Autonomous Flight Technologies

Hirrus L UAS

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1 Glossary

Acronyms	Signification
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
AV	Air Vehicle
GCS	Ground Control System
LOS	Line Of Sight
GDT	Ground Data Terminal
DL	Data Link
LPU	Light Power Unit
PU	Power Unit (module)
SAR	Search And Resque
ISR	Intelligence Surveillance and Reconnaissance
ISTAR	Intelligence, Surveillance, Target Acquisition, and Reconnaissance
RSTA	Reconnaissance Surveillance and Target Acquisition
IR	Infra Red
BMS	Battery Management System
EO	Electro Optical
AGL	Above Ground Level
ASL	Above Sea Level
V_S	Stalling Speed or Minimum Steady Flight Speed
VNE	Never Exceed Speed
IAS	Indicated Air Speed
MTOW	Maximul Take Off Weight
TBD	To Be Defined
TOD	Take-Off Distance
CEP	Circular Error Probability

2 Document purpose

This document present general description, performances and capabilities of the HIRRUS mini-UAV system.

3 Capabilities and Limitations

3.1 Capabilities

The HIRRUS mini-UAV system featured in this document exhibit various applications, but for the scope of this document, it focuses on the ones considered related to photogrammetry, detection, monitoring and surveillance missions, and it is ideal for use in remote and / or hardly accessible areas, during daytime or nighttime, for both military and civilian specific applications.

Depending on the needs, additional missions can be assigned to this system, according to different types of payload which are not included into present document.

HIRRUS mini-UAV provide the following capabilities:

- provides real time information to the decision makers having the capability to be integrated into C2 networks;
- allow the optimization of available resources allocated for specific missions, through real time monitoring of the areas of interest;
- eliminate the risk associated with the direct implications of the personnel into dangerous or hazardous missions;
- generate lower costs and increase the effectiveness for the Reconnaissance Surveillance and Target Acquisition (RSTA) missions when compared with other "traditional" solutions;
- represents a valuable asset with very high mobility and flexibility able to cover very effective large surfaces of land even in remote and / or difficult to access locations;
- able to operate in a large range of meteorological conditions;
- represents a complementary asset to traditional manned platforms or other type of specialized systems used for Emergency Situation missions or RSTA tasks.

3.2 Limitations

There are a set of limitations that applies at the system level but most of the limitations refer to the aerial vehicle operations.

Launching altitude

- Minimum: no restrictions;
- Maximum: 10.000 ft (3.300 m) AMSL.

➢ Above 10.000 ft AMSL it is still possible to launch, but due to a reduction in climb rate, additional attention must be paid to avoid the impact of the surrounding obstacles near the launch site.

Landing altitude

- Minimum: no restrictions;
- Maximum: 10.000 ft (3.300 m) AMSL.

➢ Above 10.000 ft AMSL it is still possible to land, but due to increased parachute descent rate, there is an increased risk of damaging the airframe and the payload upon ground impact.

Flight operational altitude

- Minimum: 300 ft (30 m) AGL;
- Maximum: 13.500 ft (4.300 m) AMSL.

➢ Actually, Hirrus L execute test flight missions at 20.000 ft (6.000 m) AMSL, but above 13.500 ft (4.300 m) AMSL will somehow impact the overall performances, mainly the climb rate and maximum autonomy. Also, the higher the flight altitude, the lower the image quality will be, because of the impurities in the atmosphere.

Wind speed

- Minimum: no restrictions;
- Maximum speed of front wind at take-off:
  - Constant 20 kts (10 m/s)
  - Gust 30 kts (15 m/s)
- Maximum speed of cross wind at take-off:
  - Constant 8 kts (4 m/s)
  - Gust 12 kts (6 m/s)
- Maximum wind speed at flight level:
  - Constant 35 kts (18 m/s)
  - Gust 43 kts (22 m/s)

➢ It is possible to execute flight missions if the constant front wind at take off is above 20 kts (10 m/s) but not more than 35 kts (18 m/s) constant wind speed at flight level, with following precautions:
  - mission flight speed will have to be increased, in order to better cope with turbulent air;
  - recovery altitude will have to be decreased in order to reduce the risk of landing outside the intended site;
  - maximum autonomy will be reduced.

Rain

- Maximum 0.25 inch per hour

➢ The most sensitive elements are battery chargers and recovery parachute, which are not operable during intense rain. Even if the aerial vehicle itself can perform in moderate rain, the image quality will be poor, due to water droplets that obscure the ground details.

Ambient Temperature

-In the case of low temperatures (less than 10 °C), the battery capacity could decrease by up to 60% and the elasticity of the rubber elements from the launcher can be reduced by 70%, becoming plastics;
-Rubber protective/sealing packages for MINIUAV and GCS/RVT are not used if temperatures below-20 °C are expected;
-Minimum and maximum acceptable operating temperatures for major components (°C):

Component	Range of ambient temperatures [°C]	
	Min Temperature	Max Temperature
Aerial Vehicle	-10	+50
GCS/GDT	-10	+50
Battery Charger	-10	+50
Universal Charger	-20	+50
Payload	-29	+50
Storage and transport in transport packaging	-30	+70
Launcher	-5	+50

Parameter	Day		Night	
	Normal weather conditions	Hard weather conditions	Normal weather conditions	Hard weather conditions
Vissibility	>1,5 km	<1,5km	>1,5km	<1,5km
Clouds level	>700m	<700m	>1000m	<1000m
Covering	<50%	>50%	<40%	>40%

4 Functional description

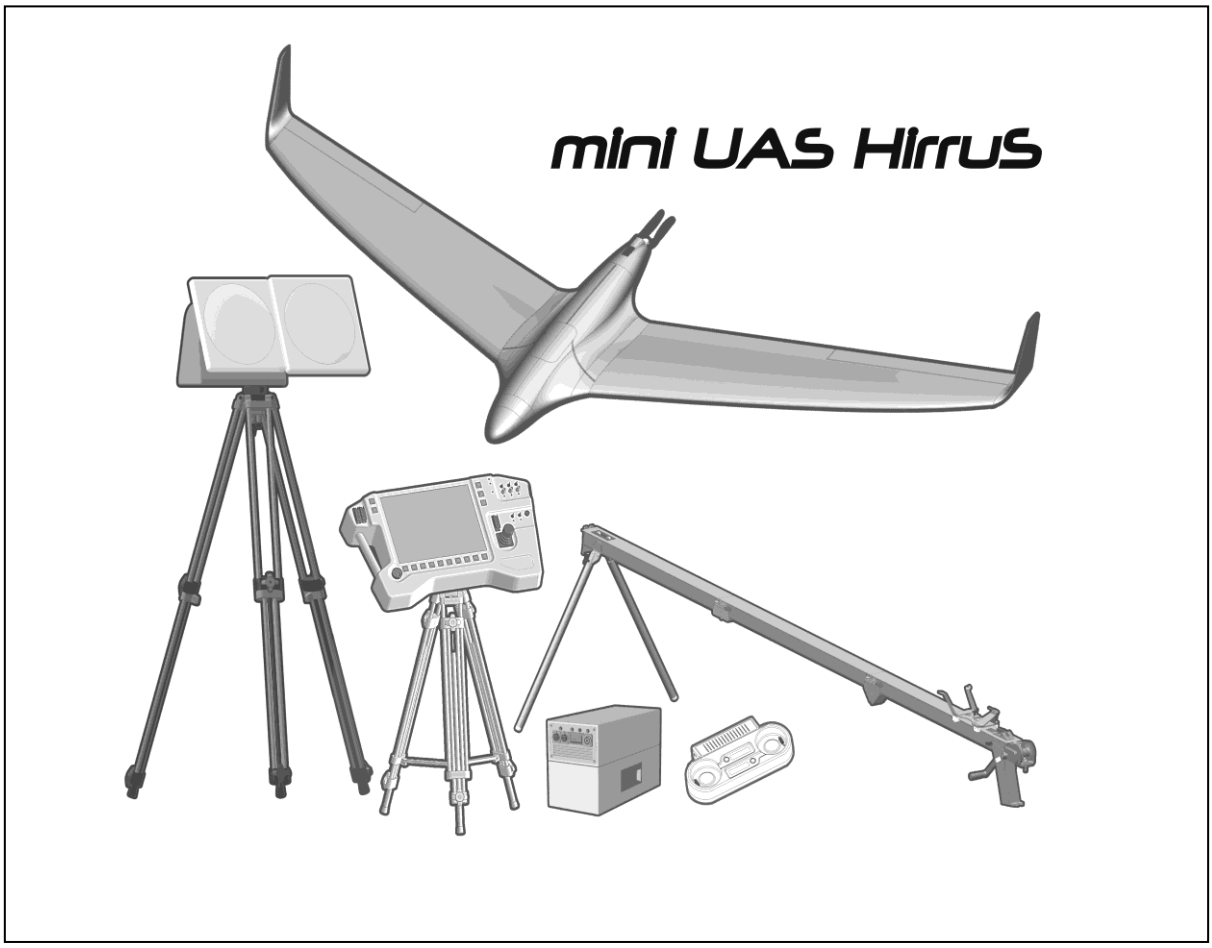
From the functional point of view, the HIRRUS mini-UAV System have the following capabilities:

- Mission planning and its transmission on board unmanned aerial platform.
- Pre-flight system configuration and verification.
- Aircraft launching.
- Video / image acquisition using the sensors installed on board.
- Real-time transmission of video data to Ground Control Station.
- Storage of the high resolution images onboard the airplane.
- Command and control of the aircraft in several modes: manual, semiautomatic and automatic.
- Mission re-planning during the flight of the air vehicle, according any updated operational needs.
- Control data transmission from the Ground Control Station to aircraft.
- Reception and display of the aircraft status data.
- Storage at the level of the Ground Control Station of all the sent and received data.
- Mission review – including analysis of the data transmitted during the flight (telemetry and data recorded by sensors).
- Allow a secure access to the resources of the system.

5 Product architecture

The main system components are being briefly presented further down this document.

Component	Acronym	PBS Code
Aerial Vehicle	AV (UAV)	H01-10
Payload EO		H01-20-15
Payload Photogrammetric		H01-20-20
Automatic Launcher		H01-30
Ground Control Station	GCS	H01-40
Ground Data Terminal	GDT	H01-50
IP Box	IP BOX	H01-55
Power System	PS	H01-60
Charger Unit		H01-63



5.1 Aerial Vehicle (AV)

- H01-10 -

5.1.1 AV characteristics

Specifications

Wingspan:	3,3 m
Wing surface:	1 m^2
Length:	1,2 m
MTOW:	9 kg
Payload:	1000 g
Take-off:	Automatic Launcher
Recovery:	Parachute
Propulsion:	Electric

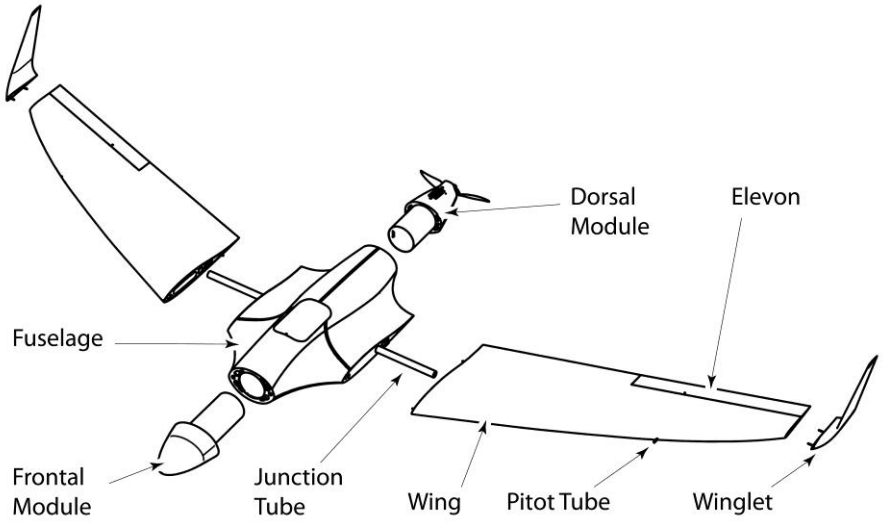
Performances

Max. speed (IAS):	110 km/h
Cruising speed (IAS):	70 km/h
V_S (IAS):	55 km/h*
Take-off distance (TOD)	
-10 m obstacle clearance:	70 m*
-30 m obstacle clearance:	190 m*
Circular Error Probability (CEP):	40 m**
Max. autonomy:	180 min*
Video Datalink range:	15 km
Telemetric datalink range	20 km

* at sea level, at 18ºC
** at zero wind speed

5.1.2AV main components and options

5.1.2.1 Main components



Fuselage - the central component of Hirrus UAV. The wings, the frontal and the dorsal modules are attached to the fuselage.
The fuselage can accommodate various payloads, in the dedicated payload bay.
The fuselage is hosting specific on-board systems (telemetry and control datalink, video datalink, auto-pilot modules). The recovery parachute is placed in the recovery system bay.
Frontal module – contain the frontal battery pack with the integrated battery management system (BMS).
Dorsal module – contain the dorsal battery pack with the integrated battery management system (BMS) and the electric propulsion unit (electric motor, controller, folding propeller).
Left wing – contain the elevon servomechanism with the satellite comand module, Pitot tube, magnetic compass.
Right wing – contain the elevon servomechanism with the satellite comand module. Upon request, it can be fitted with redundant Pitot tube and magnetic compass.

5.1.2.2 Delivery options

Fuselage

- fully equipped;
- spare part – in this case, it will not contain any electronic module, but it will be fully equipped with all electric harness and connectors;
- airframe – empty, with no electric harness, connectors, electronic modules. This require a higher training degree for the service crew.

Frontal / dorsal module

- fully equipped modules – can be ready plugged in the fuselage. To optimize on the field charging cycles, it is recommended to have the system fitted with a set of additional frontal and dorsal modules

Service and repairs of frontal / dorsal module's batteries is manatory carried out by the manufacturer.
Repairs for structural damages are done by checking the center of gravity.

5.2 Payload

- H01-20-10 -
- H01-20-20 -

For voarious applications, the Hirrus UAV may optionally accommodate three different types of payloads:

- A day payload or,
- A night payload or,
- A high speed / high resolution camera payload.

The shape, size and the look of the three payloads is almost identical – the functional difference is provided by the sensor located inside each payload.

The day payload (EO) is able to provide real time video stream during the flight of the UAV in the day time, from a distance up to 15 km from the launching point, providing that the Line of Sight (LOS) between the Ground Data Terminal and the Air Vehicle is available.

The day payload is modular, retractable and stabilized, and includes:

- Sensor. The sensors is built around a color day video camera, which has the following performances:
  - Optical zoom 10x;
  - About 2 million pixels;
  - PAL, NTSC;
  - Signal/Noise ration >= 50 dB

- Stabilized & retractable platform, which accommodate the sensor and is able to provide mechanical stabilization of the sensor for 2 axis.

The night payload (IR) is able to provide real time video stream during the flight of the UAV, in the night time, from distances up to 15 km from the launching point, providing that Line of Sight (LOS) between the Ground Data Terminal and the Air Vehicle is available.

The night payload is modular, retractable and stabilized, and includes:

- Sensor. The sensors is built around a specialized night video camera, which has the following performances:
  - 640 x 480 pixels;
  - 9 frames per second;
  - spectral band of the night sensor 8-12μm (uncooled micro bolometer);
  - NTSC/PAL format of the signal

- Stabilized & retractable platform, which accommodate the sensor and is able to provide mechanical stabilization of the sensor for 2 axis.

The high speed / high resolution camera payload (photogrammetric).
This payload is able to collect high speed / high resolution pictures during the flight of the UAV, in the day time.
Further to the landing of the airplane, the recorded pictures may be downloaded and processed. Considering the large size of the collected pictures, they cannot be transferred to the Ground Control Station in real time or during the flight.

The sensor have the general technical data:
- Resolution: 24 Megapixels;
- Focal distance: 30 or 60 mm;
- Up to 10 pictures/s

5.3 Automatic Launcher

- H01-30 -

The launch of the airplane is performed using an automatic launcher equipped with elastomeric (rubber) tubing.
This technical solution allows a smooth, silent, simple and effective launching of the UAV even in difficult weather conditions (wind, rain, low temperature) reducing dramatically the potential risks that may appear during the launching sequence.

The Launcher characteristics are the following:

- Launch energy: max 1.8 kJ;
- Launch AV MTOW: max 11 kg;
- Launch speed @ MTOW: 17 m/s;
- Dimensions: 3600 mm x 100 mm x 100 mm;
- Weight: max 20 kg;
- Time for installation/removal: 5 minutes / 5 minutes;
- Time between two successive releases: 1 minute;
- Launcher construction is modular.

The Launcher is equipped with active safety system throughout the launch preparation.

5.4 Ground Control Station (GCS)

- H01-40 -

Ground control station (GCS) provides:

- Mission planning;
- Mission loading onboard of UAV;
- Launch monitoring of UAV;
- Mission monitoring;
- Changing of the flight plan during the mission of UAV;
- Reception and storage of specific mission data (command, control data, video data);
- Offline mission play for debriefing.

GCS is equipped with a self-test system that performs automated testing at the beginning of each mission of the mini UAV, and refers malfunctions arising during the operation. The self-test detects lack of telemetry signals, autopilot system failure, on board battery status, computer system failure.

Platform control unit provides:

- Digital support (raster format maps and / or vector) for deployment;
- Definition by points (x, y, z) and associated speed of the route of unmanned aerial platform overlapped on the region map;
- The maximum number of points for mission planning: 256;
- Actions on the route points: position change by "drag & drop" actions, associated speed change and altitude change;

- Defining flight restricted areas;
- Showing obstacles and terrain elevation;
- Launching command of unmanned aerial platform; Aircraft position display over the digital map;
- Zooming on the digital map;
- Display of viewed payload area (orientation and zoom);
- Display of flight data (telemetry) to a specific window with the board instruments; Real-time alarming display of operator errors and failures;
- Remote video transmission;
- Manual control of unmanned aerial platform by sending commands: heading, speed, altitude;
- Recovery of the platform by sending the command to open the parachute.

Payload control unit provides the following commands:

- Pan / Tilt;
- Zoom;
- Retraction of sensor;
- Switch On / Off of the laser mounted into the Gimbal Assembly.

Specific control elements are located on the front: joystick, buttons, sun readable display. The GCS is mounted on a tripod and is protected by a lightweight, shock resistant case.

5.5 Ground Data Terminal (GDT)

- H01-50 -

The Ground Data Terminal (GDT) provides the link between aircraft and Ground Control Station (GCS) and include the antennae management terminal.
Ground Data Terminal is part of the Data Link System.
The Data Link system includes the Airborne Data Terminal (located onboard the airplane) and the Ground Data Terminal (located on the ground).
The Data Link System (the ground section and the airborne section) is used to support the data exchange between the Ground Control Station and the Aerial Vehicle (both telemetry and video data).

Ground Data Terminal perform the following tasks:

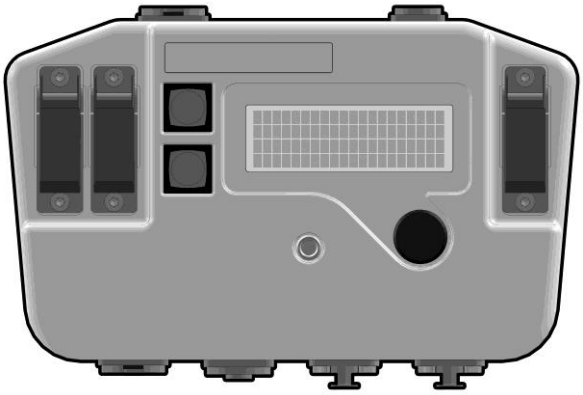
- Transmission of the data coming from the Ground Control Station to the aerial vehicle (uplink);
- Reception of the data coming from the aerial vehicle (down-link) and streaming them to
  the Ground Control Station.
  The down-link include telemetry data and video-stream data;
- Provide automatic orientation of the antennae, both in azimuth and elevation, aiming to
  maximize the gain.

The most important technical characteristics of the Ground Data Link are the following:

- Radio range:
  - 15 – 20 km: real time video streaming;
  - 30 km: without real time video streaming – telemetry data only;
- Real time transmission / reception of video data;
- Real time transmission / reception of flight parameters.

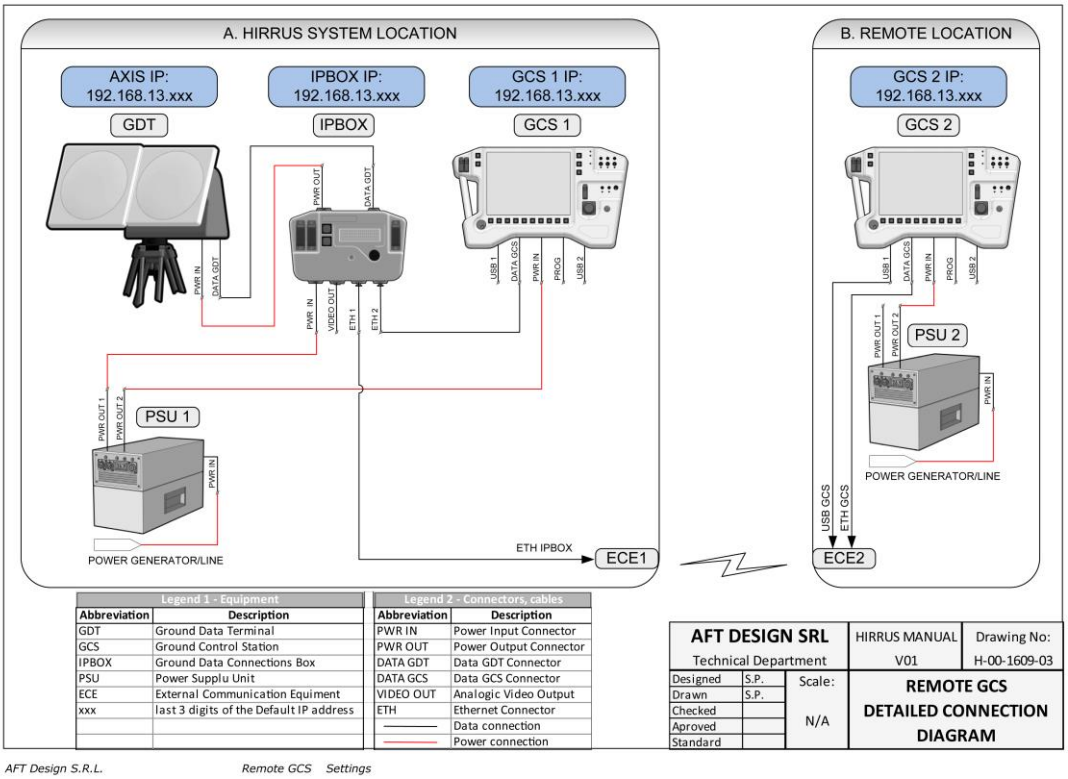
5.6 IP BOX

- H01-55 -



The IP Box is an integral part of the GDT system.
It ensures connection and access of all GCS's to GDT and, implicitly, to all AV's.
This can be made via any IP network, including the Internet.
Through the controls present in its component (corresponding to those in GCS) safety commands can be transmitted in case of loss of connection with GCS's.
It also has the role of reformatting the electrical signals sent from GDT through slip ring.

Annex 3 Remote GCS Detailed Connection Diagram



Legend 1 - Equipment	
Abbreviation	Description
GDT	Ground Data Terminal
GCS	Ground Control Station
IPBOX	Ground Data Connections Box
PSU	Power Supplu Unit
ECE	External Communication Equiment
xxx	last 3 digits of the Default IP address

Legend 2 - Connectors, cables	
Abbreviation	Description
PWR IN	Power Input Connector
PWR OUT	Power Output Connector
DATA GDT	Data GDT Connector
DATA GCS	Data GCS Connector
VIDEO OUT	Analogic Video Output
ETH	Ethernet Connector
	Data connection
	Power connection

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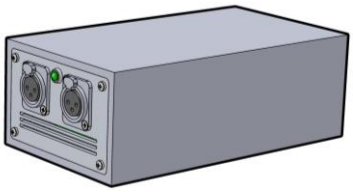
Technical Department	V01	H-00-1609-03
Designed S.P. / Drawn S.P. / Checked / Aproved / Standard	Scale: N/A	REMOTE GCS DETAILED CONNECTION DIAGRAM

AFT Design S.R.L. *Remote GCS Settings*

5.7 Power System (PS)

- H01-60 –



The Power System (PS) provides electrical power to the following components of the system:

- GCS;
- GDT;
- Charger.

Input Characteristics

- Mains supply: 220Vac, max 5A compatible with European socket;
- Auxiliary supply: 12 – 28 Vdc, max 25A, compatible with 12V and 24V vehicle battery.

Output Characteristics

- 27 V max 1000W on mains power;
- 27 V max 250W on auxiliary power;
- 20-24V max 200W on UPS power.

Main components

The Power System is composed by two main modules and an optional module, as well:

- **Power Unit (PU) module**
  The PU module can be use as a stand-alone unit, without the UPS module (see below) being attached to it. Nevertheless it is highly recommended to use the Power
  System as a whole, with the PU module and the UPS module being attached to each other.
- **Uninterruptible Power Supply (UPS) module**
  It contains a 24V, 12A Lead-Acid rechargeable battery.
  With the UPS battery fully charged, the UPS module can keep the system running for up to two hours, depending on the battery's life.
  The PU module can be stacked on top of the UPS module.
  The UPS module has a number of four fixed latches on top. These latches engage with corresponding mobile latches in the PU Module.
- **Light Power Unit (LPU)**
  The LPU is an additional power source.
  Input: 110 – 230 Vac; 50 – 60 Hz
  Output: 2 x 24 Vdc; 12,5 A
  It can simultaneously supply power to a GCS and GDT.
  It is intended mainly for indoor use, of a remote GCS, for example.

5.8 Charger Unit

- H01-63 -

The Charger Unit is responsible for charging and monitoring of AV Hirrus battery packs. It consists of two separate, micro-processor controlled, high efficiency switching mode power supplies, capable of charging simultaneously two battery packs.

The Charger Unit is meant to be powered up mainly by the Power System.
But the wide input voltage range allows charging from a vehicle power systems (12V or 24V) or external power supplies, with a maximum input voltage of 30V.

Apart from charging, the unit also:
- displays pack status information;
- signals possible errors;
- allows users to prepare the packs for storage.

MAIN FEATURES

- Two charging modes:
  - normal mode (5A charging current);
  - fast mode (10A charging current).
- Wide input voltage range:
  - 12Vdc – 30Vdc.
- High efficiency:
  - 98%, minimal heat dissipation (except discharging mode).
- Storage mode:
  - allows charging and discharging to prepare the battery packs for storage.
- Pack status information:
  - individual cell voltage;
  - capacity (in %);
  - identification (assembly date and serial number);
  - cycle count.

Input -12Vdc – 30Vdc, 500W (250W per charging port).
Output -18Vdc – 25.2Vdc, 250W per charging port.

5.9 Transport cases

Case #1

- GCS (including tripod);
- GDT (including tripod);
- Charger;
- Fuselage;
- Frontal and Dorsal Modules;
- Winglets (one set);
- Payload.

Case #1 weight (fully equipped) – 60 kg

Case #2

- Launcher;
- Power System;
- Tool Box;
- Wings (one set).

Case #2 weight (fully equipped) – 67 kg

Case #3

- Fuselages (two pcs);
- Frontal and Dorsal Modules (two sets);
- Winglets (two sets);
- Payloads (two pockets);
- Wings (two sets).

Case #3 weight (fully equipped) – 45 kg

Depending on the number of AV's, the system components are conveniently packaged in up to three sturdy transport cases.

- For **tree AV** configuration, the transport cases are fully populated with system components.
- For **two AV** configuration, in case #3 are placed just one fuselage, one frontal/dorsal module set, one winlets set and one wings set.
- For **one AV** configuration, case #3 is not necesarry.

AV qty	**Case #1**	**Case #2**	**Case #3**	**Total weight** [kg]
3	- GCS (including tripod); - GDT (including tripod); - Charger; - Fuselage; - Frontal and Dorsal Modules (one set); - Winglets (one set); - Payload.	- Launcher; - Power System; - Tool Box; - Wings (one set).	- Fuselages (two pcs); - Frontal and Dorsal Modules (two sets); - Winglets (two sets); - Payloads (two pockets); - Wings (two sets).	172
2	- GCS (including tripod); - GDT (including tripod); - Charger; - Fuselage; - Frontal and Dorsal Modules (one set); - Winglets (one set); - Payload.	- Launcher; - Power System; - Tool Box; - Wings (one set).	- Fuselage (one pcs); - Frontal and Dorsal Modules (one set); - Winglets (one set); - Payloads (two pockets); - Wings (one set).	163
1	- GCS (including tripod); - GDT (including tripod); - Charger; - Fuselage; - Frontal and Dorsal Modules (one set); - Winglets (one set); - Payload.	- Launcher; - Power System; - Tool Box; - Wings (one set).	- NA	127

Depending on the client's request concernig optional parts, these parts can be packed in additional cases, taylored to best fit the configuration.