# Research and Develpoment Center of Unmanned Aviation "Virage"

**of the National Aviation University**

designed a number of unmanned aerial vehicles:

- Twin-engine unmanned aerial vehicles of “Sky Patrol“ series:
  - M-7 (weight 90 kg),
  - M-7D (weight 150 kg),
  - M-7V5 (weight 200 kg);
- Single-engine unmanned aerial vehicles :
  - M-6 “Lark" (weight 7 kg),
  - M-6-3 “Lark-2" (weight 12 kg),
  - M-10 “Eye“ (weight 3 kg),
  - M-10 “Eye-2“ (weight 5 kg),
  - M-22 "Aerotester" (weight 18 kg);
- Unmanned aerial vehicle “Polycopter” PC-08 (weight 4 kg);
- Remote-Control Complex "Ukraine".

# UAV M-7V5 "Sky Patrol"


**Purpose:** cartography and aerial photography, real time video surveillance, patrolling of linear objects.
**Year of development:** 2010
***Patent: UA** №62929*
**Stage of development:**
- final phase of prototype testing;
- in December 2012, a request for aircraft certification was submitted to the State Aviation Administration of Ukraine

**Technical characteristics:**
Wingspan, m – 6.0
Payload, kg – up to 70
Takeoff weight, kg – up to 200
Max. speed, km/h - 250
Engines, kW - 2 x 17
Max. altitude of flight, m - up to 3000
Takeoff and landing type - airplane
Takeoff distance, m - 50
Time of deployment into operation, h – 0.5

# UAV M-7D "Sky Patrol"

**Purpose:** cartography and aerial photography, real time video surveillance, patrolling of linear objects.
**Flight test:** 2010. Patents: **№33977; № 40288**


The project is based on the task of improving the working conditions onboard observation equipment of twin-engine unmanned aircraft to increase the limits of the front hemisphere and reduce vibration. M-7D "SKY PATROL" is a twin-engine aircraft of normal aerodynamic scheme of high wing. The project has undergone significant changes to the design of M-7 "SKY PATROL". Rearrangement of PP allowed to increase its take-off characteristics due to the effect of blowing of wing by propellers.

The body is made mainly of composite materials using wood and metal. The access to the payload compartment from upper and rear part of the gondola is made in the form of removable fairing. The standard target load - gyro stabilized full CCD - camera.

**Stage of development:** flight tests of the prototype.

# UNMANNED COMPLEX M-6 «LARK»

**Purpose:** aerial photography, real time video surveillance and patrolling of linear objects (M-6B), crops protection (M-6CX-E).
***Patent: UA № 34952, №38142, №43459***


**Performance M-6 "Lark":**
**Wingspan, m- 1.85**
**Payload, kg - under 5.5**
**Takeoff weight, kg - under 12***
**Engine, kW – 1.7***
**Maximum speed, km/h - 240***
**Agricultural area coverage, hect/h – 40**
**Productivity of video surveillance (500m), hect/h – 7776**
**Maximum flight altitude, m - under 1000***
**Takeoff type – by catapult**
**Landing type – airplane/ parachute.**

**International class: mini ; mass: under 20 kg; operational range: under 10 km; flight altitude: 300m; flight duration: over 2 hours.**
**Ukrainian class: small UAV; mass: 10 to100 kg;**
**battlefield UAV/tactical UAV;**
**short flight duration: 3 to 6 hours. Year of development: 2004**
**Flight test: 2004**

# Photographs Obtained from M-6 Onboard Video Camera

Surveillance camera

Camera of the outside pilot

## UAV M-6 “Lark” at Test


# UNMANNED COMPLEX M-6 «LARK-2»

**Purpose:**

**aerial photography, real time video surveillance (M-6-3P); patrolling of linear objects (M-6-3B).**

**Performance:**

Wingspan, m – 2.98
Payload, kg – up to 3.5
Takeoff weight, kg – up to 12
Max. speed, km/h - 160
Engine, kW – 3.2
Max. altitude of flight, m - up to 3000
Takeoff type – catapult
Landing type – parachute
Productivity photography (500m), ha / h - 7776

**Dependence route distance and duration of flight mass ratio of payload and fuel**

| The Fuel Mass Kg | The Payload, kg | The Flight Duration, h | Distance, km |
|---|---|---|---|
| 3.0 | 1.5 | 9 | 1000 |
| 2.0 | 2.5 | 6 | 650 |
| 1.0 | 3.5 | 3 | 350 |

# UNMANNED COMPLEX M-10 “EYE”

**Purpose:** real time video surveillance; patrolling of surface objects and aerial photography.

**International Class:** micro; mass: under 5 kg;
operating range: under 10km;
flight altitude: 250m;
flight duration: under 1 hour*;

**Flight test:** 2011

## PERFORMANCE OF M-10 “EYE”

| | |
|---|---|
| **Maximum takeoff weight – 3 kg*** | |
| **Unloaded weight – 1.3 kg** | |
| **Cruising speed – 60 km/h** | |
| **Maximum altitude of flight - 600 m** | |
| **Variants of Payload** | |
| **Payload – 1.5 kg** | **Payload – 1.3 kg** |
| **Batteries’ weight – 0.19 kg** | **Batteries’ weight – 0.38 kg** |
| **Flight duration ~ 30 min.** | **Flight duration ~ 1 hour** |
| **Flight distance ~ 45 km** | **Flight distance ~ 90 km** |

# UNMANNED COMPLEX M-10 “EYE-2”

**Purpose:** real time video surveillance; patrolling of surface objects and aerial photography.

**International Class:** micro; mass: under 5 kg;
operating range: under 10km;
flight altitude: 250m;
flight duration: under 1 hour*;

**Ukrainian Class:** battlefield UAV
**Flight test:** 2014

The goal of the design for M-10 was to create en electric powered aircraft that is virtually silent in operation. Given small load per unit of bearing area (~ 5 kg/m$^2$), the plane takes off the hands, allowing operation in a metropolitan area or in a small clearing in wooded areas. The relatively short flight duration is compensated by the combined motor and gliding flight mode which is supported through switching the electric motor on and off.

Fight duration: under 1.5 hours using the lithium-polymer battery. After changing the battery (in10 minutes), the UAV can be in operation again. Control mode: automatic and standard handheld remote control. The aircraft is equipped with a camera and a color CCD-video camera with a transmitter.

M-10 “Eye” is intended for battlefield reconnaissance by military units of platoon level. Civil usage of the UAV encompasses patrolling of small sites, surveillance over limited areas, etc.

M-10 “Eye” is placed in transport containers of 5 kg weight and size 1.1 x 0.29 x 0.29 m. Weight of complex in transport position - about 10kg.

**Analogues: Dragonfly Tango; Micropilot CropCam (Canada); EMT Aladin (Germany); Aeronautics Orbiter, IAI Bird Eye 400 (Israel).**

# TRAINER UAV M-22 «AEROTESTER»

***Purpose:*** training of the outside pilot; «flying laboratory».
***Year of development:*** 2012



**Performance:**

Wingspan, m – 2.5

Payload, kg – under 8

Takeoff weight, kg - under 18

Power of the engine, kW – 2.7

Maximum speed, km/h - 120

Max. flight altitude, m - under 2000

Takeoff/landing type – airplane

**Stage of development:**

flight tests of the prototype

# POLYCOPTER NAU PC–08

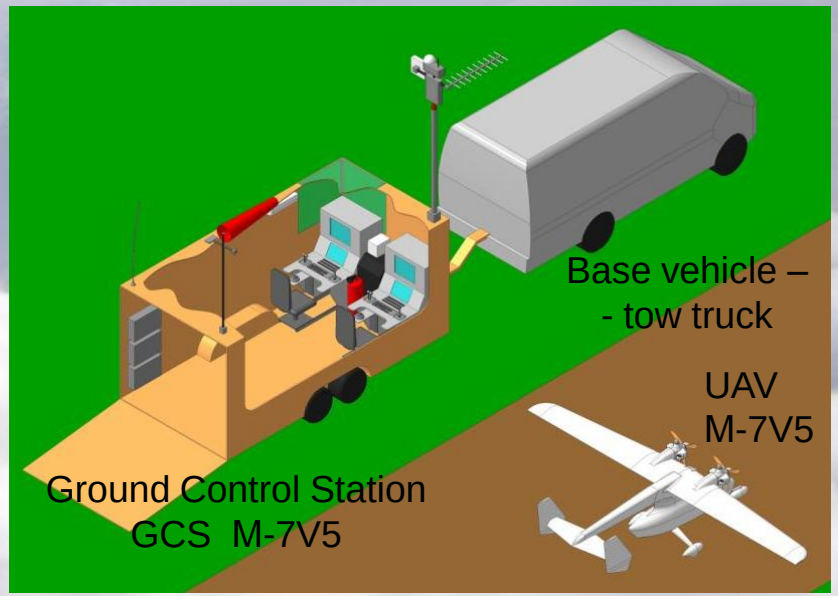
**Purpose:** aerial photography, cartography, real time video surveillance, patrolling of linear objects.
**Flight test:** March, 2013.

***Performance:***

Takeoff weight – under 5 kg;
Payload – under 2 kg;
Cruising speed : 20 – 30 km/h;
Span of attachable wing – 2.2 m;
Height – 0.6 m;
Altitude – 500 m;
Flight duration:
- without attachable wing – under 20 min.;
- with attachable wing – 55 min.

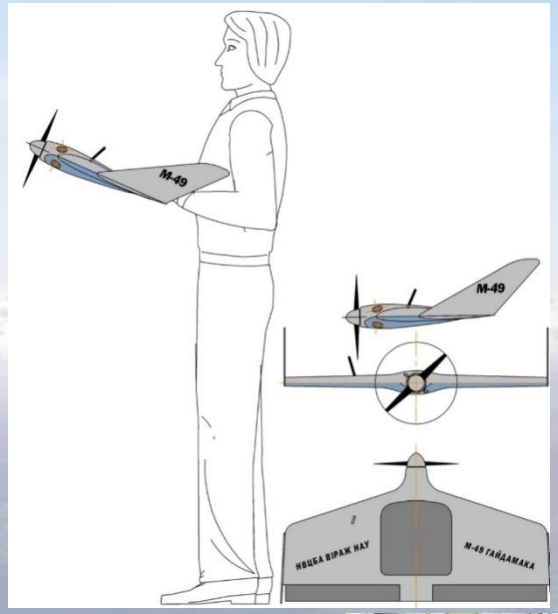
# UNMANNED AVIATION COMPLEX “UKRAINE”

**<u>Purpose:</u> unmanned aviation complex (UAC) “Ukraine” is designed to support flight of the twin-engine aircraft M-7V5 “Sky Patrol” in a designated airspace with the purpose of performing aerial works for various industries of the economy and national defense. The UAC “Ukraine” is serviced by a 4 men crew. The UAC “Ukraine” is composed of a twin-engine UAV M-7V5 “Sky Patrol”, a ground control station (GCS M- 7V5) and a transport vehicles.**




# Project of the UAV M-49 “Haydamaka"

**Purpose:** video surveillance in real time;
special operations;
cargo delivery.





**Technical Specifications**:

| | |
|---|---|
| Wingspan - | 0.82 m |
| Length - | 0.46 m |
| Max. takeoff weight - | < 4 kg |
| Empty weight - | 1.2 kg |
| Max. speed of flight - | 140 km/h |
| Cruising speed - | 100 km/h |
| Max. altitude of flight - | 2000 m |

Automatic control
Start - starting device or out of the hand
Landing – by the parachute
Limitations - local wind speed >17 m/s

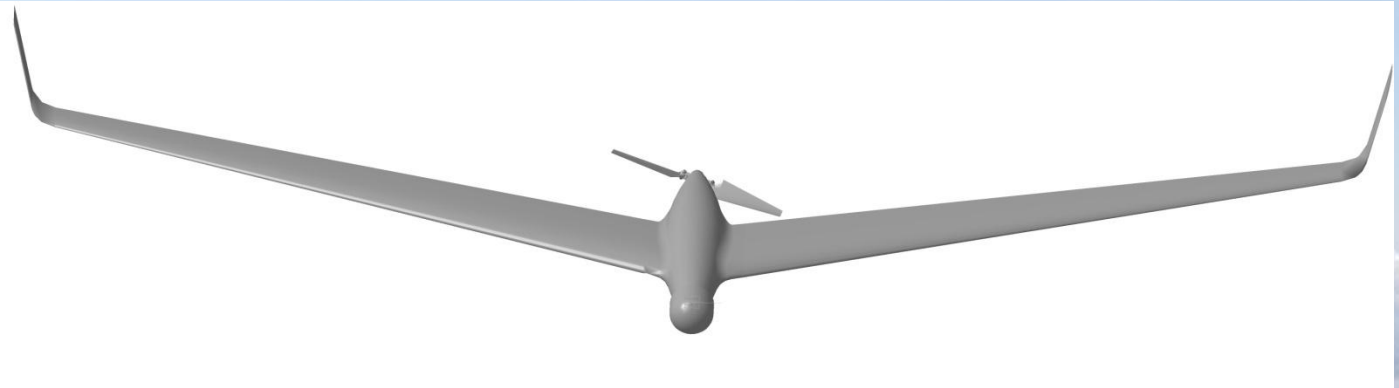
| | |
|---|---|
| Payload | - 1.8 kg |
| Weight of the battery | - 1 kg |
| Flight duration | ~ 30 min . |
| Flight distance | ~ 45 km. |

(Depending on weather conditions)

# Project “Multipurpose Unmanned Aerial Vehicle M-59 "Module"

**Purposes**: video surveillance in real time; aerial photography, cargo delivery, mail courier services, etc.

Year of design: 2015 Status: prototypes development.

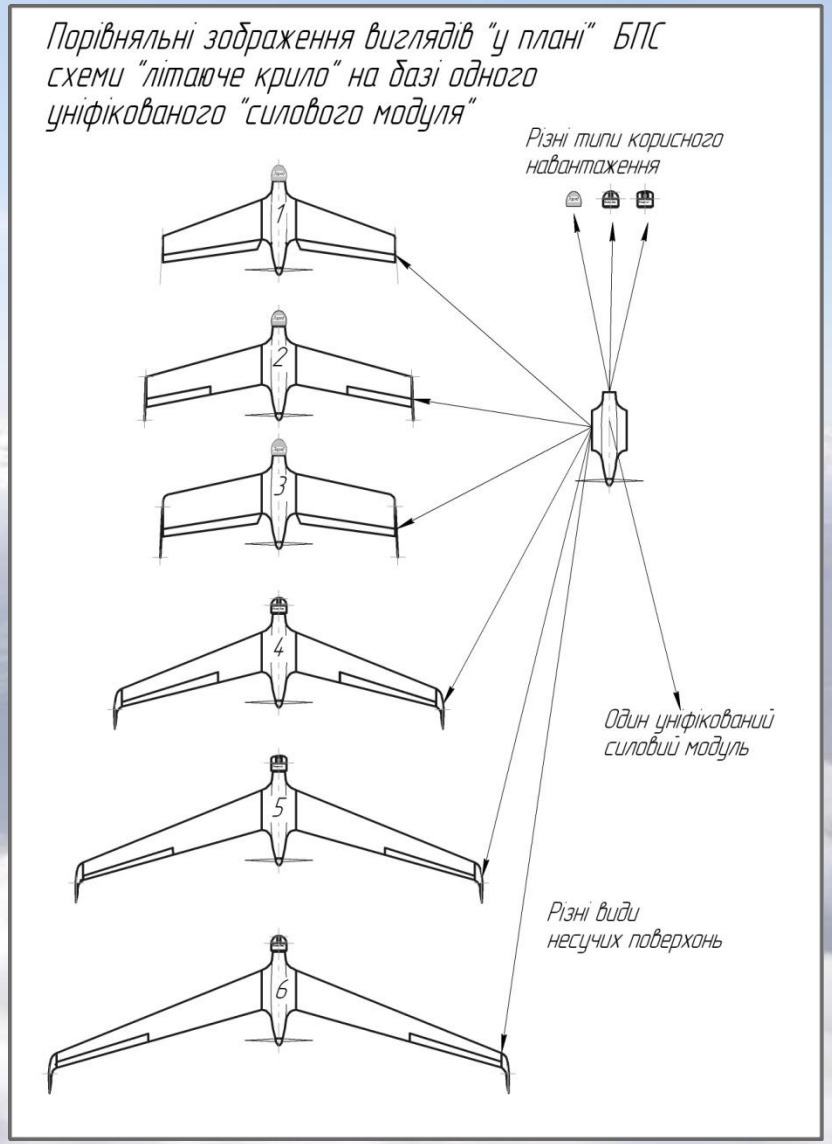


The UAV M-59 "MODULE" is a multipurpose, and designed for a wide range of aerial work including photography, video signal transmission, small cargo delivering, areas monitoring, atmospheric monitoring and others.

The feature of the UAV M-59 "MODULE“ is to use a unified power module and interchangeable pairs of wings. By replacing wings the UAV center of mass changes by a small value, and the range of distance and altitude is corrected by increasing or decreasing the number batteries. The payloads is located in the nose of the gondola and attached to the standardized mounts. Daytime and infrared cameras may be mounted onboard.

Considering the global experience in this UAV class, it can be used for the civil purpose for small objects protection, for monitoring of small areas, and other. Also, the UAV M-59 "MODULE" can be used as an individual UAV in military units for collecting intelligence.

# Project of the Multipurpose Unmanned Aerial Vehicle M-59 "Module"




## Calculated design specifications

| N. modules | Wingspan, m | Max. start. weight kg | Pay-load weight kg | Battery weight, kg | Flight durat., h | Tech. acting range, km | Route length, km |
|---|---|---|---|---|---|---|---|
| 1 | 2.28 | 8.5 | 2.2 | 2.3 | 1 | 37 | 75 |
| 2 | 2.65 | 9 | 2.5 | 2.5 | 1.4 | 50 | 102 |
| 3 | 2.34 | 10 | 3 | 2.5 | 1 | 37 | 75 |
| 4 | 3.23 | 10 | 2.5 | 2.8 | 2.2 | 68 | 136 |
| 5 | 4.0 | 12 | 3.7 | 3.4 | 3.1 | 95 | 191 |
| 6 | 4.52 | 13 | 4 | 3.7 | 4 | 120 | 246 |

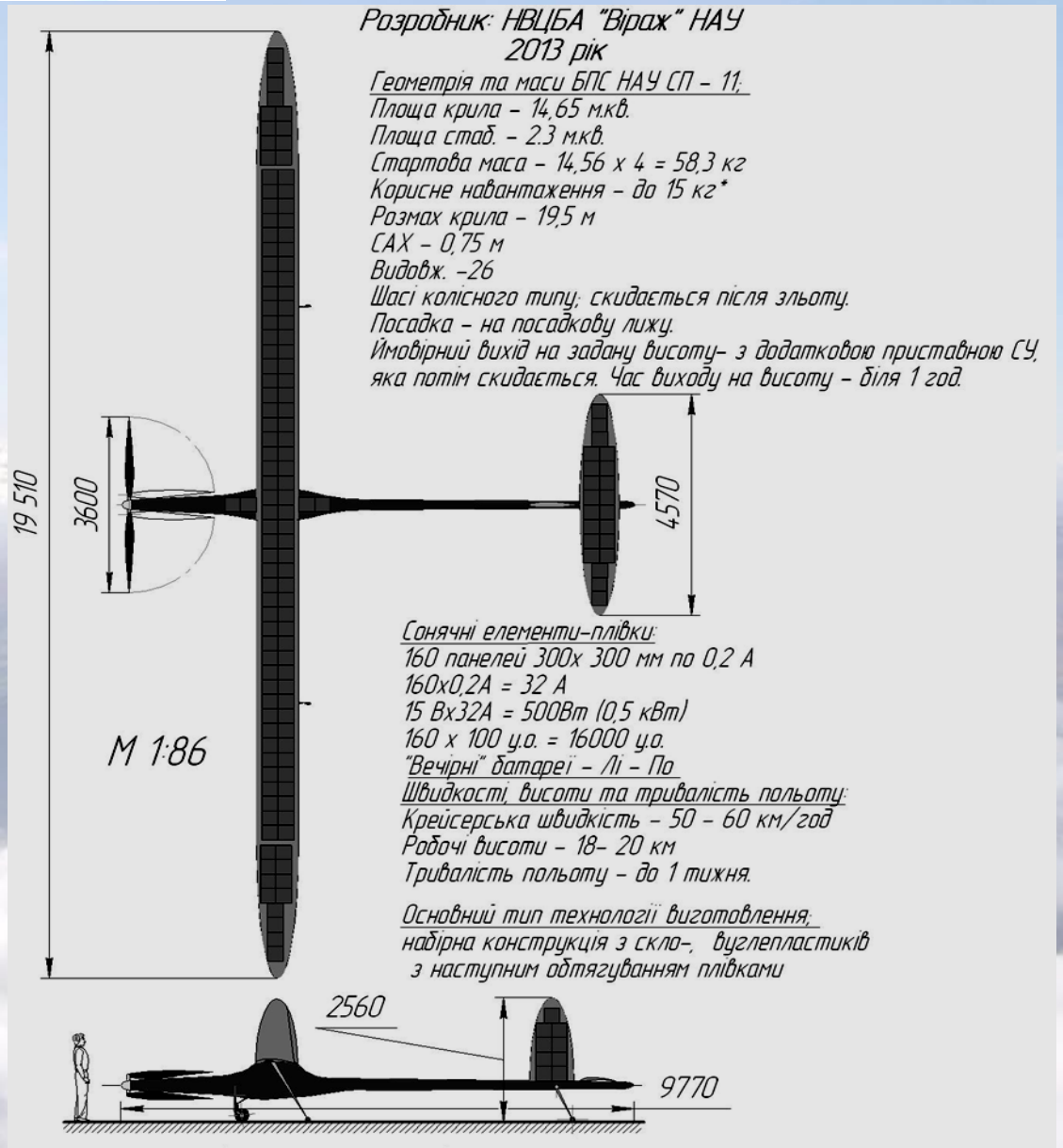
Type of control system - Automatic / semi-automatic, with the flightpreliminary planning

Takeoff - using starter including the method application holding the UAV by hands,

Landing - by parachute

Flight limitations –
local wind speed not more than 17 m/s.

# Project “Stratospheric UAV NAU SP–11”



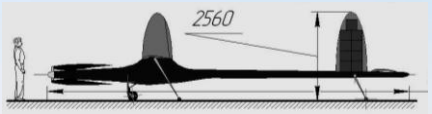

**Technical Specifications** :

| | |
|---|---|
| Wingspan - | 19.5 m |
| Length - | 9.77 m |
| Max. takeoff weight - | 58 kg |
| Payload - | 15 kg |
| Cruising speed - | 60 km/h |
| Max. altitude of flight - | 20 000 m |
| Automatic control | |
| Start - starting device. | |
| Landing - on the landing skis | |
| Flight duration | < 1 week. |

(Regardless of the weather conditions)

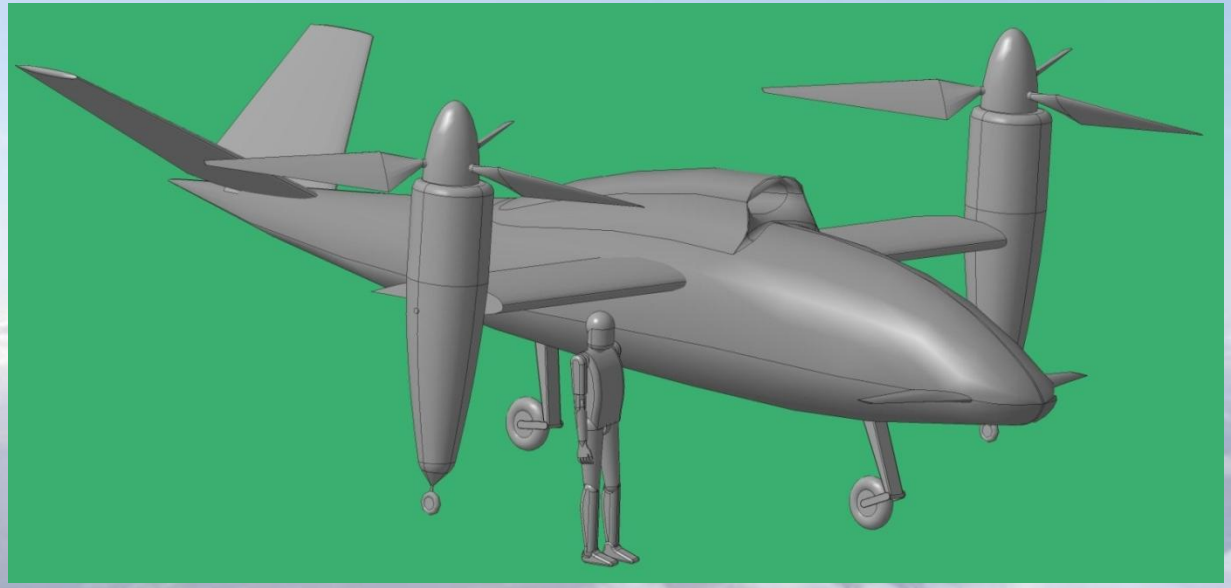
# COMPARISON IN THE CLASS

| Class | Mark. | Distance | Altitude | Duration | Weight |
|---|---|---|---|---|---|
| **Stratospheric** | STRATO | > 2000 km | >20.000 & <30.000 m | > 48 год | >2500 кг |

| Title | Photo | Flight distance | Cruise speed | Altitude of flight | Flight duration | Takeoff weight Payload |
|---|---|---|---|---|---|---|
| **SP-11 NAU** |   | < 5 000 km | 60 km/h | 20000 m | < 168 h (< 1 week) | 60 kg < 15 kg |
| Zephyr 7 QinetiQ UK |  | < 10 000 km | 90 km/h | 21000 m | < 336 h (< 2 week) | 32 kg < 15 kg |
| Solara 50 Titan Aerospace USA |  | 4 500 000 km | 110 km/h | 20000 m | < 1 year | 160 kg < 30 kg |

# Project “Multipurpose Unmanned Convertiplane of the 1500kg class”

**Purposes:** Detection of small objects;  Control of Maritime Navigation; Air photography and monitoring of the ground surface; Control of the environment;  Application in agriculture and exploration; etc.



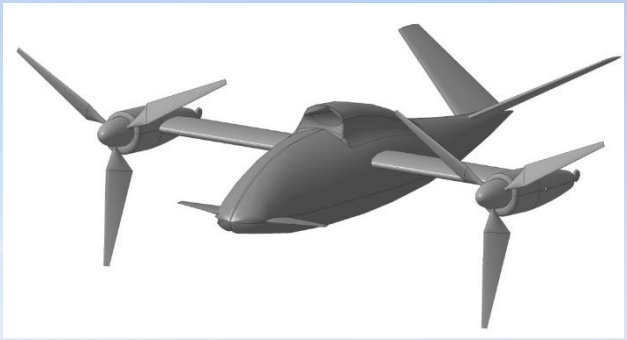
Known models of unmanned Convertiplanes

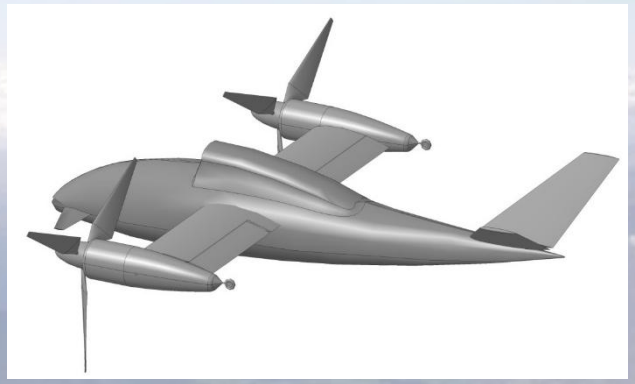
**«Eagle Eye» /Bell/ USA**

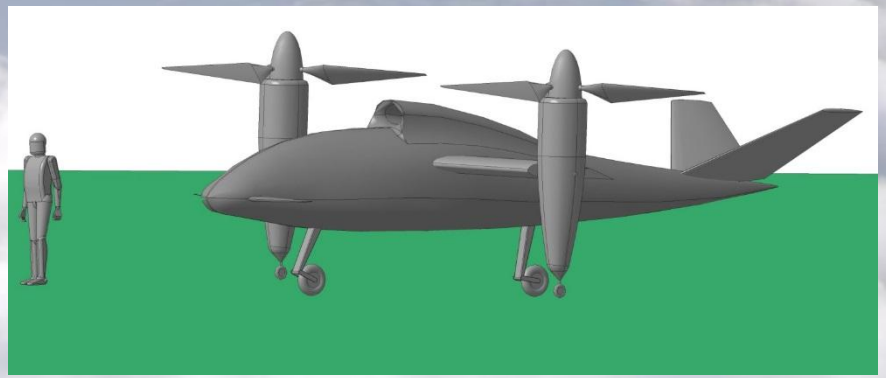
**Smart UAV /KARI/ South Korea**

**Lanser/–Kestrel Aerospase/UK**

# Project of the Multipurpose Unmanned Convertiplane in the class1500 kg





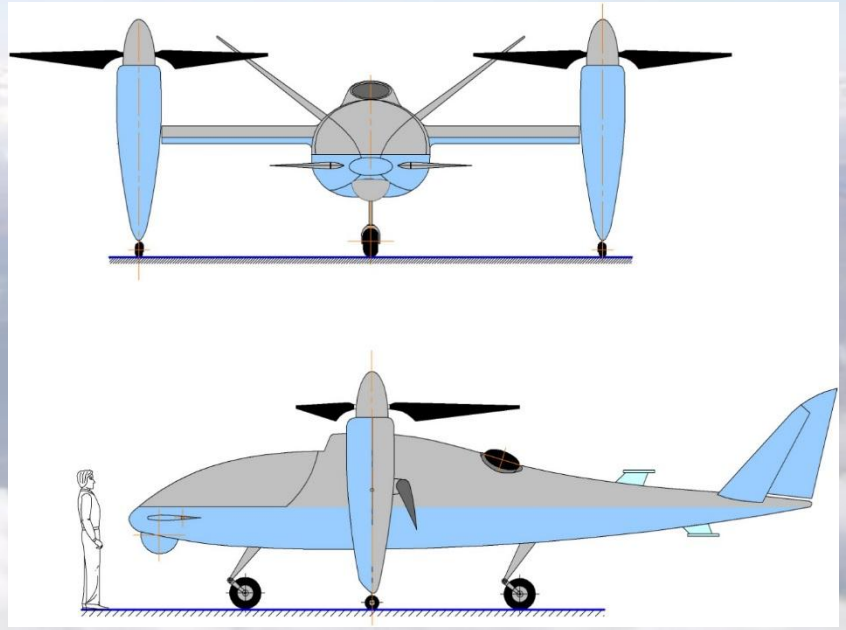


| UAV M-54 «Katia» (NAU) | Project data |
|---|---|
| Length, m | 9.2 |
| High, m | 2.1 / 3.1 chassis |
| Wingspan, m | 5.418 |
| Rotors diameter, m | 3.83 |
| Empty weight, kg | 920 |
| Takeoff weight, kg | 1500 |
| Payload, kg | up to 250 |
| Fuel weight, kg | 300/550 |
| Speed, km/h | 295 |
| Flight duration, h | 6; 9-stage |
| Technical distance, km | 1700 |
| Stage distance, km | 2700 |
| The range of application km<br>- without retranslator:<br>- with retranslator | <br>110<br>250 |
| Altitude of flight, m | 7000 |
| The power plant - type | AI-450M/ «MotorSich» |
| Equivalent Power, hp | 465 -take-off |
| Control system, type | The automatic /semiautomatic |

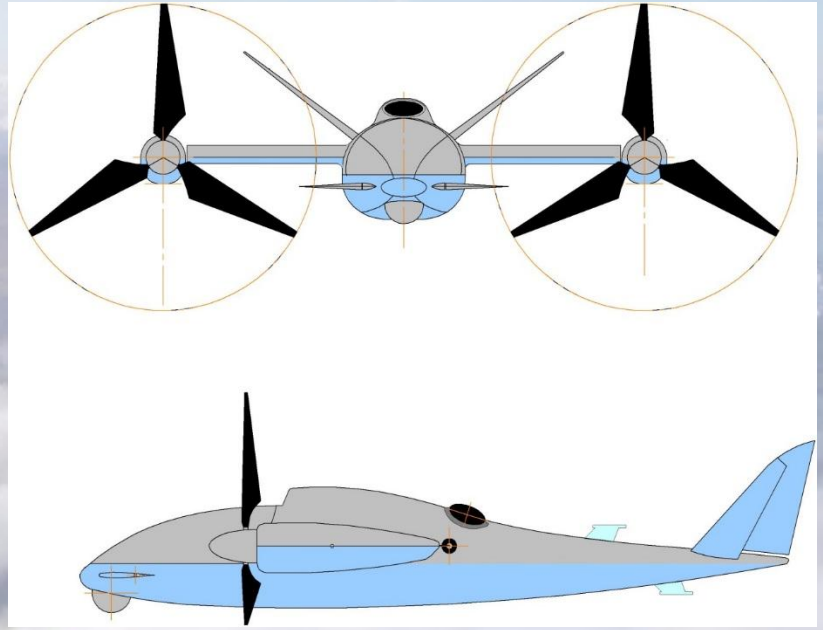
# Project “Multipurpose Unmanned Convertiplane of the 1500kg class”

- The layout design of the UAV "Convertiplane" significantly lowers its overall value due to the combination of its cruising speed as the aircraft, and ability to take off and land like a helicopter.

- Due to the wide range of UAV applications in the world and positive feedbacks from the Airline Industry, the risks of UAV remaining "unemployed" is very minimal.
- The availability of industrial Ukraine-built engine AI-450M significantly increases the viability of the project.



Projections of the Convertiplane in the "Parking lot"; chassis released

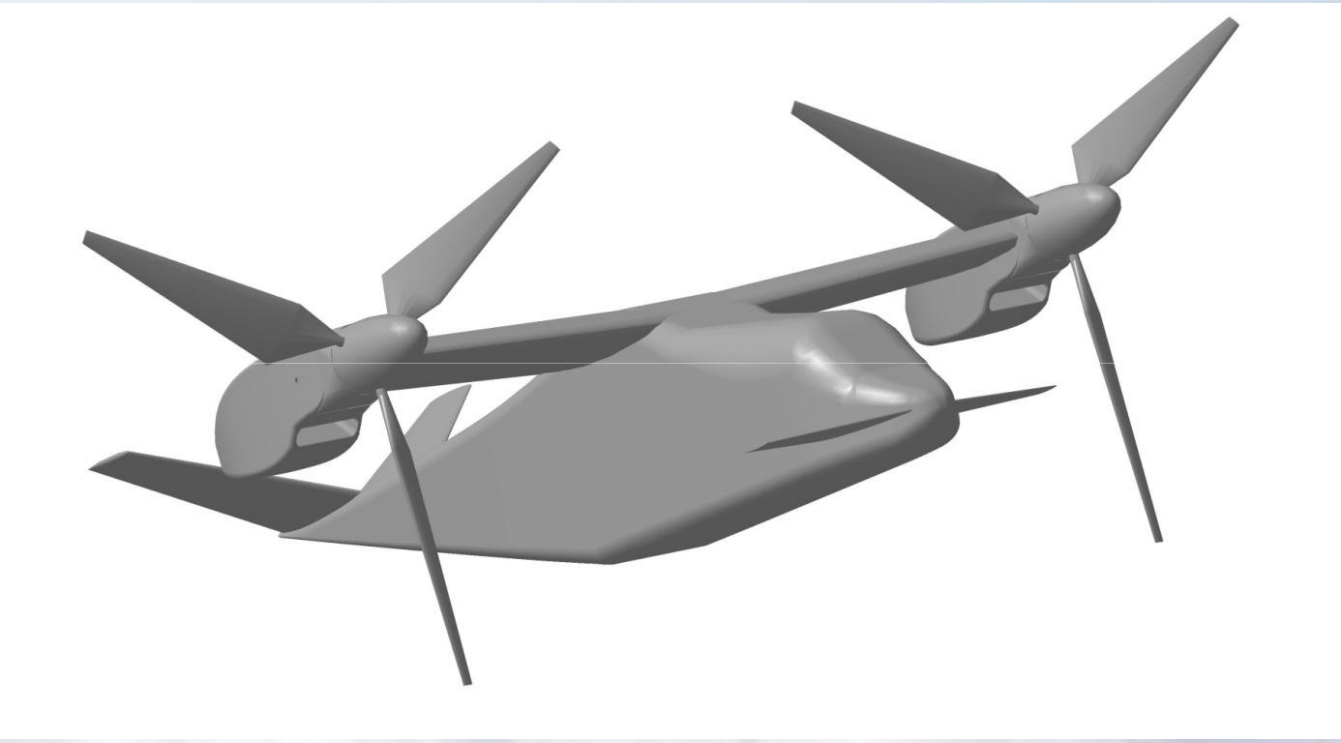


Projections of the Convertiplane in the "Cruising flight"; chassis hidden

# Project of the Multipurpose Convertiplane in the class up to 3000 kg *"NAU KM-3"*

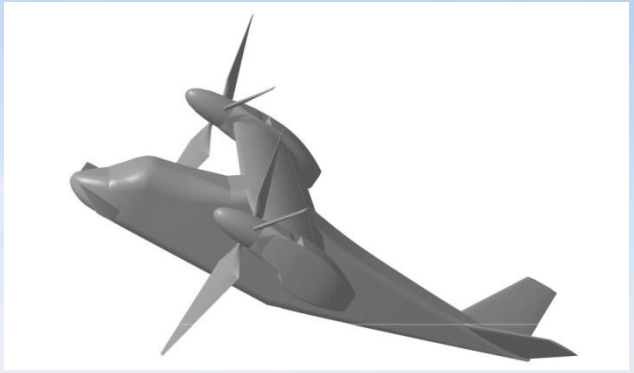
**Purposes:**

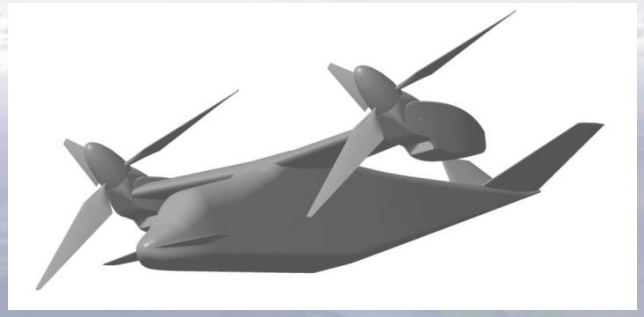
- Transporting the personnel and cargo during special operations;
- Transporting victims requiring emergency medical care (medical aviation);
- Search and rescue;
- Patrolling the linear and planar objects;
- Patrolling the borders;
- Pilots training.

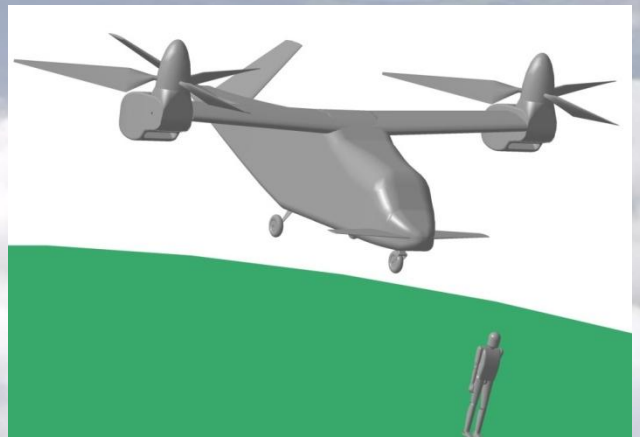


# Project of the Multipurpose Convertiplane in the class up to 3000 kg *"NAU KM-3"*

## The Project Technical Characteristics of the double-engine Convertiplane NAU – KM 3 / AI-450

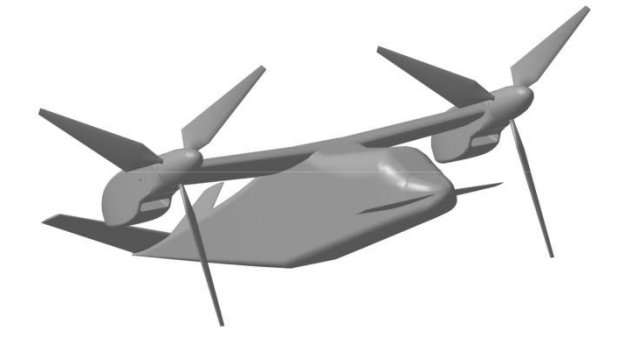






| Parameter | Project Data |
|---|---|
| Length, m | 9.3 |
| High, m | 3.37 |
| Wingspan on powerplant axes, m | 7.23 |
| Wingspan on rotors diameter, m | 13.23 |
| Wing area, sq.m. | 9.8 |
| Rotors diameter, m | 6 |
| Maximum rotors turns, rpm | ~800 |
| Empty weight, kg | 1700 |
| Takeoff weight, kg | 3500 |
| Payload, kg | 950 |
| Fuel weight, kg | 850 |
| Maximum speed, km/h | 500 |
| Cruising speed, km/h | 420 |
| Flight duration, h | 5 |
| Hourly fuel consumption, kg/h | 178.2 |
| Technical distance, km | 2100 |
| Number of passengers, pers. | 1 pilot.+ 5 pass. |
| Ferry range, km | 2900 |
| Altitude of flight, m | 6000 |
| The power plant - type / manufacturer | 2xAI-450M /MotorSich,UA |
| Equivalent takeoff power, hp | 2x465 |

# Project of the Multipurpose Convertiplane in the class up to 3000 kg *“NAU KM-3”*



## Conclusions

1. The layout design of the UAV "Convertiplane" significantly enhances its overall value due to the combination of its cruising speed as the aircraft, and ability to take off and land like a helicopter.
2. The availability of Ukraine-built engine AI-450M significantly increases the viability of the project.
3. Due to the wide range of UAV applications in the world and positive feedback from the Airline industry the risks of UAV being“ unemployed" are very small.
4. Preliminary calculations show a sharp decline by more than 50% of the cost of passenger-kilometers and decrease the cost of flying hours by 16% compared to current helicopters in the medium class such as Ka -226.
5. The combination in the Convertiplane the cruising speed as the aircraft's and the ability to take off and land like a helicopter in the perspective can allow to expect occupation of a medium helicopters niche , that potentially for Ukraine is 150-200 units.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# TRAINING OF RC-Operators AT SPCUA “VIRAGE”

Training in “FPV” mode

Project of fixed workplace for operating crew of UAV complex

Prototype Hardware of Workplace (WP1) of the opertator-pilot of UAV complex
(developed by SPCUA «VIRAGE», National Aviation University)

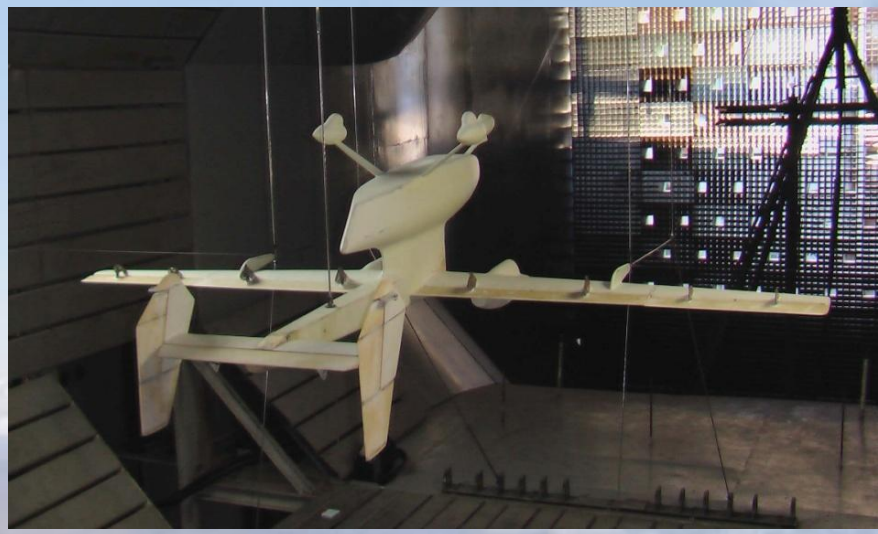
# THE UAS CONTROL CENTER FOR OPERATOR-PILOT AND TARGET WORKLOAD OPERATOR

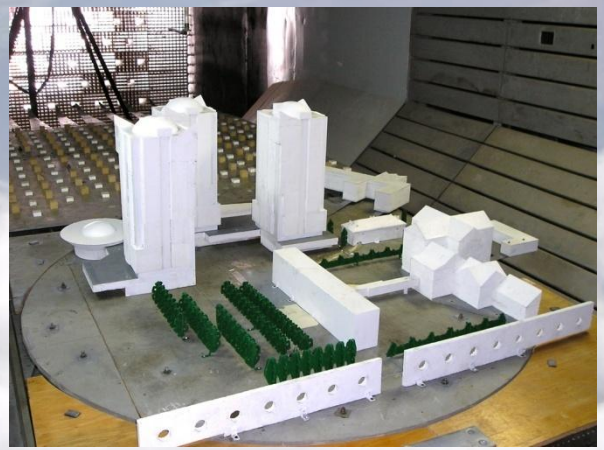
The software design of processes for flying unmanned aircraft. The system provides a simulated flight UAV among ATS, a the decision making support system to justify the flight plan of RPAS division, the training programs development for UAV operators and RPAS land personnel, the normative and technical documentation development for RPAS certification.

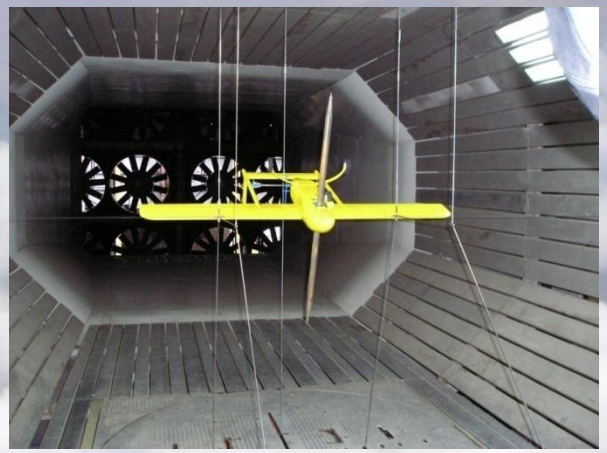
The Project SMGCS Airport Movement Simulator (SAMS) was initiated by the European Commission (EC) for research path "human operator - air/ground environment".
The project is implemented the model Advanced Surface Movement Guidance and Control System (A SMGCS), which can be explored in a variety of weather conditions.

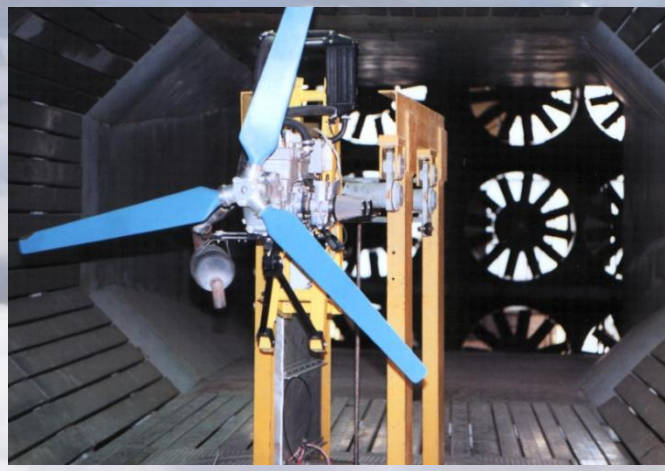
# AEROMECHANICS AND UAV FLIGHT CHARACTERISTICS

Theoretical and experimental study of critical modes of flight of unmanned aircraft based on non-stationary effects.





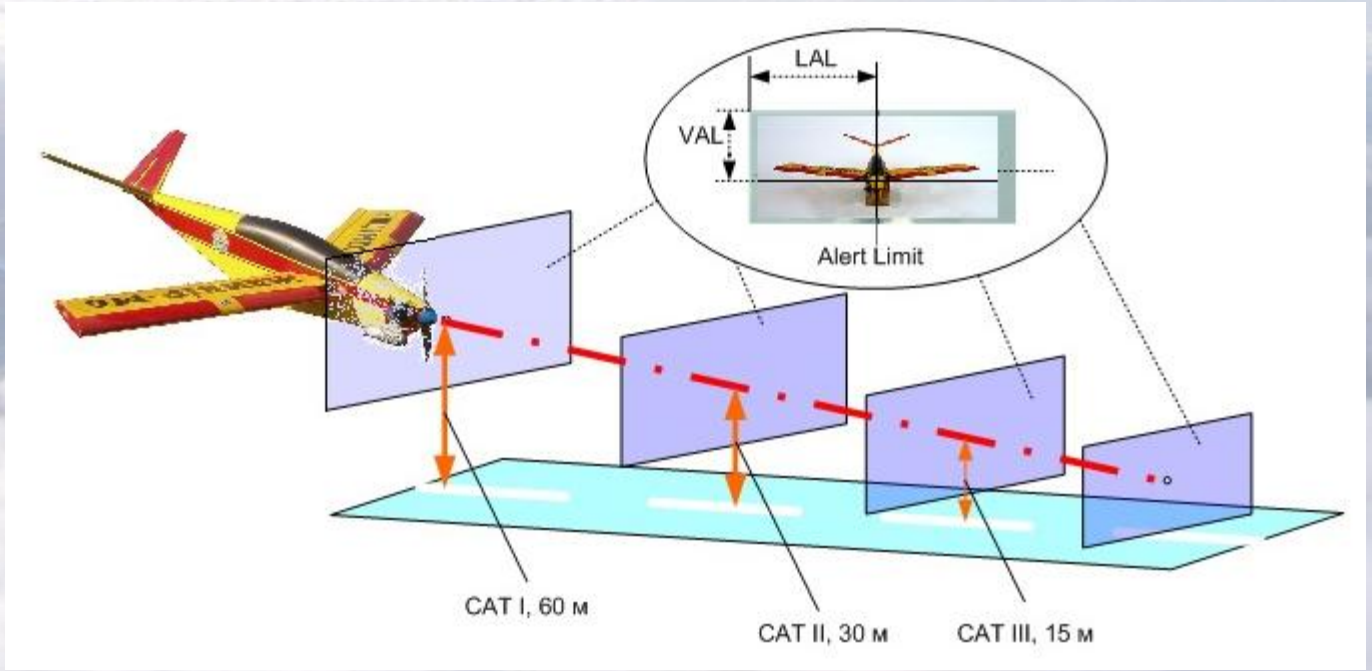




# AUTOMATED LANDING SYSTEM FOR UAV

The System is built on using the satellite navigation systems, information and communication technologies, microelectronics, in the form of an automated control system unmanned aircraft.

To ensure that the vehicle is safely controlled for proper landing, the system takes into account its current position (with modifiable degree of accuracy), its technical characteristics, and maintains continuous communication channel with the control center.



The **Research and Training Center "Aerospace Center" of NAU** performs researches and practical implementations in the priority areas of science, including **global navigation satellite systems, information technology, UAV integrated navigation and automatic flight control systems**.

**Experimental facilities** for performing test validations of developed UAV integrated GPS/INS navigation and automatic flight control systems

**GNSS Laboratory** for teaching students and performing research

# Automatic flight on the route

## The automatic flight control system

**allows to perform** :

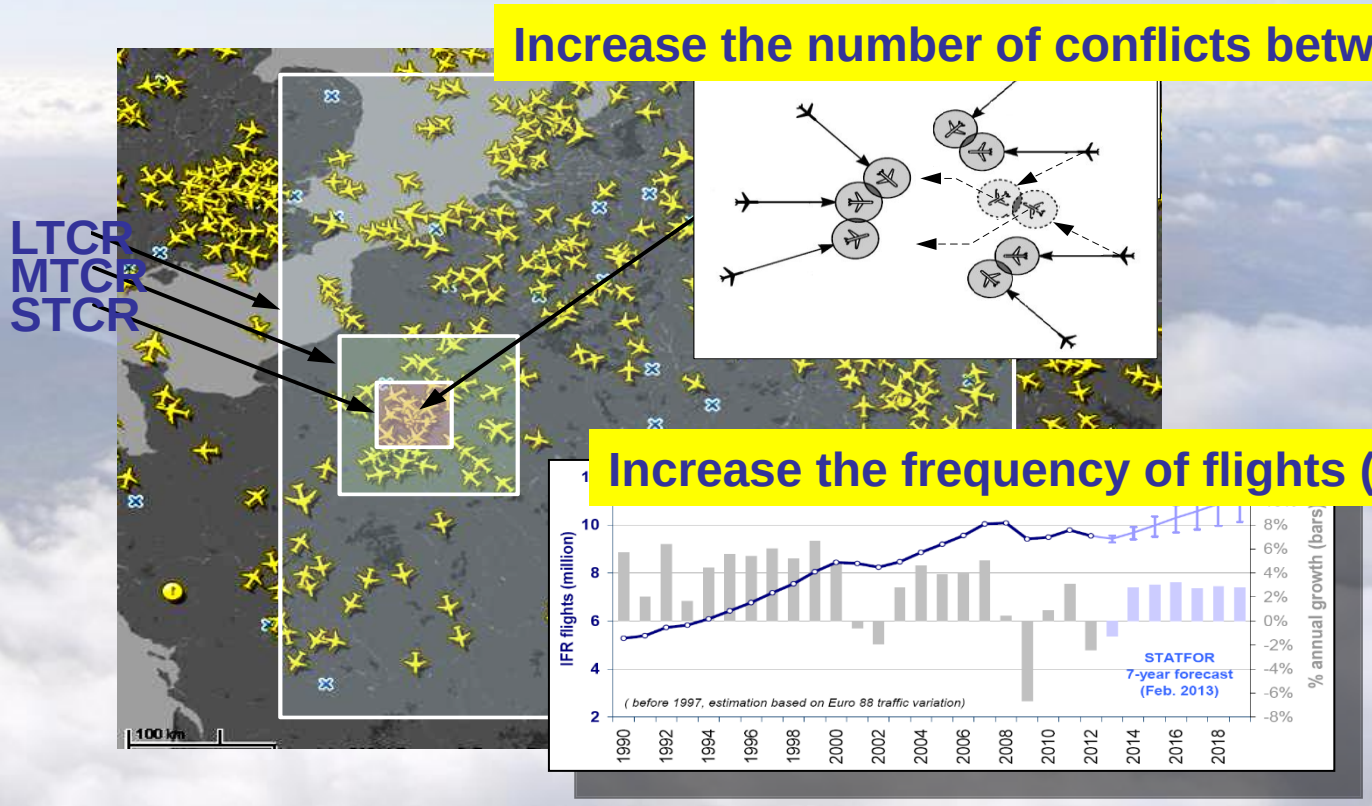
- automatic stabilization of the angular position of the UAV along the three major axes;
- automatic altitude stabilization of the UAV;
- automatic stabilization and control of true airspeed of the UAV's flight using control traction motor(s);
- automatic flight on the route;
- restrictions limiting regimes of the UAV;
- improvement in stability and controllability of the UAV;
- recording on the independent onboard flash memory and transmission of the data to the ground station
- control of the navigation and telemetry data over a radio channel.

**Integrated inertial equipment, satellite navigation systems and automatic flight control**

# CONFLICT RESOLUTION

The most important issue in the implementation of ALS into the non-segregated airspace is current inability to create the universal method for conflict resolution.

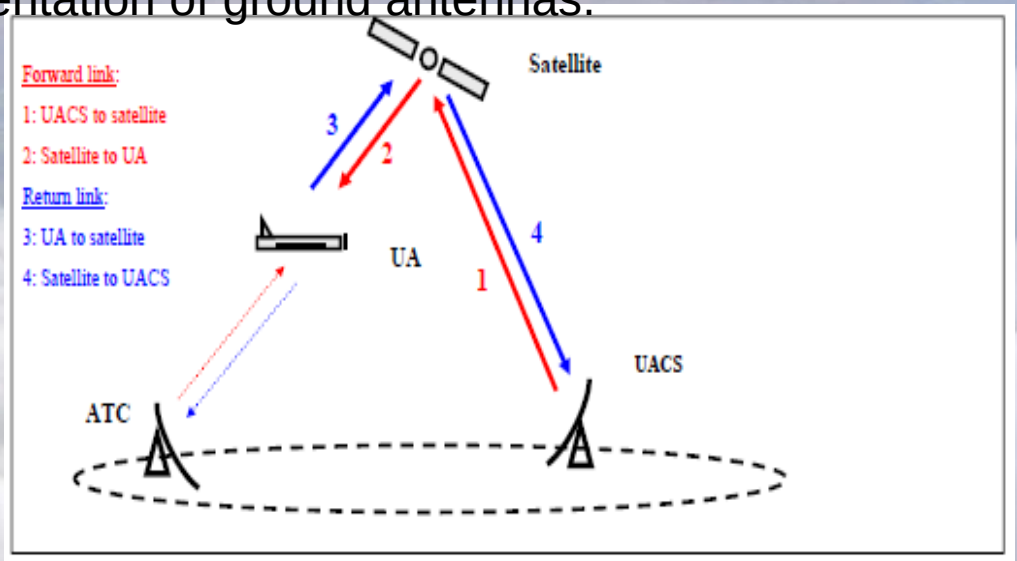
NAU has developed an innovative method of solving the poly-conflicts.



# PROTECTION OF TELEMETRY DATA AND VIDEO SURVEILLANCE TRANSFER

Experimental equipment for secure exchange of telemetry data from UAV board to the ground control unit consists of three parts:

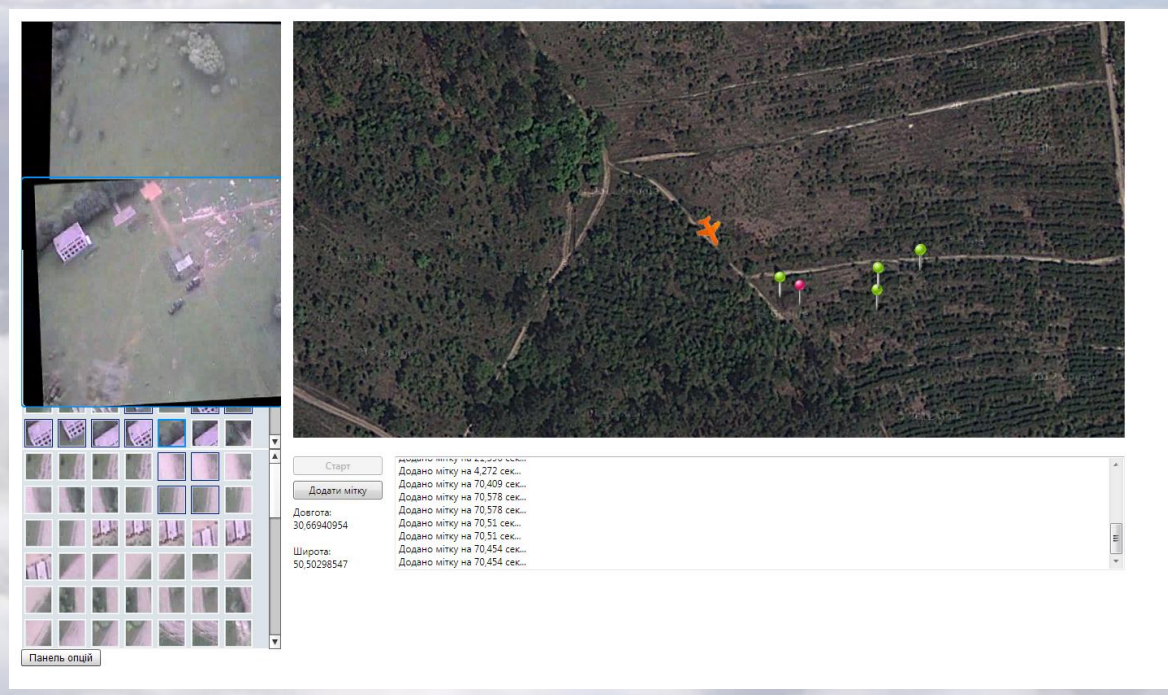
1 - The equipment to secure exchange of telemetry data between the ground unit and the UAV;
2 - The equipment of data exchange between the CCTV cameras on board and ground control unit;
3 - Automatic orientation of ground antennas.



# Automated system of processing data received from UAV in real time

As part of an automated information system, NAU has developed a proprietary software complex “UASAnalizer”, that receives and processes the following data: current geographic coordinates, flight path, photos and videos. Video processing module includes real time identification procedure of a foreign object, search and detecting moving targets by etalon data in the video.

The system allows detection of objects in the video in real time by etalon data (object image). Once an object is recognized in a video frame, the system goes to tracking target procedure. That allows tracking of the object’s trajectory.



# OPERATIONAL DATA PROCESSING RECEIVED FROM THE UAV

Tasks that require the use of the following methods and tools :

- Previous online-processing digital video data and aerial photography (filtering, smoothing, solarise, digital stabilization, etc.);

- Identification and selection of streaming video sequences of moving and static objects of observation for further research and analysis;

- Determining the current coordinates of the observed objects and assigning images to digital map area.

# Aerial photo (video) data processing

•**At the preliminary and preparatory phase** images can be subjected to numerous transformations that can later be used in the implementation of methods and processing technologies. As an example, list the following transformation: based on the statistical characteristics (mean, variance, skewness, kurtosis, energy, entropy, 7 moment invariants); Fourier transform; linear contrasts; logarithm; equalization; multiple-scale analysis; select boundary points (vertical and horizontal boundaries) of image; implementation of image segmentation by identifying points, line angles 45, -45, 90, 0 degrees, image angles; procedures of enlargement and narrowing image; low, high, contrast filters, stabilizer filters, etc.

**Possible solution of such problems:**

•The issue of converting images based on over 25 methods and operators including the transition to the frequency range image;

•Select geometric features of the image, contour analysis the objects, used in recognition of heterogeneous objects;

•Methods for selection of homogeneous structures to further define the total area and the length of objects;

•Selection of heterogeneous structures and areas that can be used to monitor the technical condition of certain areas, etc.;

•Selection and comparison the singular points with the original image, which makes it possible to monitor objects in time for the issue of monitoring of some object and changes at the area (validation);

•Overlay data objects shooting on the electronic map and the areas classification issue;

•Texture classification based on controlled and uncontrolled clustering.