UAV ADVANCED SYSTEM
UAV SYSTEM DESCRIPTION

UAV system is the third generation UAV platform. The system consists of two main parts - autonomous air vehicle and the human operated ground segment - Ground Control Station. UAV is a multi-purpose UAV system that can be used in various scenarios, for example:

- border patrol
- reconnaissance/observation
- aerial photography
- geophysical prospecting
- disaster monitoring
- coastguard service
- radiation probing or sampling
- day/night reconnaissance
- battlefield monitoring
- target positioning
- target/artillery spotting
- battlefield damage and casualty assessment
- atmosphere gas analysis

The UAV is powered by an internal combustion engine. Takeoff is performed via pneumatic catapult and the plane lands by deploying its parachute together with inflating the airbag for additional impact dampening. The parachute is automatically released after the plane hits the ground. The UAV can be operated in various environmental conditions in a wide temperature range (-20°...+50°C). The system is designed with the latest technology to provide high functionality with low pricing.
## UAV Specifications

### Plane Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wingspan</td>
<td>3.075m</td>
</tr>
<tr>
<td>Length</td>
<td>1.960m</td>
</tr>
<tr>
<td>Weight</td>
<td>12…15kg</td>
</tr>
<tr>
<td>Engine</td>
<td>4.0hp 35cc 4 stroke</td>
</tr>
<tr>
<td>Video</td>
<td>Gyro stabilized gimbal</td>
</tr>
<tr>
<td></td>
<td>Video camera</td>
</tr>
<tr>
<td></td>
<td>IR camera</td>
</tr>
<tr>
<td></td>
<td>Dual gimbal option</td>
</tr>
<tr>
<td>Photo</td>
<td>Gyro stabilized mechanism</td>
</tr>
</tbody>
</table>

### Flight Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational ceiling</td>
<td>150m</td>
<td>2500m</td>
</tr>
<tr>
<td>Range</td>
<td>-</td>
<td>150km*</td>
</tr>
<tr>
<td>Flight time</td>
<td>-</td>
<td>180min*</td>
</tr>
<tr>
<td>Fuel capacity</td>
<td>-</td>
<td>3.0L</td>
</tr>
<tr>
<td>Speed</td>
<td>80 km/h</td>
<td>130 km/h*</td>
</tr>
<tr>
<td>Wind</td>
<td>-</td>
<td>7 m/s</td>
</tr>
<tr>
<td>Datalink range</td>
<td>-</td>
<td>50km*</td>
</tr>
<tr>
<td>Videolink range</td>
<td>-</td>
<td>40km*</td>
</tr>
</tbody>
</table>

### Imaging Sensors

<table>
<thead>
<tr>
<th>Type</th>
<th>Video</th>
<th>IR</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>FCB EX20D SONY</td>
<td>TAU 640 FLIR</td>
<td>DMCGF1C Panasonic</td>
</tr>
<tr>
<td>Zoom</td>
<td>10x opt.</td>
<td>8x digital</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.25lx 1/60s</td>
<td>&lt;50 mK at f/1.0 with FLIR proprietary noise reduction</td>
<td>F2.0 ISO 6400 1/1.6*</td>
</tr>
<tr>
<td>Controlling</td>
<td>Gyro + GPS</td>
<td>Gyro + GPS</td>
<td>Gyro</td>
</tr>
<tr>
<td>Data storage</td>
<td>&gt;4h</td>
<td>&gt;4h</td>
<td>&gt;2000 images*</td>
</tr>
</tbody>
</table>

### Expansion Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART TTL</td>
<td>1</td>
</tr>
<tr>
<td>PWM</td>
<td>10</td>
</tr>
<tr>
<td>GPIO</td>
<td>10</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>3-12V</td>
</tr>
</tbody>
</table>
**SYSTEM CAPABILITIES:**

- Real time video from gyro stabilized gimbal
- On board video recorder
- Stabilized digital photo camera
- Fully autonomous flight control including takeoff and landing
- Autonomous mission execution with option to change all parameters during flight
- Ability to select active waypoints and/or change waypoint coordinates and parameters
- Different preprogrammable flight patterns
- Definable actions in case of errors and loss of data link (Return Home, Proceed with Mission, Emergency landing after critical error etc)
- Multi sensor usage
- Fast and easy takeoff by catapult
- Low noise and weak radar footprint
- Controllable navigation lights

**UAV DIMENSIONS**
UAV SYSTEM COMPONENTS

UAV system consists of 2 main sections - Air unit and Ground unit, which in turn divide into following parts:

**AIR UNIT**
- UAV (plane and sensors + spare parts)

**GROUND UNIT**
- **GROUND CONTROL STATION**
  - Manpad – portative control station
  - Charging station
  - Power generator
- **LAUNCHING SYSTEM**
  - Catapult
  - Pressure unit with air compressor and power supply
- **ANTENNA SYSTEM**
  - Antenna tracker
  - Standard antenna module on tripod
- **MAINTENANCE AND TOOL MODULE**

**AIR VEHICLE DESIGN**

The UAV has a twin boom, inverted V-tail, pusher propeller configuration and the airframe has a rugged yet low-weight fiberglass carbon fiber construction.

The main fuselage consists of three main parts – center body, nose module and engine with mount. The fuselage is divided into separate compartments for flight control electronics, photo camera, parachute, air bag, fuel tank (3.0L), power control unit and exchangeable battery module.

The nose module includes all the video imaging sensor components (gimbal mechanism, daylight or IR camera, video transmitter and recorder) and is quickly exchangeable.

The wings consist of three parts – middle section, which mounts to the fuselage with 4 bolts and easily attachable left and right wingtips. V-tail is attached to the middle section using two booms.

**SENSORS**

Currently the UAV supports the usage of 3 different sensors, which have been integrated to the system. It is possible to expand the range of supported sensors when needed. The standard sensors, which come with the system, are as follows:

- Daylight camera Sony FCB-EX20D and IR camera TAU 640 in the nose module and digital photo camera Panasonic Lumix DMC-GF1C in the photo camera section under the fuselage.

Camera gimbal in the nose module is gyro stabilized and geo-oriented, which provides the automatic tracking of selected coordinates. The photo camera is mounted on a mechanism, which compensates the UAV's movement along roll axis and therefore keeps the photo camera always leveled.

The daylight and IR cameras can be in separate nose modules or together in one gimbal providing simultaneous daylight and IR imaging.
ENGINE

UAV is propelled by vibration dampened 35ccm 4 stroke gasoline engine which in turn drives a 3-phase alternator for electric energy. The vibration dampening system consist of 2 stages preventing most of the high frequency and -amplitude vibrations from reaching the fuselage thus increasing the overall image quality provided by the sensors.

CONTROL ELECTRONICS

UAV II is guided by MicroPilot MP2128 autopilot. The sensors and rest of the functionalities are controlled through an integrated main controller.

DATA COMMUNICATION

Telemetry and flight control data is transmitted using frequency hopping spread spectrum 128bit encrypted datamodem Microhard n1320. The modem supports peer-to-peer transmission that enables relay UAV and – station usage between the main UAV and ground control station. Data modem can be turned on and off if radio silence is needed.

VIDEO TRANSMISSION AND RECORDING

UAV is equipped with one live video transmitter and parallel onboard recorder. Video transmission frequency and output power are selectable. Onboard video recorder can be turned on and off both manually and automatically.

MISSION TYPES

RADIO SILENCE

Fully preprogrammed flight with autonomous takeoff and landing. Ground control station is not needed in any stage of the mission. Radio can be configured to wait for the ground control station link initiation or be completely turned off.

STANDARD FLIGHT

Autonomous takeoff, flight and landing with active datalink. All flight parameters and waypoint coordinates can be changed throughout the mission.
CATAPULT

The UAV is launched by a portable pneumatic catapult, which is driven by compressed air. Catapult comes with a battery operated air compressor and tank. Catapult consists of 3 sections, which fit into 160x30cm storage box. Air tank and compressor are permanently in a separate container. Catapult has an optional engine cooling device, which redirects air to engines cylinder head and cools it in warmer temperatures during UAV motor test runnings on the catapult.

EMERGENCY RETRIEVAL SYSTEM

UAV is equipped with independent Emergency Retrieval Systems - radio beacon - with autonomous power supplies.

GROUND CONTROL STATION

OVERVIEW

There are two types of UAV control stations: portable MANPAD and vehicle mounted container. Portable control station consists of three modules that provide the complete control of UAVs for 2 hours. A portable electric generator extends this time and recharges the batteries. Elements of portable control station: video monitor(1), video recording device(2), control computer(3), video gimbal joystick(4), control station batteries(5), video antenna(6), data antenna(7), antennae connection cable(8), recharging and power converter module(9), power module connection cable(10).

Container GCS has the working area for two people – operator (pilot) and data analyst (camera operator, fire control, etc). Antenna mast with the tracker is attached to the container.
The MANPAD includes a portable antenna that is automatically directed and has a range of about 20km LOS (with omni directional antenna). Antenna mast and tracker are included in a container control station. This system provides a maximum range of about 50km LOS. The tracker is equipped with an IMU (inertial measurement unit) that compensates the movements of the antenna mast.

The software is designed to allow fast and easy mission planning, execution and analysis.

Telemetry and flight control – user interface is designed to represent the critical flight information clearly and visual gauges and alarms are supported by audio.

Maps and overlays – the software can handle large and detailed maps by dynamically loading only the area that is being viewed. It is possible to add overlays – such as aerial photos or informational layers – to the base map or not use the base map at all. Our software has DEM (Digital Elevation Model) support to enable mission planning in mountainous terrain.
Waypoints – these are the main mission planning elements. Each waypoint has a location that can be changed in-flight by the operator. They can have actions added to them (change altitude, change speed, orbit for 10 minutes, start photographing an area, point the video camera at specified coordinates, manipulate custom payload etc).

Flight patterns – these are predefined trajectories that can be started during the flight or in a waypoint. Examples are: a simple 250 meter right orbit, figure 8 pattern, a scan pattern that takes detailed pictures of a 2 square kilometer area. Patterns can be changed or new ones created. Up to six different patterns can be defined.

Photo and video synchronization – all the video and photo files are synchronized with the GPS and IMU data that is recorded on board and on the ground in the GCS. It enables to analyze georeferenced video and photo data after the flight with the included software.

Target spotting and fire control – coordinates can be estimated using the onboard video that can be overlayed on the map in realtime. Then the underlying map can be used to increase the accuracy of the actual coordinates of targets by aligning terrain features.

**DATA RECORDING**

The plane records all the video, photos and telemetry on board so that the data can be used after the flight to automatically georeference the visual material even if the ground link is disrupted or not present at all.

**UAV TEAM**

The minimum UAV team consists of three members. An operator who controls the plane can also be called a pilot, a data analyst/mechanic and mechanic/driver. Data analyst and driver set up the plane and perform preflight checks and thus are called mechanics too.

<table>
<thead>
<tr>
<th>Operator or pilot</th>
<th>Data analyst/mechanic</th>
<th>Driver/mechanic</th>
</tr>
</thead>
</table>

**MISSION**

The mission consists of a series of waypoints that are flown through sequentially. While the datalink is up an operator can redirect the plane to any of the waypoints and change waypoint locations. The mission ends with approach direction waypoint and engine cutoff point. These points are automatically calculated using the desired landing point and wind speed and direction. There can be a maximum of 500 waypoints.

**WAYPOINTS**

Waypoints are a series of coordinates that the plane must navigate between. Every waypoint can have actions assigned to them. Actions can be: change altitude, change speed, manipulate payload (photo camera, video camera, custom payload), start a flight pattern. Waypoint coordinates can be changed during the flight.

**CONTROLLED FLIGHT**

Controlled flight is a mission during which a constant datalink is maintained. It enables the operator to change the flight path, speed, altitude and manipulate the payloads at any time of the flight. The landing procedure can be started at any point or it can be automatically start at the end of the mission. The operator can specify what happens after the loss of the datalink – the plane can return to GCS location, continue the preprogrammed mission or do something else.
AUTONOMOUS FLIGHT

When the operator specifies that the flight is autonomous then there is no need for a datalink. The plane flies through the predefined waypoints performs all the actions and lands at the designated landing area without any interaction from the GCS. Operator can establish a datalink at any point or can switch off all the radios onboard to fly in a radio silence. Radios can be configured to automatically turn on and off at any waypoint.

MULTI UAV MISSIONS

The system supports multi-UAV missions. Operator can switch between the UAVs that are being actively controlled. Only one can be controlled at a time from one GCS, the others will fly autonomous missions until the operator acquires the control. The total number of UAVs on the air depends on the type of missions and on the choice of datamodems. Control can be switched between three UAVs while an unlimited number of UAVs can fly fully autonomous missions.

LANDING

The plane lands using a parachute and an airbag and is fully automatic. Operator has to designate a landing area on the map where the plane tries to land. The landing accuracy depends on how accurately the wind speed and direction is measured and entered to the program. For safety reasons a 500x500m field is recommended.

TRAINING

Training takes about 30 days and includes theoretical and practical parts. Trainees learn how the plane is constructed and how it functions. After learning the basics of flying and meteorology the practical part introduces how to assemble and service the UAV. Final part consists of preflight procedures and checks. The ground control system operator (UAV pilot) receives additional software training.
The whole system is packed inside transportable cases. Smaller MANPAD system is packed in rugged suitcases that can be carried around. Larger system and UAVs are in special storage and transportation cases.
DATA ANALYSIS AND USAGE

The information collected by the plane is put into a database using the software called Mapic can then be visualised on a map and analyzed. The pictures can also be shown on a map using only the GCS software. In addition to georeferencing images and putting them on a map it is possible to stitch them together to create mosaics. For this purpose a software called EnsoMOSAIC by MosaicMILL Ltd is used. It allows to create highly detailed images from large areas.

MODIFICATIONS AND POSSIBLE DEVELOPMENTS

UAV system can be developed and modified according to clients requirements and needs. STC