International Civil Aviation Organization

Twenty Fifth Meeting of the Communications/ Navigation and Surveillance Sub-group (CNS SG/25) of APANPIRG

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Agenda Item 12: Discuss and share experience and application of new technologies, including big data analysis, artificial intelligence, Digital Tower, counter UAS detection and identification system, UTM, etc.

STANDARD ESTABLISHMENT OF UAS-BASED FLIGHT INSPECTION SYSTEM IN CHINA

(Presented by China)

SUMMARY

CAAC published the first technical specification of fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system in September 2020, as a big move of the standard establishment plan for UAS-based flight inspection technology and application. The issued standard specifies essential functions, performance requirements, system components, antennas, and requirements of the core units, including inspection receiver, signal acquisition unit, evaluation and processing unit etc., as well as requirements for tag, documentation, transportation, and storage.

1. INTRODUCTION

1.1 The joint research and developing team in China have been dedicating UAS-based flight inspection technology for years and developed two generation of flight inspection systems deployed in fixed-wing or hybrid-wing UAS.

1.2 A couple of flights have been completed with both fixed-wing UAS and hybrid wing UAS, whose results validated the feasibility of the frontier UAS-based flight inspection concept and the creditability of UAS-based flight inspection system.

1.3 The team drafted the technical specification of fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system. CAAC completed the review and issued it as tentative trial via Information Bulletin on September 27, 2020 (No. IB-TM-2020-005).

2. DISCUSSION

2.1 The CAAC IB-TM-2020-005 specifies the general technical requirements for civil aviation fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system.

2.2 This bulletin applies to the configuration and use of civil aviation flight inspection systems based on fixed-wing/hybrid-wing UAS.

2.3 CAAC IB-TM-2020-005 mainly consists of essential requirements, technical requirements, and miscellaneous requirements.

2.3.1. Essential requirements

A civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS refers to the application that airborne mission system equipment is mounted on fixed-wing or hybrid-wing unmanned aircraft to achieve inspection, calibration, and evaluation of aviation navigation and surveillance facilities via an air-to-ground coordinated manner, including issuing flight inspection reports.

The specification describes the essential requirement of the system, including the least inspection functions, quality assurance, applicable scope, anti-crosswind disturbance, anti-jamming capabilities, man-machine interface, ground communication, testing and maintenance, power supply control. Performance requirements of the system cover standard compliance, operation frequency band, power supply, reliability and validity, self-check, temperature monitoring, spatial-temporal reference. The environmental conditions of airborne subsystem and ground-based subsystem are specified respectively.

2.3.2. Technical requirements

The civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS consists of two parts: airborne subsystem and ground-based subsystem. The airborne subsystem generally includes antennas, inspection receiver(s), signal acquisition unit, airborne component of spatial-temporal reference unit, airborne component of air-ground data link unit, radar inspection supporting module, runway lighting inspection supporting module, and airborne ADS-B module. The ground-based subsystem mainly includes the evaluation and processing unit, the ground component of spatial-temporal reference unit, the ground component of air-ground data link unit, and the calibration unit.

The specification requires the general functions, core performance, special features of the core components in the system described above.

2.3.3. Miscellaneous requirements

The specification contains requests for equipment tag, documentation, transportation, and storage.

2.4 Please refer to Appendix for the English version of the specification.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the material provided.

b) provide feedback on the technical specification attached in this working paper.

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Appendix: Technical specification of fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system (Tentative trial) (CAAC IB-TM-2020-005)

Information Bulletin

Bureau of Aviation Regulation, CAAC

No：IB-TM-2020-005

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Technical specification of fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system

(Tentative trial)

Content

Technical specification for fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system (Tentative trial)

1 Scope

This bulletin specifies the general technical requirements for civil aviation fixed-wing/hybrid-wing UAS-based civil aviation flight inspection system.

This bulletin applies to the configuration and use of civil aviation flight inspection systems based on fixed-wing/hybrid-wing UAS.

2 References

The following documents are indispensable for the application of this bulletin. For dated reference documents, only the dated version applies to this document. For undated reference documents, the latest version (including all amendments) is applicable to this document.

[1] 《Classification and grading for civil unmanned aircraft system》（GB/T 35018-2018）

[2] 《Aeronautical radio navigation aids Part 1: Technical requirements for instrument landing system (ILS)》（MH/T 4006.1-1998）

[3] 《Aeronautical radio navigation aids Part 2：Technical requirements for very high frequency omnidirectional range (VOR)》（MH/T 4006.2-1998）

[4] 《Aeronautical radio navigation aids Part 3：Technical requirements for distance measuring equipment (DME)》（MH/T 4006.3-1998）

[5] 《Aeronautical radio navigation aids Part 4：Technical requirements for non-directional radio beacon (NDB)》（MH/T 4006.4-1998）

[6] 《Technical standards for ATC secondary surveillance radar》（MH/T 4010-2016）

[7] 《 Regulations on the Management of Civil Unmanned Aircraft Pilot 》（AC-61-FS-2018-20R2）

[8] 《Civil Aviation Ground-based Navigation Equipment Flight Inspection Specification》 （AC-86-TM-2016-01）

[9] 《Civil Aviation Communication, Navigation and Monitoring Equipment Flight Inspection Management Rules》（CCAR-86）

[10] 《ICAO Doc 8071 Manual on Testing of Radio Navigation Aids Volume I- Testing of Ground-based Radio Navigation Systems》（Fifth Edition）

[11] 《ICAO Doc 8071 Manual on Testing of Radio Navigation Aids Volume II- Testing of Satellite-based Radio Navigation Systems》（Fifth Edition）

[12] 《ICAO Doc 8071 Manual on Testing of Radio Navigation Aids Volume III- Testing of Surveillance Radar Systems》（First Edition）

[13] 《ICAO Annex 10 Aeronautical Telecommunications Volume I Radio Navigational Aids》（Seventh Edition）

[14] 《ICAO Annex 10 Aeronautical Telecommunications Volume IV Surveillance and Collision Avoidance Systems》（Fifth Edition）

[15] 《Environmental Conditions and Test Procedures for Airborne Equipment》（RTCA DO-160G）

[16] 《IEEE Standard Test Procedures for Antennas》（IEEE Std 149-1979 R2008）

[17] 《Categorization and Classification of Civil Unmanned Aircraft Systems》（ISO 21895:2020）

[18] 《US Standard Flight Inspection Manual (USSFIM) with CHG 1》（FAA Order 8200.1D）

3 Terms, definitions, units, and abbreviations

3.1 Terms and definitions

The following terms and definitions established in 《Civil Aviation Ground-based Navigation Equipment Flight Inspection Specification》（AC-86-TM-2016-01），[1]《Civil Aviation Communication, Navigation and Monitoring Equipment Flight Inspection Management Rules》（CCAR-86），《Classification and grading for civil unmanned aircraft system》（GB/T 35018-2018），《Regulations on the Management of Civil Unmanned Aircraft Pilot 》（AC-61-FS-2018-20R2）and 《Categorization and Classification of Civil Unmanned Aircraft Systems》（ISO 21895:2020）are applicable to this document.

1) Civil unmanned aircraft system (UAS)

A system composed of remote piloted aircraft engaged in civil flight activities, control unit, data link, mission load, and operation support unit. In this technical specification, it is referred to as unmanned aerial vehicle for short.

2) Distance measuring equipment (DME)

A radio navigation equipment which works in the UHF band and provides continuous and accurate slant distance from the aircraft to the ground station by receiving and emitting radio pulse pairs.

3) Fixed-wing UAS

According to the platform architecture, it is classified as a fixed wing, a kind of unmanned aerial vehicle that is heavier than air, driven by power. Its flight lift is mainly generated by the wing surface that remains unchanged under given flight conditions.

4) **Flight inspection**

Flight inspection is to ensure flight safety, the processing of using flight inspection aircraft equipped with professional inspection equipment to check and evaluate the space signal quality and tolerance of various navigation, radar, communications, and other equipment in accordance with relevant flight inspection specifications, as well as the feasibility of the airport's entry and departure flight procedures, and issue official reports based on the results of inspections and evaluations.

5) Flight inspection system calibration

The process of using standard aviation signal sources to test and calibrate the flight inspection system.

6) Hybrid-wing UAS

According to the platform architecture, it is classified as a hybrid configuration, also known as a vertical take-off, and landing fixed wing, a kind of unmanned aerial vehicle that is heavier than air. The vertical take-off and landing are achieved by a helicopter, multi-rotor similar take-off and landing method or direct thrust. The horizontal flight is realized by the fixed-wing flight mode, and the vertical take-off and landing and horizontal flight modes can be freely switched in the air.

7) Instrument landing system (ILS)

A system that provides the aircraft with lateral, vertical guidance information and distance information from the threshold, and guides the aircraft to approach and landing according to instrument instructions. The instrument landing system includes a very high frequency (VHF) localizer, a very high frequency (UHF) glideslope beacon, a VHF marker beacon or distance measuring equipment (DME), as well as supporting monitoring systems, remote control and indicating equipment.

8) Multicopter UAS

According to the platform architecture, it is classified as multi-rotor, a kind of unmanned aerial vehicle that is heavier than air. Its flight lift is mainly generated by three or more power-driven rotors. The manipulation of changing its motion state is generally realized by adjusting the rotation speed of the rotor.

9) Non-directional radio beacon (NDB)

A radio navigation equipment which works in the medium and long wave bands, propagates non-directional signals through the ground surface to provide an aircraft with an azimuth angle relative to the ground beacon.

10) Precision approach path indicator (PAPI)

A visual navigation aid lighting device providing the pilots visual and precise approach path indications for landing.

11) Secondary surveillance radar (SSR)

The secondary surveillance radar is a radar system that locates aircraft through the inquiry of the ground interrogator and the response of the airborne transponder.

12) Very high frequency omni-directional range (VOR)

A radio navigation system that works in the VHF band and provides the magnetic azimuth information of the aircraft with the proper airborne equipment relative to the ground equipment.

3.2 Units and abbreviations

The units included in the technical specification of this bulletin and their definition are shown in Table 1.

Table 1 Units

Symbol	Definition	Symbol	Definition
nm	nautical mile	s	second
m	meter	ms	millisecond
ft	foot	dB	decibel
Hz	hertz	dBm	decibel milliwatt
kHz	kilohertz	W	watt
MHz	Megahertz	℃	Celsius
km	kilometer	%	percentage
kbps	kilobits per second	g	acceleration
DDM	Difference in the depth of modulation	Grms	total rms acceleration
VDC	Volts of direct current	°	degree

The abbreviations included in the technical specification of this bulletin and their definition are shown in Table 2.

Table 2 Abbreviations

Abbreviations	Definition
ADF	Automatic Direction Finder
ADS-B	Automatic Dependent Surveillance - Broadcast
ATMAS	Air Traffic Management Automation System
BDS	Beidou Navigation Satellite System

DC	Direct Current
DME	Distance Measuring Equipment
DGNSS	Differential Global Navigation Satellite System
GIS	Geographic Information System
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
GS	Glide Slope
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IP	Ingress Protection
LOC	Localizer
MLAT	Multilateration
MSL	Mean Sea Level
MKR	Marker
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NDB	Non-Directional Beacon
PAPI	Precise Approach Path Indicator
PSR	Primary Surveillance Radar
RMS	Root Mean Square

RTK	Real Time Kinematic
SMR	Surface Movement Radar
SSR	Second Surveillance Radar
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
UTC	Universal Time Coordinated
VHF	Very High Frequency
VOR	Very high frequency Omnidirectional Range
VTOL	Vertical take-off and landing
1090ES	1090MHz Extended Squitter

4 Essential requirements

4.1 Overview

Flight inspection is to ensure flight safety by using a flight inspection aircraft equipped with special inspection system to check and evaluate the space signal quality and tolerance of various navigation, radar, communications, and other equipment in accordance with the relevant regulations of flight inspection, as well as the feasibility of the airport's entry and departure flight procedures, and the process of issuing official reports based on the results of inspections and evaluations.

The basic principle of flight inspection is to use the precise position of the aircraft which is equipped with inspection system to compare and analyze the received radio navigation signal in space with the ideal signal that should be acquired at this time, this position, then obtain the inspection evaluation data and as the last step, according to relevant standards, judge whether the equipment to be checked meets the requirements of safe operation.

A civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS refers to the application that airborne mission system equipment is mounted on fixed-wing or hybrid-wing unmanned aircraft to achieve inspection, calibration, and evaluation of aviation navigation and surveillance facilities via an air-to-ground coordinated manner, including issuing flight inspection reports.

4.2 General requirements

4.2.1 Inspection functions

The civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS shall have the abilities to inspect and evaluate the listed aviation navigation and surveillance equipment at least:

- ILS
- VOR
- DME
- NDB
- MKR
- PSR/SSR
- GNSS
- ADS-B
- Surface surveillance: SMR, MLAT
- ATMAS
- PAPI

4.2.2 Quality assurance

The flight inspection system warranty shall not be less than 1 year.

The equipment maintenance period shall be no less than 10 years.

4.2.3 Applicable scope

The civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS can be used for inspection and evaluation of aviation navigation and surveillance equipment in terminal areas and routes.

4.2.4 Anti-crosswind disturbance

When the crosswind influences the UAS to fly the intended route, the flight inspection system needs to correct the influence caused by the route deviation on the inspection result. When the deviation is too large to be corrected, an alert is required.

4.2.5 Technical requirements for anti-jamming capabilities

1) Anti -jamming performance of GNSS receiver

The anti-jamming performance of the GNSS receiver used for inspection shall comply with the relevant regulations in ICAO Annex 10 Volume I 3.7.4.

2) Anti-interference requirements for differential GNSS data link

The differential GNSS data link used for flight inspection should have narrow-band anti-jamming communication capabilities.

4.2.6 Technical requirements for man-machine interface

The flight inspection system should provide good man-machine interaction interfaces between the inspection crew and the system equipment. The interfaces include at least the follows:

1) System status monitoring and alarm indication

2) Temperature monitoring and alarm indication

3) Data link status monitoring and alarm indication

4) Flight trajectory and relative position display between the aircraft and the station under inspection

5) Receiver working status control and output parameter monitoring

6) Data management of stations under inspection

7) Fast inspection mission establishment and automatic inspection evaluation

8) Automatic storage of inspection results and raw data

9) Reevaluation and post processing based on raw data

10) Monitoring the audio identification of the device being inspected

11) Network port and USB port for data communication and data backup

4.2.7 Ground communication

The ground subsystem shall have independent communication equipment to maintain the communication among the inspector, the support personnel, the UAS pilot, and the control tower during the inspection flight.

4.2.8 Testing and maintenance

The system equipment should have a testing interface.

The system shall have the ability to self-check, provide monitoring and status indication of the main equipment of the airborne subsystem and the ground-based subsystem.

The system shall have failure monitoring, diagnosis, and alarm functions.

The key components of the system should be repairable or replaceable.

When the system components are being repaired, the maintenance personnel should be able to easily access each repairable part.

Each component of the system should have effective error proofing measures and clear markers.

4.2.9 Power supply control

The flight inspection system should provide the UAS pilot with a power switch for the whole onboard subsystem.

4.3 Performance requirements

4.3.1 System requirements

The flight inspection system in this technical specification is the instrument and equipment for flight inspection. It should have the reliable detection, inspection and evaluation capabilities for main civil aviation navigation and surveillance equipment; its measurement uncertainty and evaluation tolerances should comply with both international and state standards, regulations.

4.3.2 Operation frequency band

The operating frequency band of the civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS should meet the operation frequency band of the main civil aviation navigation and surveillance equipment listed in Table 3.

Table 3 Operation frequency bands of main navigation and surveillance equipment for civil aviation

Equipment	Operation frequency band
LOC	108.10MHz~111.95MHz
GS	328.60MHz~335.40MHz
MKR	75MHz
VOR	108.000MHz~117.975MHz
DME	Transmission：962MHz~1213MHz； Reception: 1025MHz~1150MHz；
NDB	190kHz~1799.5kHz

SSR	Transmission：1030MHz Reception：1090MHz
GPS	L1、L2、L5
BDS	B1I、B1C、B2a

4.3.3 Power supply

The onboard subsystem should be able to work under the condition of 28VDC±10% power supplied by the UAS. The power supply of airborne subsystem can be controlled remotely by sending commands through the ground-based subsystem.

The power of the airborne subsystem shall be less than 150W. The power of the ground-based subsystem shall be less than 1500W.

4.3.4 System reliability and validity

The mean time between failures (MTBF) is not less than 2000 hours.

The mean time to repair (MTTR) is not more than 2 hours.

The validity of the system is not less than 99.9%.

The service life of the equipment is not less than 10 years.

4.3.5 Self-check function

The failure detection rate of the system self-check should not be less than 98%, and the failure false alarm rate should not be greater than 1%.

4.3.6 Temperature monitoring

The airborne subsystem shall have temperature monitoring and warning functions: the monitoring accuracy is better than ±2 ℃.

4.3.7 Spatial-temporal reference

1) Timing based on multi-frequency and multi-constellation (GPS, BDS at least) shall be provided with an accuracy better than 10ms.

2) The position reference shall meet the requirements in Table 4.

Table 4 Position reference accuracy of flight inspection system

	Accuracy (degree)		Accuracy (meter)		
	Horizontal	Vertical	Horizontal	Vertical	Constraint point（See Note）
ILS CAT I	0.020	0.018	1.0	0.2	C
ILS CAT II	0.007	0.009	0.3	0.06	T
ILS CAT III	0.006	0.009	0.2	0.06	D
VOR/DME	0.3	-	3.0	-	To station 0.3nm
PAPI	-	0.05	-	5.0	To T point 3nm
NDB	0.5	-	50	-	To station 3nm

Note: reefer to ICAO Doc 8071 for constraint point details.

4.3.8 Environmental conditions

4.3.8.1 Airborne subsystem

Operating: -40°C-70°C (installed in the compartment)

-45°C-70°C (installed outside the fuselage)

Storage: -40°C-75°C；

Altitude: not less than 25000ft MSL

Humidity: RTCA DO-160G A Class (installed in the compartment)

RTCA DO-160G C Class (installed outside the fuselage)

Waterproof: RTCA DO-160G W Class (installed in the compartment)

RTCA DO-160G R Class (installed outside the fuselage)

Dustproof：RTCA DO-160G D Class (installed in the compartment)

RTCA DO-160G S Class (installed outside the fuselage)

Shock (with vibration isolator): 15g, 10ms, final peak sawtooth wave

Vibration: 15-500Hz, 0.3Grms

Electromagnetic compatibility: RTCA DO-160G M Class

4.3.8.2 Ground-based subsystem (ground components of air-ground data link unit and spatial-temporal reference unit)

Operating: -40°C-65°C

Storage: -40°C-70°C；

Altitude: not less than 15000ft MSL

Humidity: 100%, condensation

Waterproof and dustproof: IP56

Shock (with vibration isolator): free falling to a hard surface at a height of no more than 1 meter

4.3.8.3 Ground-based subsystem (Inspection & evaluation unit and calibration unit)

Operating: -40°C-50°C

Storage: -40°C-70°C；

Altitude: not less than 15000ft MSL

Humidity: 80%, condensation

Waterproof and dustproof: IP53

Shock (with vibration isolator): free falling to a hard surface at a height of no more than 1 meter

5 Technical requirements

5.1 System components

The civil aviation flight inspection system based on fixed-wing / hybrid-wing UAS consists of two parts: airborne subsystem and ground-based subsystem. The airborne subsystem generally includes antennas, inspection receiver(s), signal acquisition unit, airborne component of spatial-temporal reference unit, airborne component of air-ground data link unit, radar inspection supporting module, runway lighting inspection supporting module, and airborne ADS-B module. The ground-based subsystem mainly includes the evaluation and processing unit, the ground component of spatial-temporal reference unit, the ground component of air-ground data link unit, and the calibration unit.

5.2 Antennas

5.2.1 General requirement

The antennas used for the inspection of aviation navigation and surveillance equipment in the flight inspection system should all complying with the airworthiness certification requirements

5.2.2 Antenna performance

The antennas shall fulfill the requirements in Table 5.

Table 5 Antenna requirements

Type	Frequency (minimum)	Polarization
LOC	108.00MHz~111.95MHz	horizontal
GS	328.6MHz~335.4MHz	horizontal
DME	960MHz~1215MHz	vertical
Marker	75MHz	horizontal

VOR	108MHz~117.975MHz	horizontal
NDB	190kHz~1799.5kHz	vertical
SSR	1030MHz (transmission) 1090MHz (reception)	vertical
GNSS	GPS：L1、L2、L5 BDS：B1I、B1C、B2a	Right-hand-circular

5.2.3 Antenna calibration

The antenna used to verify the coverage of the precision approach guidance equipment must undergo a calibration with an accuracy shall not be less than 2dB.

Antenna calibration should include the loss of cables, radio frequency switches and power divider in the working frequency band; it should include the directional pattern of signal strength at different working frequency; the calibration process should compensate for the received signal strength according to the loss and directional pattern in the working frequency band The distribution diagram

For airborne equipment using field strength as measurement unit, the antenna calibration should include the equivalent antenna coefficients in the working frequency band.

5.3Inspection receiver

5.3.1 General requirement

The inspection receiver obtains the signal in space from the system to be inspected via the antennas, and outputs analog signals, discrete signals or bus data that can be employed for signal measurement and evaluation.

The inspection receiver should meet the measurement accuracy requirements specified in ICAO Doc 8071 and AC-86-TM-2016. The measurement accuracy should be one order of magnitude or at least 5 times better than the error tolerance of the equipment under inspection.

The inspection receiver should be calibrated regularly.

The check receiver should have a self-check function.

The inspection receiver shall provide a status indication. The core components of the inspection receiver shall meet the airworthiness certification requirement or be verified and applied in the used flight inspection system.

5.3.2 Accuracy

Inspection receiver shall fulfill the accuracy requirements of Table 6 and Table 7.

Table 6 Inspection radio navigation receiver accuracy

	Mode	Parameter	Accuracy
VOR	-	angle	± 0.2°
	-	30 Hz REF (reference) modulation	± 1.0 % of reading
	-	30 Hz VAR (variable) modulation	± 1.0 % of reading
	-	9960 FM	± 0.2
	-	signal strength	± 1dB
ILS	LOC	difference in depth of modulation (zero offset)	± 0.003DDM (-70dBm)
	LOC	sum of depth of modulation	± 1.0 % of reading
	LOC	signal strength	± 1dB

	GS	difference in depth of modulation (zero offset)	± 0.002DDM (-70dBm)
	GS	sum of depth of modulation	± 1.0 % of reading
	GS	signal strength	± 1dB
ADF	-	bearing	± 3.0°
	-	signal strength	± 1dB
DME	-	distance	± 0.05nm
	-	signal strength	± 2dB
MKR	-	signal strength	± 1dB

Table 7 GNSS receiver accuracy

Mode	Parameter	Accuracy (RMS)
Single frequency	horizonal	1.5m
	vertical	3m
Dual frequencies	Horizonal	1.2m
	vertical	2.4m
RTK	Horizonal	0.02m
	vertical	0.04m

5.4 Signal acquisition unit

5.4.1 General requirement

The design of the signal acquisition unit should comply with aviation standards.

The signal acquisition unit should adopt a real-time operating system.

The signal acquisition unit should be able to automatically store and back up the inspection data collected in real time.

5.4.2 Multi-source signal acquisition

The signal acquisition unit should have the capabilities of acquiring analog signals, discrete signals, bus data (such as ARINC 429, RS 232/422/485) in real time.

The signal acquisition unit should be able to obtain the parameters listed in Table 8 (but not limited to) in real time from the UAS's avionics and other equipment of the airborne subsystem.

Table 8 Acquired parameters

Type	Parameter
VOR	bearing
	30Hz REF modulation
	30Hz VAR modulation
	9960 FM
	signal strength
	Identification
ILS	difference in depth of modulation
	sum of depth of modulation
	signal strength
	Identification
	difference in depth of modulation
	sum of depth of modulation

	signal strength
ADF	bearing
	signal strength
DME	distance
	signal strength
	Identification
MKR	signal strength
GNSS	longitude
	latitude
	ellipsoidal height
	mean sea level
	dilution of precision
	satellite list
	positioning status
	UTC time
flight	roll
	pitch
	heading
	pressure altitude
	ground speed

5.4.3 Data synchronization

The flight inspection system shall have the ability to synchronize multi-source data with an accuracy of 50ms or better.

5.4.4 Data update frequency

The update frequency of flight inspection data shall not be lower than 20Hz.

5.5 Spatial-temporal reference unit

The time-space reference unit can use highly precise inertial navigation units, cameras, laser altimeter, precise barometric altimeter, GNSS, DGNSS, integrated navigation and other different ways to obtain accurate position and time information for the flight inspection system to build signal evaluation benchmark. For the accuracy requirements of the space-time reference unit, refer to section 4.3.7.

The spatial-temporal reference unit can use common navigation equipment with the UAS.

The positioning data used by the spatial-temporal reference unit should be independent of the equipment under inspection. The spatial-temporal reference data should be defined in the same coordinate system as the equipment under inspection.

The flight inspection system shall provide continuous positioning reference information.

5.6 Data link module

The data link module is used for a two-way transmission of airborne subsystem control commands and inspection data. The operating frequency of the data link module should be compatible with other airborne inspection equipment, and the frequency band used should comply with the state radio regulations. The downlink signal of the data link cannot interfere with other inspection equipment. For specific operating frequencies of other airborne inspection equipment, refer to section 4.3.2.

The data link module should meet the following requirements:

1) Coverage range: not less than 50 km

2) Bit error rate: not more than 10^{-6}

3) Latency time: not more than 100 ms

4) Date rate: not less than 500 kbps

5.7 Radar inspection supporting module

To evaluate the ability of radar to identify target in the air, in case that the UAS platform does not have the target reflection ability or is weak, a reflection device that can be recognized by the air traffic surveillance radar should be installed.

5.8 Runway lighting inspection Supporting Module

The airborne subsystem contains camera and recording device to identify precision approach path indicator which can perform PAPI inspection with reference information.

5.9 Airborne ADS-B unit

The unit should have 1090ES ADS-B OUT function, automatically broadcast its location, speed, altitude, code, and other information.

It works in Mode A/C/S mode, with configuration of ICAO address code, flight number, answering machine code.

5.10 Evaluation and processing unit

5.10.1 Equipment database

The equipment database should contain basic information such as frequency, coordinates, and equipment parameters. The flight inspection system should have the functions of creating, editing, and managing the equipment database safely.

5.10.2 Inspection and evaluation

Refer to AC-86-TM-2016 and ICAO Doc 8071 for the evaluation calculation of inspection data and their tolerance standards.

The inspection and evaluation results provide by the flight inspection system based on UAS should be consistent with the inspection results of the flight inspection system used in civil aviation in the state.

5.10.3 Data recording and management

The unit should have functions of data recording and management:

- Record raw data and calculated data.
- Record the time and type of the trigger signal of the inspection event.
- Automatic data backup with a period not less than 6 months.
- Historical data and curve retrieval and playback for comparison and reference.
- The inspection data post processing, which can redo the inspection evaluation, when necessary, based on raw data to improve the flight inspection efficiency.

- Data retrieval and extraction: provide specified data records according to user needs, and form data files according to the specified format.

5.10.4 Data display

The unit should have the functions for data display as follows at least:

- Present inspection data as curves with partial observation and data indication.
- Display the event marks on the graph.
- Sectional display of various data such as flight data, signal acquisition data, inspection parameters, positioning reference data, etc.
- A graphical display of aeronautical chart, waypoint, virtual instrument, flight position, flight trajectory and the position of the equipment under inspection.
- Load and display UA flight plan route.
- Automatically save the inspection results and curves as PDF documents.

5.10.5 Parallel processing

To improve the efficiency of flight inspection, the unit should have the capability of multitasking and execution.

5.10.6 Virtual instrument

The unit shall present the information via virtual instrument for:

- Heading beacon
- Decline beacon

- Omnidirectional beacon
- Non-directional beacon
- Flight altitude and attitude

5.10.7 Inspection report

The unit should be able to automatically generate an inspection report.

The generated inspection report should comply with AC-86-TM-2016 normative documents and ICAO Doc 8071 standard.

5.10.8 Remote control

The unit should have the remote-control functions via transmitting commands to the airborne subsystem.

- Remotely control the power supply of the airborne subsystem.
- Remotely tune the inspection receiver in the airborne subsystem.
- Remotely controlling the working mode and working status of the inspection receiver in the airborne subsystem.
- Remotely controlling the working status of the signal acquisition unit of the airborne subsystem.

5.11 Calibration unit

5.11.1 Calibration method

A specific radio frequency signal is generated by an aviation signal source, input to the inspection receiver. And the output of the receiver is compared with the desired value to calculate the accuracy and uncertainty of the receiver's outputs.

The unit should cover the operating frequency band of the calibrated equipment.

When calibrating signal strength, the power loss of the cables and interfaces should be corrected.

5.11.2 Calibration environment

The calibration can be carried out in the inspection aircraft or in the laboratory.

The ambient temperature for calibration should be relatively stable. The ambient temperature and temperature variation during calibration should be indicated in the calibration report.

The humidity of the calibration environment is not more than 80%.

5.11.3 Signal source

The signal source used for flight inspection system calibration should meet the relevant calibration and measurement requirements of the CCAR-86 document.

The signal source should be calibrated regularly and traceable to the state measurement standard.

The calibration signal source should be used within the validity period of the calibration.

5.11.4 Calibration report

The flight inspection system has an automatic calibration function and can automatically generate a calibration report.

The calibration data can be managed according to the device number. The calibration report should indicate the instruments used and their own calibration expiration date, calibration environment temperature, calibration validity period, recheck results, calibration time, operators, calibration units and other information.

The calibration report shall include the measurement uncertainty of the calibration parameters.

6 Tag, documents, transportation, and storage

6.1 Tag

6.1.1 Equipment tag

The equipment tag of the flight inspection system shall include the following contents:

- Manufacturer
- Name
- Specification and model
- Part number
- Serial number
- Production date

6.1.2 Certificate of conformity

The certificate shall provide at least the following information:

- Manufacturer
- Name and model
- Part number
- Serial number
- Production date
- Inspection date
- Inspector code

6.2 Technical documents

The technical documents provided with the system should include the following:

- System operation manual
- System maintenance manual
- System training manual
- List of equipment parts
- List of minimum operating spare parts
- Technical manual of parts and components
- Flight test report
- Ground test report

6.3 Transportation

General transportation is adopted. and severe shock, vibration, rain, and snow splashes during transportation must be prohibited.

6.4 Storage

The packed flight inspection equipment should be stored in a well-ventilated room where the ambient temperature meets the requirements of Section 4.3.8, is free of corrosive gas.