E2000S

Intelligent Photogrammetric System

High-precision aerial photogrammetry and
three-dimensional reconstruction of the real world

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Intelligent Photogrammetric System

E2000s is an intelligent aerial photogrammetric UAV system for professional users to meet the needs of high-efficiency,high-efficiency, and high-precision aerial phtogrammetry and remote sensing applications. It is equipped with a 24.3 million-pixel aerial photographing module which can support two operating modes, i.e., orthographic and oblique. The standard take-off weight of the E2000s is 2.8 kg, the standard load is 200g, and the endurance time is 60 minutes.

E2000S is equipped with a high-precision differential GNSS board and dual-differential antennas, and can optionally be equipped with a physical GNSS base station to realize large-scale image-free control applications based on RTK and PPK fusion calculations. The E2000S comes standard with the software named UAVManager Professional Edition, which has various route modes for different application requirements and supports accurate three-dimensional route planning, precise terrain following flight, three-dimensional real-time flight monitoring. Also, the software supports GNSS fusion calculation, control point measurement, aerotriangulation, one-key to output and browse multiple data results such as TDOM, DOM, DEM, DSM and so on.

System parameters

Net weight	2.8 kg
Symmetrical motor wheelbase	598 mm
Dimensions (excluding blades)	495 mm × 442 mm × 279 mm (Unfold) 495 mm × 442 mm × 143 mm (Fold)
Navigation satellites	GPS, BeiDou, GLONASS
Power mode	Electric
Maximum speed	20 m/s (When the UAV platform is tilted 25 degrees)
Endurance	60 mins
Range	50 km
Working temperature	-20 ℃ ~ 45 ℃

Maximum climb speed	8.0 m/s (manual), 5.0 m/s (automatic)
Maximum descent speed	5.0 m/s (manual), 3.0 m/s (automatic)
Hovering accuracy in RTK mode	Horizontal 1 cm + 1 ppm, Vertical 2 cm + 1 ppm
Differential GNSS update frequency	20 Hz
Maximum take-off altitude	4000 m
Wind resistance	Grade 6 (10.8 m/s ~ 13.8 m/s)
Task response time	Unfold ⩽ 10 mins, Withdraw ⩽ 15 mins
Control radius	10 km
Take-off and landing mode	VTOL without remote control

Image control-free topographic mapping

E2000S is equipped with 20 Hz high-precision differential GNSS board; At the same time, it is equipped with 24.3 M pixel APS-C frame sensor, supports orthophoto and oblique operation modes, has GCP-free mapping capabilities, and can adapt to various aerial survey applications.

Long endurance, high efficiency and high reliability

The hovering time at sea level for a single flight is 60 minutes. The modules such as IMU, barometer, magnetometer, and GNSS module adopt redundant design. The componets such as ultrasonic wave, optical flow module and double differential antennas are utilized to provide multiple guarantees. A number of components and the whole UAV platform have passed the reliability test to ensure product safety and reliability.

Dual-differential antenna

Double dual-differential antennas are the standard configurations of the E2000S, which enhance the anti-interference ability and help to operate in complex environments such as mining areas, bridges, and ship-borne take-off and landing platforms.

Precise terrain following flight

Combined with the software of UAVManager Professional Edition, the E2000S can achieve accurate terrain following flight, improving the image acquisition resolution and ensuring the consistency of image resolution.

Automatic obstacle avoidance

E2000S is equipped with a front-mounted milliwave radar obstacle avoidance module, which can automatically detect obstacles ahead and improve the safety level.

One-stop software solution and advanced data processing workstation

The software of UAV Manager Professional Edition supports the whole process from accurate 3D flight route planning, 3D real-time flight monitoring, control point measurement, aerial triangulation to providing and browsing a variety of data results such as DOM, DEM, DSM, TDOM, LiDAR point cloud and so on.

Cloud-based active service

Based on cloud services, the system supports information push, project synchronization, flight data sharing, active UAV maintenance, flight real-time display and playback afterwards. Also, remote monitoring and video streaming can be accomplished based on 4G/5G networks.

Platform configuration

Order	Part name	Unit	Quantity
1	E2000S UAV platform	Set	1
2	E2000S ground data transmission module	Set	1
3	UAVManager Professional Edition (Surveying Edition E)	Set	1
4	E2000S intelligent battery	Groups	2
5	E2000S intelligent battery charger	Set	1
6	E2000S transport box	Set	1
7	E-CAM2000 aerial photogrammetric module (24.3 M)	Set	1

System characteristics

Battery

Dual differential antennas

Blade

Quick release structure

Millimeter wave radar

Magnetometer

Payload

Motor

Landing gear

Optical flow

Ultrasonic

Exploded views

Transport box

Moduler design, easy to carry and transport

Dimensions

55 cm × 29.5 cm × 67.5 cm

Total weight

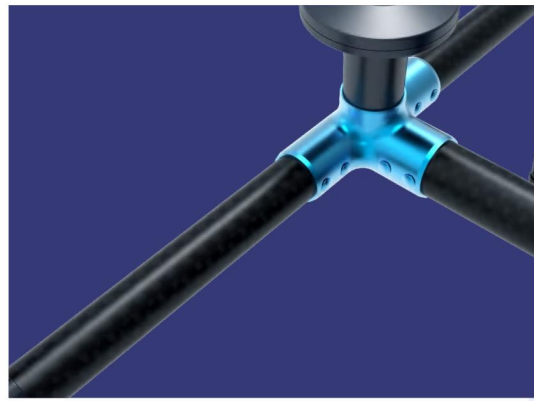**12.34 kg**
(including standard modules and accessories)

Battery disassembly

Propeller disassembly
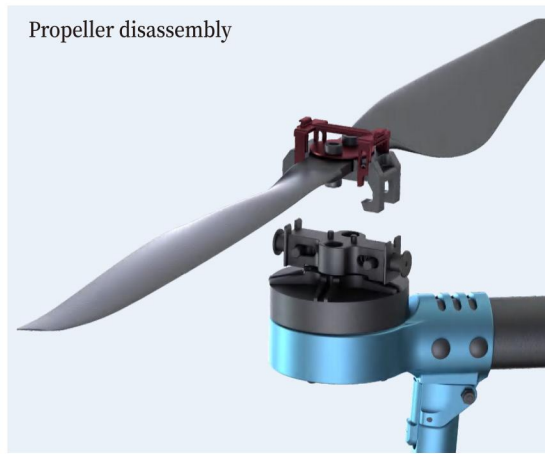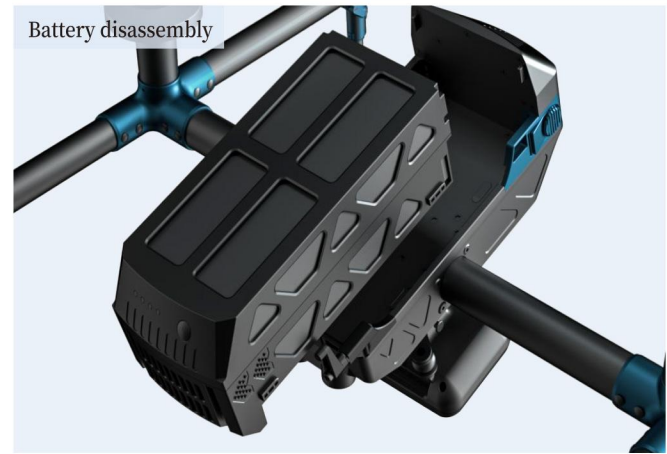
Key components

Carbon fiber structure

The fuselage of E2000S can be folded quickly, and the whole body can be stored in a transpot box for easy transportation.

Motor

High efficiency, high reliability, low vibration, low noise motor

Intelligent battery

With an innovative battery protection scheme, it is easy to view parameters such as battery power and battery working status. Moreover, a complete safety protection logistic is developed to reasonably and comprehensively ensure the safety of battery use.

Quick release propeller

Professional pneumatic shape design and exquisite processing technology ensure the performance and quality of the propellers. The propellers of E2000S can be quickly disassembled and assembled without tools, which is convenient and reliable.

UAV special data transmission radio

E2000S with 840.5 MHz~ 845 MHz special frequency band, which is certified by the Radio Approval Committee of China.The radio adopts hopping design to enhance anti-inteference capability.

RTK100 GNSS base station (optional)

RTK100 is a GNSS reference stations, supporting RTK and PPK fusion solution via the software of UAV Manager Professional Edition.

Autopilot & safety mechanism

Autopilot of E2000S

Model-based flying control logistics

Advanced multi-sensor data fusion algorithm

Redundant sensor design for increased operational security

Real-time fault detection and fault isolation algorithms

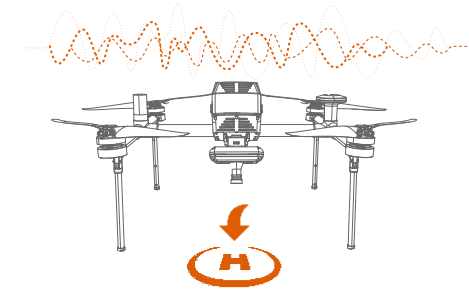High-precision heading and attitude measurement system

Fully automatic task mode

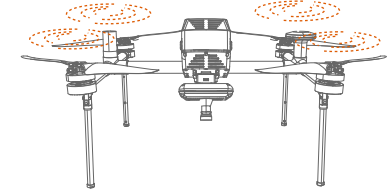Efficient embedded software system and modular design, supporting multiple payloads

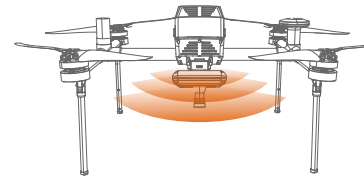Supporting RTK, PPK and their fusion solution to provide centimeter-level positioning accuracy
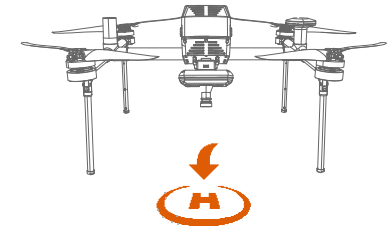
Automatic return without GNSS

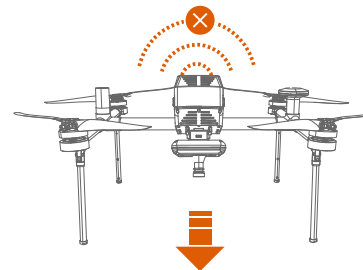Lower and hovering when GNSS is out of lock

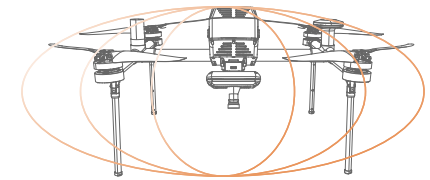Forward radar to avoid obstacles

Automatic return when datalink fails connection

Landing when sensor failure happens

Automatic check after poweringup the UAV

Payload

E-CAM2000
Photogrammetric module

Camera model	SONY ILCE-6000
Sensor size	23.5 mm × 15.6 mm (aps-c)
Effective pixels	About 24.3 million
Lens	25 mm fixed focus

Flight efficiency table (orthophoto photographing)

Speed	GSD	Relative altitude	Area of each sortie	Daily area	Flight range
(m/s)	(cm)	(m)	(km^2)	(km^2)	(km)
13.5	2	128	2.09	16.72	45
	3	192	3.12	24.92	
	5	321	5.13	41.04	
	8	513	8.10	64.80	

Supposing 8 sorties per day, 80% × 60% overlap degree, conventional route design

Flight Efficiency Table (oblique photographing)

| Speed	GSD	Relative altitude	Area of single sortie		Daily area		Flight range
			For best texture	Routine work	For best texture	Routine work	
(m/s)	(cm)	(m)	(km^2)	(km^2)	(km^2)	(km^2)	(km)
8	1.5	74	0.08	0.12	1.45	1.63	30
13.5	2	98	0.20	0.29	3.13	3.48	45
	2.5	123	0.24	0.37	3.90	4.39	
	3	147	0.28	0.45	4.64	5.28	

Supposing 8 sorties per day, one block, 80% × 80% overlap degree, cross-route design

Applications scenarios

High-precision topographic mapping

1-1 Topographic mapping
1-2 Engineering survey (water conservancy)
1-3 Land survey
1-4 Urban planning
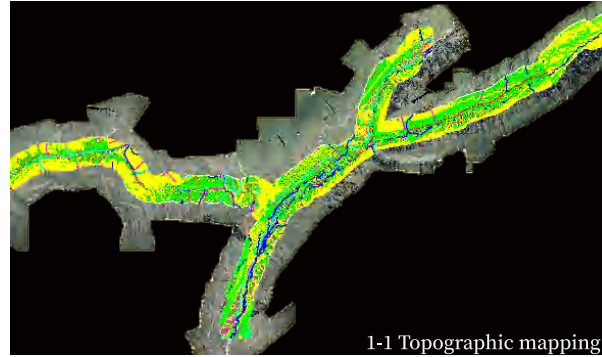
High-precision 3D modeling

2-1 Digital city
2-2 Cultural relics protection
2-3 BIM application
2-4 Emergency monitoring

1-1 Topographic mapping

2-3 BIM application

1-4 Urban planning

1-2 Engineering survey (water conservancy)

2-1 Digital city

1-3 Land survey

2-2 Cultural relics protection

2-4 Emergency monitoring
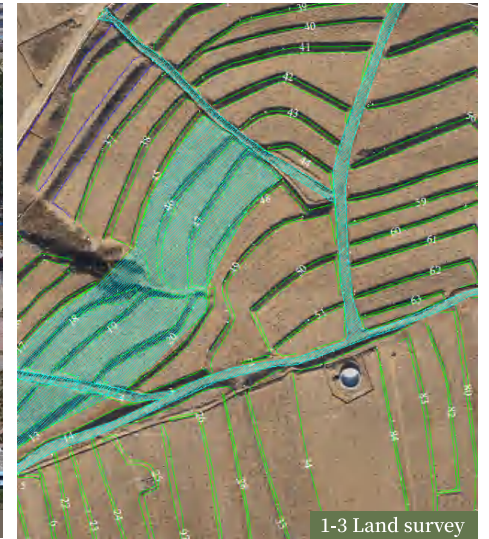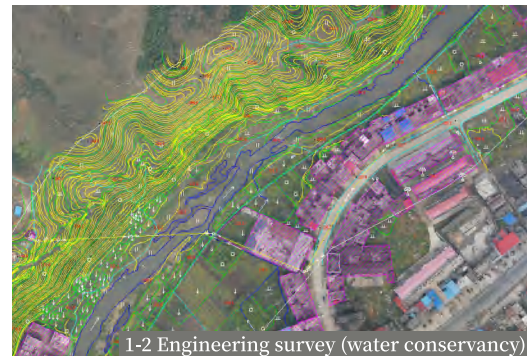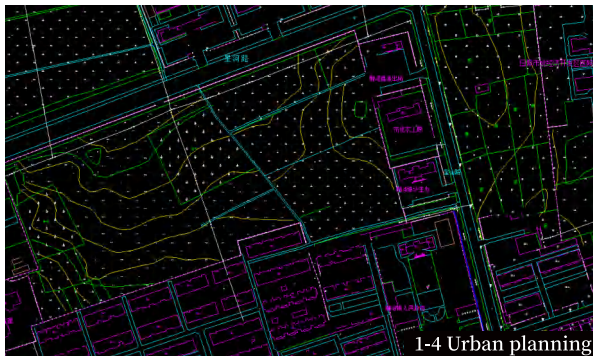
Large-scale image-control free mapping test (control strip)

The E2000S is equipped with a single camera for data acquisition in a certain area. The route is designed as a control strip mode. The relative altitude is 255 meters with the corresponding ground resolution being 5 centimeters. And the forward overlap and side overlap are 80% and 65% respectively. Besides, RTK and PPK fusion differential solution is adopted to acquire high-precision GNSS data.
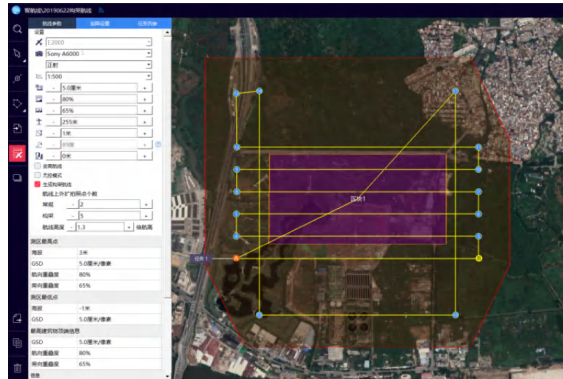
Route design

Measuring positions relative to actual positions of check points (m)

ID	TYPE	Dxy	Dz
xk0184	CHK	0.12	-0.12
xk0284	CHK	-0.052	0.08
xk0384	CHK	0.081	-0.043
xk0584	CHK	0.076	0.052
xk0684	CHK	0.085	-0.12
RMSE		0.085	0.089

Output DOM and DEM accuracy statistics

Result map

Application cases

Regular oblique photographing

The flight area of this case is a suburb of Dongguan City, Guangdong Province, China, and the survey area is about 0.16 square kilometers. After adjusting the E-CAM2000 mounted on the E2000S to the tilt mode, SmartPlan module of UAVManager Professional Edition is utilized to generate the oblique photographing route.

The designed route, i.e., a cross route with a range of about 20 kilometers, has a relative flight height of 147 meters, a image resolution of 3 centimeters, and both the forward and side overlap of 80%. Only one sortie is needed and 658 images are acquired.

The pictures below shows the route planning interface in SmartPlan module and the result digital map.
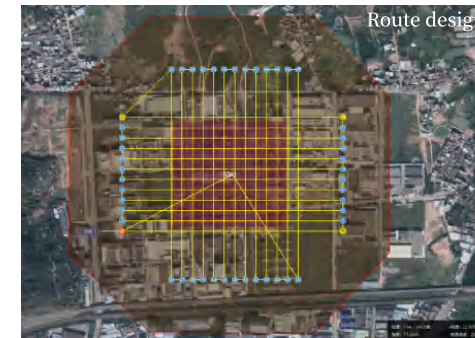
Route design

Result map (enlarged view)

Result map

Orthophotography
(for areas of undulating terrain)

For areas with undulating terrain, the E2000S' precise terrain following flight can be adopted to ensure the consistency of image resolution.

A set of orthographic data was obtained by precise terrain following flight in a certain area in Shandong Province, China, with a relative altitude of 191 meters, a ground resolution of 3 centimeters, a forward overlap of 80%, and a side overlap of 60%. One 13 minutes sortie is needed and 340 images are acquired. Besides 10 checkpoints are set up in the same area. RTK and PPK fusion calculation is adopted to test the image-control free large-scale mapping ability.

After the POS-assisted aerotriangulation calculation, check the point prediction of the checkpoints, and it can be seen that the RMSE of the checkpoints is within 2 pixels. According to the aerot-riangulation report, the RMSE of plane in the X direction is 0.047 meters, 0.035 meters in the Y direction, and the RMSE of elevation is 0.066 meters.
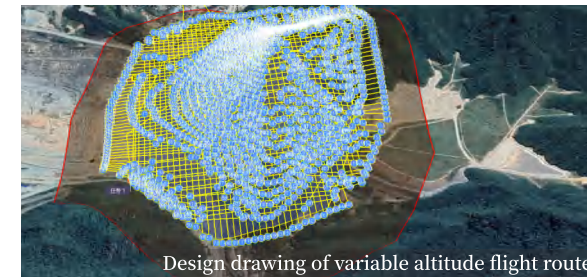
Accuracy report of GCP-free aerotriangulation

ID	TYPE	Dx	Dy	Dz
F1	CHK	-0.055	0.03	-0.065
F2	CHK	-0.006	-0.042	-0.036
F3	CHK	0.045	-0.027	0.03
F4	CHK	-0.023	0.032	-0.083
F5	CHK	-0.070	-0.013	-0.08
F6	CHK	0.045	0.012	0.056
F7	CHK	-0.067	-0.023	-0.072
F8	CHK	0.035	0.067	0.08
RMSE		0.047	0.035	0.066

Route design of variable altitude

Application cases

Oblique photography
(for areas of undulating terrain)

The flight area of this case is a mountainous area with large terrain fluctuations in Henan Province, China. Precise terrain following flight is adopted to obtain high-resolution image data. The survey area is about 1 square kilometers. After adjusting the E-CAM2000 mounted on the E2000S to the tilt mode, SmartPlan module of UAVManager Professional Edition is utilized to generate the oblique photographing route.

The designed cross route has a relative flight height of 98 meters, a range of 118 kilometers, a image resolution of 2 centimeters, and both the forward and side overlap of 80%. Three sorties are needed and 7400 images are acquired.

Result map (enlarged view)

Design drawing of variable altitude flight route

Result map (enlarged view)

Result map

UAVManager Professional Edition

SmartPowerLine

SmartPlan

SmartMonitor

SmartFly

Maintenance

SmartCheck

UAVManager
Professional Edition

⊞ Win iPad

3D Viewer

SmartProcess

SmartPointCloud

SmartMap

SmartLiDAR

UAVManager Professional Edition is a one-stop intelligent GIS system for UAV flight plan and manipulation, data acquisition, data processing, display and management, and UAV maintanence.

Accroding to different kinds of application purposes, automatic and accurate flight planning based on real scene 3D terrain data are integrated to UAVManager Professional Edition for both fixed-wing UAVs and rotor-crafts. Moveover, 3D real-time monitoring, fast quality inspection for flights, pre-processing tool box, robust accruacy control and automatic stitching, 4D outputs, visual monitoring center, and cloud services (e.g., system update, intelligent maintanence, and information pushing) are provided by UAVManager.