive only works when the UAV goes into multicopter mode, therefore, the wind load can be ignored.

Based on the results of the adjustment calculation, the following regulators were obtained, presented on the slide.

16

In the course of **the fourth** task, the resulting model (clk) was studied by the LAFC and PFC and the stability margins were determined. The operation of the drive model was tested in 3 modes: (clk) acceleration, movement without acceleration and deceleration. (clk) This represents the response of the position, speed, and current loops to an input. As can be seen from the current graph, (clk) its peak values do not exceed the allowable values. (clk)

17

The gear ratio of the regulators was translated in the discrete region using the Tustin method. According to the results of the LAFC analysis (clk), the graphs almost coincide with the continuous system. As a result, a (clk) difference equation was derived, which can be integrated into the microcontroller.

18

As **the fifth problem,** (clk) direct and inverse problems in position and velocity were derived . The coordinates are considered to start from the coordinate (clk) of the UAV center of mass to the camera platform. (clk)

19

The general block diagram in the Matlab environment is presented on the slide. (clk) The slide shows the areas where one or another implementation in the simulation corresponds. In a real system, the aircraft can turn in space. Therefore, (clk) artificial UAV tilts were introduced . The slide (clk) shows modeling in 3D. Ideally, it is necessary to ensure that the aircraft flies straight, level and does not change altitude.

20

In general, when simulating a single drive (clk) gives good accuracy results. The errors of the entire system shows (clk) a satisfactory accuracy value. In detail, (clk) the error value of the entire system is greater than the 0.6 degrees calculated earlier. This is due to the frame folding effect. The error occurs at the tactical level, not at the executive level. Therefore, to solve this problem, it is necessary to additionally apply optical and matrix stabilization.

21

As part of **the sixth** task, the following requirements for structures were derived. (clk) Design documentation, drawings, assembly drawings and (clk) specifications were drawn up from the listed requirements . The assembly drawing of the video camera stabilizer is presented at (clk) **2 sheets** . Under Assembly drawing of the stabilizer arm is presented on (clk) **3 sheets** . The slide shows (clk) modeling in 3D.

22

Structural elements such as shafts, bearings and (clk) mechanical transmissions were calculated, many drawings are presented in Appendix A and B of the graphic part of the RPG.

23

When calculating case products, they were carried out by the modern finite element method in the NX Pre / Post environment.

For example, for the shoulder body, the calculation steps in the program are as follows: (clk)

More detailed calculations were carried out in the design part of the RPZ.

24

Simulation analyzes show that all values do not exceed ultimate contact strength. The safety factor does not exceed the allowable one.

25

For other parts, the calculation algorithm is carried out in the same way.

26

This study has become the final part of my work.

The following results were achieved in the course of the WRC. (clk)

Thank you for your attention, my report is over.